FREQUENZSALAT - TOWARD UNIFORM FREQUENCIES FOR VARIOUS TYPES OF AVALANCHE VICTIM LOCATORS[1]

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Use of incompatible frequencies for avalanche victim location devices has created problems in rescue operations. Discussion covers the frequencies in use, their characteristics, proceedings for selection of uniform frequencies, and possible consequences.

INTRODUCTION

The search for effective electronic devices for location of buried avalanche victims has led inventors to experiment with systems using many different frequencies. The use in the field of different systems operating on different frequencies has led to problems in a number of rescue operations. For example, in March 1983, an avalanche accident near St. Antonien, Switzerland, buried some German ski tourers who were equipped with transceivers transmitting on a frequency of 2275 Hz. The Swiss rescue team was equipped with receivers operating on 457 kHz. Of course, the searchers were not able to locate the buried victims. Finally, by use of some 2275 Hz receivers obtained from the survivors, the victims were located but five had already died. Problems of this sort, involving incompatible transceiver frequencies, are estimated to have interfered with many rescues and to have cost as many as 10 lives in the European Alps in the past decade.

So many different systems have been placed in service, operating on so many different frequencies, that the problem has been referred to by some comentators as a "frequenzsalat", that is a salad of frequencies.

These problems have, in turn, stimulated discussion in many parts of the world concerning the characteristics of these systems, and the possibility of achieving compatibility of systems by using uniform frequencies.

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CLASSIFICATION OF SYSTEMS

Each of the practical electronic systems in use today may be placed in one of two general classifications. First are those systems using a search apparatus which is usually kept at a standby station. In the event of an accident, the search device is called for and brought to the site by a rescue team. These devices can be referred to as "rescue team systems".

The second general classification consists of those systems for "companion help", in which the search device itself is routinely carried by the persons exposed to avalanche hazard. In this case, the search device is usually at the scene when the avalanche accident occurs.

In general, the desired capabilities of the search device will suggest a range of frequencies in which it must operate, and this will, in turn, determine the method of search and other characteristics of the device.

RESCUE TEAM SYSTEMS

Two general types of rescue team electronic systems are being placed in use in various countries. One of these involves a transmitter which is operating on a very high frequency, and is located by a directional antenna. An example of this type of device is the French L'ELP which operates on a frequency of 156.845 mHz. The transmitter is very compact, and is worn on a neck chain which is itself the antenna. Battery life of the transmitter is about 3 or 4 weeks of continuous operation, or one season for the typical skier. In the event of an accident, the searching unit, which weighs about five pounds, is brought and, by means of the Yagi antenna, the direction of the transmitter is determined very accurately. The range of L'ELP is well in excess of 1000 feet.

The second principal type of rescue team system is a responder or secondary radar system. These devices necessarily operate in an even higher frequency range, and some have been experimented with in the gHz range. The idea itself was suggested by John Lawton, inventor of the SKADI, at the 1975 Vanni Eigenmann Symposium. It has now been put into practice in various forms in Sweden, Italy and Yugoslavia. Each of the three present systems operates on a frequency different from the others. Each depends on having the avalanche victim wearing one or more ceramic diodes. Search is by portable radar, and the diode is activated by the radar signal, and gives back a coded response that can be received and identified by the radar.

One example of this system is the Swedish RECCO, which operates on a frequency of 915 mHz. Under ideal conditions, this system can search a path as wide as 100 meters, but the effective range depends very much on the depth of the burial and density of the snow, and an avalanche search should typically be of a band about 10 meters wide.

All rescue team systems are at a disadvantage in an operation where time is of the essence, because of the delay necessarily involved in calling for the search device and in transporting it to the scene of the accident. There are also questions of cost and availability of the search devices, and an overriding question whether sufficient numbers of prospective avalanche victims will equip themselves with the proper transmitters or diodes in order to enable the system to be used on a general basis within a particular geographical area.

COMPANION HELP SYSTEMS

All companion help systems consist of personal avalanche rescue transceivers. The need for a compact, easily portable combination of transmitter and receiver without cumbersome antennae had dictated that these devices operate on somewhat lower frequencies than the rescue team systems, and the use of lower frequencies has in turn dictated the methods of search. Since such transceivers are in general use throughout the world, problems of frequency incompatibility have arisen in a number of rescue attempts, and it is here that the problem of frequenzsalat is most severely felt.

