ELECTROMAGNETIC COMPATIBILITY OF
AVALANCHE TRANSCEIVERS

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ABSTRACT: Every once in a while, the issue of ElectroMagnetic Compatibility (EMC) of avalanche transceivers is popping up. There are at least three mechanisms by which avalanche transceivers may suffer some kind of interference from other equipment. Besides the best known interference to a searching receiver, there may also be interference to a transmitting transceiver or even to a transceiver in any state. After explaining the mechanisms of interference, some hints are given on how to check for various types of interference.

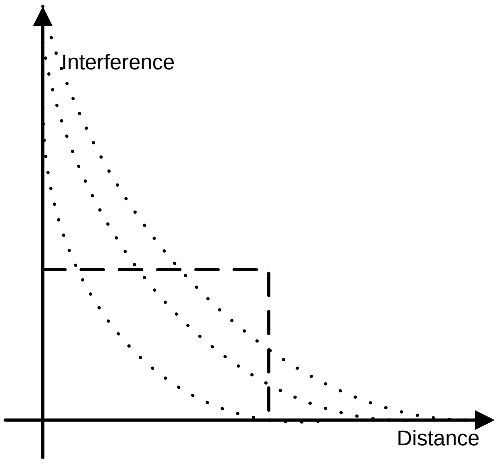
The main conclusions are: Keep as much distance as possible from other devices. Watch for some interference even when other devices are switched off. Do not position any metal devices or magnets near a transceiver.

KEYWORDS: Avalanche Transceiver, Electromagnetic Compatibility, Interference.

1. INTRODUCTION

The issue of ElectroMagnetic Compatibility (EMC) of avalanche transceivers has been discussed in the past [1], [2], [3], [5], [6].

EMC is a very complex issue, since the effects of interference are not very deterministic; they depend on many parameters. And interference is not a hard limit item; it will decrease gradually with increased distance:



The rate of decrease at a specific distance may vary according to any kind of reflector and/or absorber being placed in the vicinity of the other device and of the transceiver or to the type of interference.

Formally, the EMC requirements of avalanche transceivers are covered by the EMC standard for Short Range Devices (SRDs) [7], [8]. However, this standard does not guarantee that avalanche transceivers will not suffer from or produce any interference, it just sets maximum limits. Also, it just covers interference in a general sense, there is no specific mention of any potential interferers, and there are no guidelines for field practitioners.

For most types of interference, it is possible to specify a minimum distance between the transceiver and the other device that should be kept in order to avoid any interference problems. The indications given in this paper should be OK for at least 98% of the cases. But if you are not sure about some device, you should do your own testing, using one of the methods described later in this paper.

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2. INTERFERENCE FROM OTHER SOURCES

Interference from other sources may be caused by various items:

- Devices radiating electromagnetic waves
- Devices emitting a static magnetic field
- Metallic objects
- Metallic conductors above or below the earth surface
- Metallic layers in clothing

For electromagnetic waves at the operating frequency of avalanche transceivers (457 kHz), most interference sources will be at a distance far below 105 m. 105 m is what is termed the near field limit at 457 kHz. At distances below the near field limit, the field strength is inversely proportional to the third power of the distance. If the distance between the source of interference and the transceiver is doubled, the interference will decrease to $1/2^3$, i.e. 1/8. If the distance between the source of interference and the transceiver is quadrupled, the interference will decrease to $1/4^3$, i.e. 1/64.

For static magnetic fields, the field strength generally falls off by the inverse square of the distance. When the distance between the source of interference and the transceiver is doubled, the field strength will decrease to $1/2^2$, i.e. to ¼.

Interference caused by metallic conductors above or below the earth surface can be very annoying. When doing a search, you may be sent walking around in circles, never finding the positive signal maximum that you are searching for. Keep this in mind when using transceivers in inhabited areas or underneath power lines. There is no general rule about minimum distances for this case.

