THE FREQUENCY CHOICE FOR

AVALANCHE BEACONS[1]

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Abstract. The purpose of this paper is to explain matters of the frequency controversy for avalanche beacons. Also, to promote new areas for avalanche victim rescue. Elements of a new antenna design and the possible use of lasers and acoustics for preventing and locating avalanche victims will be mentioned.

The danger of snowbound travel and the element of survival of the unexpected has played an integral role in the develope-ment of the avalanche transceiver. Anyone who has used an avalanche transceiver and traveled snowbound for extended periods can understand the probable nature of beacons. The philosophy is one of rescue and not prevention. This paper is to describe some of the reasons for choosing a particular frequency and point out some useful characteristics of beacons in general. Also some new concepts for locating and preventing avalanche victims will be promoted.

The avalanche transceiver has only recently achieved an international political status through the use of differnt freq-uencies. The incompatibility of these frequencies has lead to the DIN 32924. The DIN is a manufacturing specification designed to promote a standardized and tested product. DINs apply to many other products where a safe standard is needed.

The use of differing frequencies is an obvious danger. This has lead the DIN to specify a dual frequency beacon until 1989 when all beacons will be 457 khz.

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As described by Lind and Smythe(1984 ISSW) both the 2.275 khz and the 457 khz beacons are of magnetic nature and emit the characteristic dipole field. They also reported the relation between the angle of the receiving antenna and the transmitted dipole field. This angle, they said, has a direct bearing on the signal strenght in the receiver. Of more important note, they reported the false projection of the actual location of the beacon when the angle of the emitting beacon is at a angle with respect to the snow surface. This was reported in the close (nigh) zone near the beacon.

The dependence on the respective angles of both the transmitter and receiver lead the rescuer to the process of finding these optimums. Since the coupling between receiver and transmitter is transformer like the dependence on frequency has little to do with the rescuers process.

An interesting study by Walker noted the deflection of a compass needle in the area close to the beacon.[3] The deflection was porportional to the distance from the transmitted signal. Significant deflection was noted at a distance of less than a foot. Whether a buried victim could be located using a compass has yet to be proven. However, it is mentioned here as an option when a compatable transceiver is not handy.

3 This was a coarse study done by Walt Walker of Fort Lewis College, Durango, Colorado.

Coarse reports of watches, shovels, radios, and other magnetic field absorbing materials affecting the field configuration of a beacon have lead to concern. The shape and magnetic permeability of carried objects and this affect on the field configuration is hard to measure. However, the magnetic suseptibility of most materials is near unity except for ferromagnetic materials such as iron and steel. Sensitive rescuers have proven these limitations can be overcome.

The developement of the DIN 32924 and the 457 khz transceiver have rendered the 2.275 khz transceiver as the waning frequency choice for the future. The reasons are of natural evolution. With a frequency laden Europe, the 457 khz frequency offers a near interference free frequency. Walter Good mentioned the reasons for this as being the proximity of the 457 khz frequency to the 455 intermediate frequency(IF) and that the 457 khz frequency is one of the least jammed frequencies in Europe.[4]

An IF is the frequency that a radio channel is converted to before demodulation. An IF of this kind is used in some types of common AM broadcast receivers. To demonstrate this concept in the same coarse study by Walker he mentions the induction of the 457 khz tone into a common AM receiver at a distance of less than six inches. The tone was heard when optimum coupling was obtained and the radio was tuned to an arbitrary channel.

With a sensitive magnetic receiver interference poses a possible problem. A popular backcountry skiing area is powerline cuts. The 457 khz frequency, being just below the AM broadcast band is suseptible to powerline magnetic interference. Other broad band interference can come from electric motors, ignition systems, and faulty electrical grounding. Also, strong magnetic disturbance can come from powerful low frequency transmitters such as the Ground Wave Emergency Network (GWEN) (Mideke, 1984).

The frequency choice seems to be to accept the DIN 32924 or not. However, the 457 khz beacon has shown faster search times in a coarse study by Walter Good (1984 ISSW) and it has a greater range.[5]

4
A letter from Walter Good, Swiss Fedral Institute for Snow and Avalanche Research.

5
I assume that the greater range of the 457 khz beacon is common knowlege.

BATTERIES

The affect of temperature on batteries is worth noting. The affect of temperature on the voltage recovery and internal resistance is important for optimum performance. The reduction of chemical activity and the increase in internal resistance at low temperatures may affect certin types of batteries more than others. It can be seen from figure 1 that the alkaline MnO_2 batteries are relitivly stable over the temperature range specified by the DIN 32924 (-20 to +40 C).

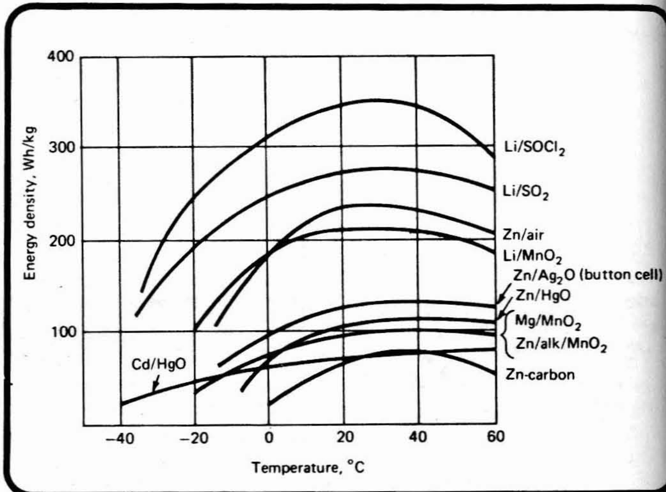

Figure 1. Gravimetric energy density of primary batteries. From the Handbook of Batteries and Fuel Cells, Linden, 1984, Mc Graw Hill.