Although a decade ago there were at least 25 different transmitter-receiver combinations in operation on at least 15 different frequencies, today there are only two frequencies in general use for avalanche rescue transceivers. These are the so called North American frequency of 2275 Hz and the so called European frequency of 457 kHz.

In 1968, John Lawton invented and produced the first combined transmitter-receiver, the SKADI. He selected the frequency of 2275 Hz in designing this system to operate on the principal of audio induction, the frequency appearing to be a good compromise to meet the requirements of effectiveness of the ferrite antenna, perceptibility to the human ear, frequency stability, absence of interference, simplicity of circuitry and low manufacturing costs. A few years later, production was begun in Austria of the Pieps transceiver, designed to operate on the same frequency. Since that time the frequency 2275 Hz has been in use in much of Europe, and has been adopted as the national standard by several nations.

Continuing studies, conducted by Dr. Walter Good of the Swiss Federal Institute for Snow and Avalanche, indicated that a device of longer range would provide a higher probability of live recovery in the typical avalanche search. He assumed a maximum probable search area of about 100 meters square, made certain assumptions about how fast the typical rescuers would move, and determined that, in order to achieve a 98% probability of locating the victim within the first ten minutes, it would be necessary to have a transceiver range considerably in excess of the maximum typically achieved by the devices operating at 2275 Hz. Based on this information, and study of existing interference patterns at various frequencies, the Swiss Army selected the frequency of 457 kHz for its transceivers. Thus in 1973, the VS-68 or Baryvox transceiver, manufactured by Autophon of Switzerland, was placed on the market. These transceivers have since been supplied in large numbers to the military forces of various countries, and are in use by a large segment of the European skiing public.

The proliferation of systems operating on these two incompatible frequencies has brought about the problems described above, as well as the current debate over possible standardization on a single frequency.

FREQUENCY DEBATE

The forum for the current debate over possible frequency standardization is the International Mountain Rescue Commission (IKAR/CISA), and in particular, the Avalanche Subcommission of that organization. The subcommission has been bombarded with information from manuacturers and academic authorities in many nations, setting forth the relative merits of the two frequencies. The perceived characteristics of these frequencies include the following:

Characteristics of 2275 Hz

The very low frequency of 2275 Hz is itself audible to the human ear, even one which has been damaged by exposure to explosives, and devices using this frequency have no need for electronic circuitry to convert a radio signal to one which is audible. The signals propogated at frequency 2275 Hz are not subject to absorption and deflection by snow structure, water, rocks, timber, debris or soil, nor are they subject to reflection. The frequency 2275 Hz is not subject to interference from most marine radio transmissions, broadcast radio stations, nor other transceivers which are transmitting away from the locality of the rescue operation. The use of this frequency is not legally regulated in any country, and therefore audio induction devices can be used without prior licensing. Due to the simplicity of circuitry, devices operating at 2275 Hz should be able to be made with great reliability for somewhat less cost than devices on radio frequencies, and thus be more easily available to the skiing public and other persons needing protecting from avalanche. Finally, it is readily possible to achieve a range of at least 30 meters, which has been shown to be sufficient for effective use under conditions prevailing in the United States.

Charcteristics of 457 kHz

The frequency 457 kHz falls in the low end of the broadcast radio range. This frequency has been reserved by international treaty adopted at Buenos Aires in 1952 for the use of marine mobile radios. In the United States the use of the 457 kHz frequency is prohibited (except for low power devices) by the Federal Communications Commission. However, it seems likely that the typical avalanche rescue transceiver could be certificated as a low power device, given the proper evidence of field strength measurements, and thus exempted from frequency and licensing requirements.

The principal advantage claimed for the frequency 457 kHz can be summed up in one word - range. Due to increased antenna efficiency, given the same amount of battery power, the 457 kHz frequency device will achieve longer operating range. It is acknowledged that wet snow and water absorb some of the signal at 457 kHz, but that is thought to be more than compensated by better transmission efficiency. Some authorities also favor the fact that the 457 kHz device can readily be equipped with a loud speaker (rather than an ear phone). It is generally acknowledged that the cost of the 457 kHz devices should be about 10% higher than for the competing devices.