2.1. INTERFERENCE TO THE 457 kHz RECEIVER

The receivers of avalanche transceivers have been optimized for maximum sensitivity. They are therefore very susceptible to interference from various sources, e.g.

- Cellphones
- GPS receivers
- Digital cameras
- MP3 players, e.g. iPod
- Wristwatches
- Combustion engine ignition systems
- Switching power supplies, such as in headlamps, heated gloves or shoes
- Any kind of liquid crystal (LCD) display
- Medical devices
- Aerial radio navigation
- Corona discharge from power lines
- Lightning (thunderstorms)
- Portable radios
- Video cameras

Most of these potential sources of interference do not emit explicitly at 457 kHz. However, any device that does some kind of current switching at any rate will give raise to broadband noise, blanketing a wide range of frequencies and thus also the 457 kHz frequency. Most cellphones use TDMA (Time Division Multiple Access), which involves switching the carrier on and off at the multiplex rate. Many devices incorporate a LCD display. LCD displays are particularly good at producing interference, since the voltage that is applied to the individual segments or raster pixels must be alternated periodically in order to prevent a detrimental electrochemical process in the crystal liquid. Analog quartz wristwatches incorporate a stepper motor that is actuated once per second for advancing the seconds hand. Medical devices that provide some periodic action, such as pacemakers, may have a similar effect as wristwatches [5]. Switching power supplies as used in headlamps, heated gloves or shoes periodically switch large currents in order to provide an average current that is some percentage of the peak current.

The 457 kHz frequency as used by avalanche transceivers lies in a frequency band that is reserved for aerial radio navigation in some areas. Up to the 1990ies, there was actually a radio navigation transmitter at Gleichenberg in Austria. The transmitter today operates at 426 kHz, so it does not pose a problem anymore.

Under special meteorological conditions, high voltage transmission lines exhibit a lot of corona discharge. This can well be heard when being close to or underneath the line, since it produces a crackling noise. Corona discharge is made of an uncountable number of small sparks, each producing a small amount of wideband interference, and so it may interfere with a transceiver in search mode.

Wind turbines are also known to emit interference.

Portable radios, while transmitting, may cause the receiver circuits of a transceiver to saturate, thus rendering any 457 kHz signal reception impossible. While performing a search, keep all devices that are transmitting radio waves at any frequency switched off.

Video cameras have also been reported to produce significant interference. It may therefore not be a good idea to record a search with such a camera.

RECCO stickers do not interfere. However, the RECCO search device should not be used near a searching transceiver, and it should not be pointed at a searching transceiver either [4].

Barkhausen [1] has done a lot of testing on the interference from personal electronic devices. He concludes that such items should be kept at least 40 cm (32 inches) from the transceiver while performing a search. This correlates very well with this author's own experience.

2.2. INTERFERENCE TO THE 457 kHz TRANSMITTER

The transmitter electronics operate at significant power levels and are thus not susceptible to interference from other sources.

The transmitter output signal power is applied to the transmitting antenna, and that antenna is operating in resonance mode at 457 kHz for maximum efficiency. Any nearby metal object that de-tunes the transmitting antenna, thus changing its resonant frequency, will lead to a reduction of radiated power [2]. The impact of metal objects depends on the relative permeability of the metal. Iron and Nickel are good examples of metals with high relative permeability. The relative permeability of Aluminum is 1, so Aluminum objects will not have any effect. This effect does not manifest at distances larger than about 10 cm (4 inches). Note that this effect is independent of any interfering device being switched on or off. Also, the interfering device needs not to incorporate any electronic circuits.

2.3. MODE INDEPENDENT INTERFERENCE

When conducting items are placed very close to any antenna of the transceiver, then they may show an adverse effect through eddy currents that are generated in the conducting material. This effect does not manifest at distances larger than about 2.5 cm (1 inch). Note that this effect is also independent of any interfering device being switched on or off. Also, the interfering device needs not to incorporate any electronic circuits. Make sure the gloves you use when holding a transceiver in search mode do not have any conductive layer inside. Also, garments with a metallic layer in the fabric should not be worn together with a transceiver.

