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FAXED 14:26 9/21/92

FACSIMILE TRANSMISSION

TO: **Laura Colton**

OF: **CALIFORNIA DEPARTMENT OF FISH & GAME**

FROM: **William P. Burger, Staff Biologist**

DATE: **21 Sep 1992**

FAX NUMBER: **916-653-1856**

THIS TRANSMISSION CONSISTS OF 4 PAGE (S) INCLUDING THIS PAGE.

Dear Laura,

I'm writing this fax as a follow-up to our recent conversations regarding measurement of output power from the wildlife transmitters that we produce.

As we have discussed, there are several ways to measure output power of transmitters. Perhaps these can be grouped into two basic categories.

- One category involves measurements made when measurement instruments are connected directly to the transmitter itself under controlled circumstances. These are the type of measurements that we make at TELONICS. These measurements are repeatable, quantifiable, and provide good information regarding consistency of transmitters.

- The second type of measurement involves attempts to measure the radiated signal strength of transmitters. This type of measurement is extremely difficult to do well. In addition, even if the measurement could be done well, the results would still not transfer into what might be encountered in the field because of the wide variation in the impedances seen by the transmitting antenna and the wide variation in radiation patterns of the antenna when the equipment is actually deployed on animals.

During the production of our transmitters, there are a variety of tests conducted at different stages. After the transmitter electronics have been assembled and tuned to the frequency of operation, we perform power tests. We use a coaxial cable to directly connect the transmitter circuit board to an RF power meter. This provides a measurement of total output power of the transmitter when connected to a 50-ohm load. With our transmitters equipped with standard output power (such as those that you at the California Fish & Game almost always utilize), the total output power is approximately 15 milliWatts. This is not a continuous output power, but in fact, is limited to approximately 1-2% of the total time which is when the transmitter is pulsing. More specifically, the pulse width of the transmitter is approximately 15 milliseconds, and the pulse period (the time between the start of one pulse and the start of the next pulse) is usually between 800 milliseconds and 1200 milliseconds. The 15 milliWatt power output is applicable to the 15 millisecond pulse width. This results in an average output power of approximately 225 microWatts. In addition to the measurement just described, we also connect the transmitter electronics directly to a spectrum analyzer, again, using a coaxial cable to maintain a 50-ohm impedance. Using the spectrum analyzer, we are able to be sure that the transmitter is tuned so that the primary transmission frequency is at least 10 dB above any harmonics. Both the measurements just described are quite repeatable and easily performed, given the appropriate test equipment. They are both performed by directly connecting the transmitter electronics to the test equipment using a 50-ohm load.

Using the measured values that we take at TELONICS, it is possible to roughly approximate power losses resulting from the type of transmitting antenna used. Note that this is in contrast to many communication applications where the transmitting antenna would result in gains. Limitations of what can reasonably be used on wildlife result in a ¼ wavelength whip antenna typically being all that is feasible. Such an antenna results in loss rather than gain. For most applications on wildlife, the losses are probably in the vicinity of -12 to -20 dB relative to the power measured at the transmitter circuit board. With a starting point of 15 milliWatts, a reduction by 12 dB would result in a power level of approximately 0.900 milliWatts, or 900 microWatts. Again, this represents the peak output power. If losses of 20 dB are assumed, then the predicted radiated power would be closer to 100 to 200 microWatts. These values are probably fair [illegible]sentations of the predicted radiated output power of wildlife transmitters during the [illegible]self. Because of their 1-2% duty cycle and very low output power, wildlife transmitters [illegible]nally represent only low level background noise in any sort of communication equipment. Instances of the transmitters breaking squelch on any sort of communication equipment are very rare. Receivers designed and used for wildlife telemetry are very sensitive and, thus, are able to receive these transmitters at fairly long distances. When using such receivers, it is common to receive transmissions from various other transmitter sources. Such transmissions may not even be directly on the frequencies being monitored because harmonics from higher power transmissions are often greater in power than the output power on the primary frequency for wildlife transmitters. For example, handheld two-way radios are often 3-5 watts, mobile units may be 20 watts or more, and radio broadcasts and other transmissions may be hundreds to thousands of watts.

When packaged in their final configuration for deployment on various wildlife species, the measurements mentioned above can not be made because it is not possible to connect directly to the transmitter circuit board. This is why measurements of radiated power are sometimes suggested. The problem is that both the impedance and radiation pattern of the antennas vary as influenced by objects in close proximity, e.g. the animal, the ground, vegetation, etc. These factors make any meaningful measurement of power output in the completed transmitter unit very difficult. Further, any measurements which are taken must be expected to vary when the transmitter is actually deployed.

If radiated output power was to be measured with the transmitters of concern, the proper procedure would be to utilize an anechoic chamber. To our knowledge, there are two of these in the U.S. that would permit accurate measurements, given the frequencies of concern, and the output powers that are being utilized. These anechoic chambers have specially designed walls that absorb all signals so that measurements can be made without any interference from bounced signals. In the absence of such a chamber, measurements will be influenced by any movement of people or objects within the area that the measurement is being taken. The reason for this is that the signals will be bounced off different surfaces and, thus, the power arriving at the receiving antenna used for the measurement will vary. A further drawback in trying to measure radiated power is that even if the measurement could be accurately taken from a transmitter prior to deployment, the impedance of the antenna and the radiation patterns of the antenna will vary when the transmitter is placed on the neck of a deer, bear, etc. Further, addition variance will be introduced when animals and collars become wet, when the antenna moves with animal movements, or when the antenna is possibly bent or broken off. All of these factors combined make measurement of radiated output power an unrealistic way to represent the type of transmitters used for wildlife telemetry.

As a final note, it is probably worth considering that over the past 25 years or so, well over one-hundred thousand transmitters of this type have been used on wildlife throughout California, the U.S., and the world. It is quite common for people tracking animals to encounter interference relating to higher power sources, such as voice communications. To our knowledge, the FCC does not have any record of wildlife transmitters interfering with any other type of transmission.

I hope that this information helps, please contact me if I can be of further assistance.

Sincerely,

Bill Burger

William P. Burger

WPB/tp