Transceiver Testing

In December, 1983, the President of IKAR/CISA requested interested parties to carry out transceiver tests for the purpose of gathering data to be submitted to the meeting of the Avalanche Subcommission in October, 1984. A standard test method was developed by the Swiss Federal Research Institute for Snow and Avalanche, and was published to the members of IKAR/CISA. The test results record the maximal distance at which the transmitted signal is first received as well as the time and accuracy of location, using various combinations of compatible transmitters and receivers on the two respective frequencies.

The test method is somewhat skewed in favor of longer range devices, in view of the size of the test bed (100 meters by 150 meters), which is larger than most avalanche deposition found in the United States. In such a large test bed a transceiver with a maximum range of approximately 30 meters is at a disadvantage as against one with a maximum range of 50 to 100 meters.

Preliminary test results indicate that the transceivers operating on 457 kHz had an average range of a little over 80 meters while those operating on 2275 Hz had a range of a little over 30 meters. The 457 kHz frequency devices also produced more rapid location in 45 tests out of 47 conducted. These results may have been affected by the test methods used as well as by the selection of specific types and models of transceivers.

The testing thus far has principally emphasized range, while other characteristics such as frequency stability, minimum and maximum field strength, freedom from interference, performance in various media and absorption by materials, operating temperatures, battery type and life, controls, resistance to vibration, reliability, and cost must be considered in attempting to specify the ideal avalanche rescue transceiver.

Nevertheless, field experience indicates that the longer range devices are achieving more rapid locations. This is true because the operators are able to use a wider search band and thus cover the deposition zone more rapidly.

PRESENT STATUS

In response to the discussions at the International Mountain Rescue Commission, an _ad hoc_ committee was formed in the United States, the committee consisting of transceiver manufacturers, electronics authorities, and avalanche personnel. This committee, after studying the characteristics of the frequencies in question, produced a paper setting forth the various advantages of the frequency 2275 Hz.

At its meeting in October, 1984, the Avalanche Subcommission of IKAR/CISA considered the United States committee's paper as well as numerous recommendations from other nations. The subcommission had before it the recommendation of the IKAR/CISA Board of Directors that, effective immediately, only dual frequency transceivers be built and sold, and that the frequency 457 kHz be adopted as the worldwide standard in 1989.

The representatives of the United States and Canada were able to persuade the Avalanche Subcommission that North America presently has no frequenzsalat problem, and that the proposed resolution would introduce a problem where none presently exists. The discussion at the subcommission made it apparent that interference problems exist with all proposed frequencies. Therefore it was agreed that further study will be done to determine the practical effects of such intereference on the proposed frequencies.

The resolution of the International Mountain Rescue Commission, as finally adopted, stated that IKAR/CISA and the German national commission on standards (DIN) have made tests that clearly show the higher frequency systems perform better in all parameters, but that, pending a solution of questions of interference, and reevaluation of conditions in North America, the commission plans to select a single frequency in 1986, and to require that all transceivers conform to that frequency by 1989.

While the recommendations of IKAR/CISA do not have the force of law in any country, it appears that these recommendations will be picked up rapidly by the various national standard setting bodies. For example, the German and Austrian institutes for setting standards (DNORM and ONORM respectively) are preparing to adopt similar regulations. This matter also is the subject of an on-going study by the American Society for Testing and Materials (ASTM) in the United States.

PROSPECTS

It is not possible to predict with certainty what the effect of these regulations will be on the future of avalanche transceivers in the United States. In view of the absence of any units operating solely on 457 kHz, there is no frequenzsalat problem to be addressed at this time. The many transceivers presently in the field designed to operate at 2275 Hz will continue in use for the time being. However, if it is determined that the interference problems on frequency 457 kHz are not too severe, it is likely that the longer range devices will eventually be preceived as providing better results. It remains to be seen how the skiing public and the manufacturers of transceivers will respond to this challenge.