It is recomended that manufactures specifications be followed. This could be important for optimum performance.

A NEW ANTENNA

The redesign of the antenna by shortening it and increasing the diameter holds a promise of reducing the receiver sensitivity to the typical nulls encountered when manipulating the magnetic field of a victims transceiver. Core loss and permeability are a problem with a large solid core. To combat this problem a solinoidal shell with an air core is proposed. The theory is based on the "sloppiness" in the received maximum signal. A received maximum is when the receiving antenna is parallel to the field lines. The "sloppiness" is a geometrical problem with respect to the area of the receiving antenna.

As mentioned by Lind and Smythe(1984 ISSW) the voltage induced in the receiver is:

$$V(t) = A_r B_1 w \sin(w(t - \frac{R}{c}))\cos\Theta_r$$

Where A_r is the receiver antenna area, B_1 is the amplitude of the magnetic field at the receiver, R is the distance from the receiver, w is the angular velocity, O_r is the orientation of the receiver, and c is the speed of light.

If the area of the receiver is increased the voltage induced is porportional to this increase. However, if the relitive area is the same--same lenght of wire is used, then the "sloppiness" in the receiver antenna is increased. This is shown in figure 2.

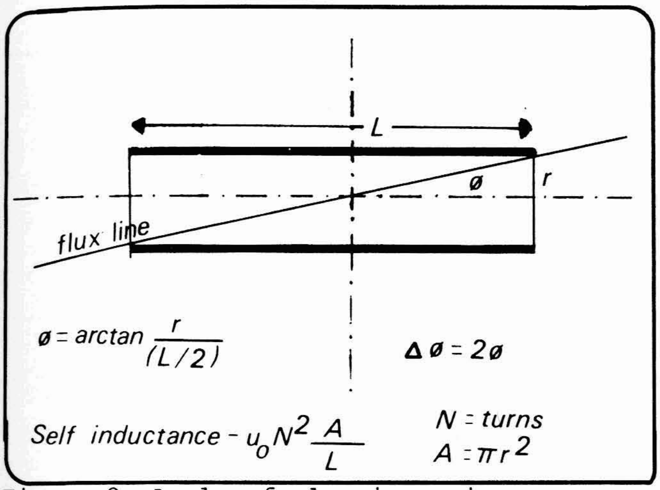

Figure 2. Angle of sloppiness in a maximum signal. The receiver antenna.

The increased angle differential could lead to less fiddling with the beacon when searching for a victim and might lead to faster search times.

The antenna when used as a transmitter would roughly have the same dipole field as existing antennas if the diameter is not increased dramaticly. This concept was originally developed to concentrate more field in the nigh zone.

This antenna has not been tested and is mentioned here for its theoretical significance. One of the problems is obtaining a core that will operate near saturation. The cores would have to be manufactured--to my knowlege there is no commercially available cores of this nature.

NEW THINGS

In a letter from Rob Faisant, national avalanche advisor, he states where the National Ski Patrol stand on the beacon issue, "We feel a responsibility to come to a scientifically sound conclusion so that the intrests of the Winter public will best be served, apart from any matters of politics or national pride." If the needs of the Winter public will be meet by the 457 khz beacon only the future will tell. However, there are other areas to be explored before a sound conclusion can be made. These other areas are the interaction of light and acoustics with the Winter environment.

Warren(1981) in a thesis on the optical properties of snow mentions the use of infared reflectance (albedo) as a way of remotly sensing the snow pack. He mentions the general spectral changes in the snow pack also.

The ideal channel for snow pack sensing falls in the range of modern highly efficient semiconductor lasers. This range is 1.0 - 1.2 um in wave lenght(Warren, 1981). This concept demands vigirous study, yet, this might lead to a remote snow sensing device from the air or adjacent hillside. Even a remote device for locating avalanche victims might be possiple. This would be useful for large catastrophies and dangerous remote areas. Also, this concept might prove useful for the study of wind laden slopes.

The human ear is currently used as the transducer for locating victims. Magneto-optic effects on the visible light spectrum might hold a promise of a visible search for avalanche victims. The solar reflection as it interacts with the snow and magnetic pulse of a beacon might be visible and lead to a quick and accurate search. This might be possible through the use of "3D" glasses or filters. This concept has not been studied for possibilities.

Johnson(1984 ISSW) through his reports on the acoustical properties of snow mentions the heavey antenuation of low frequency sound in the snow pack. Ultrasound, sound bejond the human definition, might hold a future in collapsing the air-ice interface of snow grains. This would be similar to an acoustical shear gauge or density tester. This could be used to test portions of the snow pack rapidly leading to an increased knowlege of conditions.

Some interesting features of this concept are that the sound at a specific frequency might be propigated by layers with larger air space and antenuated by layers with less.

This concept was formulated through the use of resonating either the cavity of air or the crystal to break the physical bonding. As mentioned by Johnson(1984 ISSW) the transmission loss through snow is

$$TL = 10 \log(I_i/I_t)$$

Where I_i is the incedent intensity and I_t is the transmitted intensity. Intensity is the flow of energy per unit area in a unit time(Stanley, 1968). With high intensity Ultrasound the above mentioned concepts might be possible.

Vigorous study is needed on these new concepts to test feasibility. Also, they need to be throughly tested and criticized. To settle on a simple beacon frequency is a major achievment in itself. Some how the survival game demands the philosophy of prevention and rescue.

The question is--What happens next?

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