Some transceivers use a magnet inside a slider to actuate a relay contact within the transceiver for mode switching (OFF – TRANSMIT – RECEIVE). This is a very elegant approach to making a transceiver waterproof. Known transceivers with such an arrangement are the Pieps DSP and the Mammut OPTO 3000. Any other magnet in the vicinity of these transceivers may also cause an unwanted mode switch. Such magnets can be found in the loudspeakers of portable radios, in some models of the ABS balloon system, on smartphone flap cases or in buttons of some garments. Make sure you keep these items at least 10 cm (4 inches) from your transceiver! Also see [2].

A similar reasoning goes for transceivers that use a magnetic compass during search for enhancing user information. Those compass sensors may also be disturbed by nearby magnets [3].

Some people carry two transceivers, e.g. for protection from a secondary avalanche while performing a search. This can have disastrous effects, since the resonance circuits of one transceiver may couple with the resonance circuits of the second transceiver, resulting in completely altered characteristics and signals. Never carry two transceivers, even if the second transceiver is switched off! If you must carry a second transceiver, keep it at least 50 cm (20 inches) from the transceiver you are actually using.

3. INTERFERENCE TO OTHER DEVICES

At a distance of 10 cm (4 inches), the

maximum strength of the magnetic field as produced by a transceiver in transmit mode is about 2.2 A/m rms (root mean square).

3.1. INTERFERENCE TO OTHER TRANSCEIVERS

Some old transceivers used to keep the 457 kHz oscillator on permanently while in transmit mode, and only control the power amplifier for transmitting pulses of 457 kHz. Known models exhibiting that behavior are the Barryvox VS68 and the Ortovox F1 Focus. When getting close to such a transceiver with another transceiver in search mode, this would result in a continuous tone on analog transceivers or to no indication on digital transceivers, thus disabling any pinpointing search.

3.1. INTERFERENCE TO MEDICAL DEVICES

Dorenkamp et al. [6] did very extensive testing on the influence of transceivers on pacemakers and cardioverter-defibrillators. They found no interference with the intrinsic functions of pacemakers or implantable cardioverter-defibrillators. However, there was some interference to telemetry access to those devices. Since telemetry is not used while out in the field on a backcountry trip, that poses no problem.

Most manufacturers recommend that persons with a pacemaker should wear their transceiver on the right hand side of their body, so it is kept at a minimum distance from the pacemaker.

3.2. INTERFERENCE TO MAGNETIC COMPASSES

The antennas inside a transceiver all are made of a number of turns of some wire around a core that is made of ferrite material. Ferrite materials exhibit a very high relative permeability, so they will distort the magnetic field of the earth in their vicinity. Make sure that you keep any kind of magnetic compass, including wristwatches and smartphones with a magnetic field sensor, at least 20 cm (8 inches) from any transceiver while relaying on direction indications. This also applies when the transceiver is switched off.

4. TESTING

If you are wondering about a particular source of interference, there are some simple tests to give you some indications:

4.1. INTERFERENCE TO THE RECEIVER

Use a transceiver that provides analog tone, such as a Barryvox Pulse or Ortovox F1 Focus. Switch it to search mode. Select the most sensitive setting. With no particular interference around, you will hear some background noise. Now slowly approach the suspected source of interference. When the noise increases, or when you hear some periodic changes in noise characteristic, then you are at the interference limit.

4.2. INTERFERENCE TO THE TRANSMITTER

Place transceiver A in transmit mode on the ground. Put transceiver B on the ground in receive mode at a distance of about 20 meters, keeping the main axes of both transceivers aligned. Read the distance indication on transceiver B. Now slowly place the suspected interfering object closer to transceiver A. When the distance indication on transceiver B starts increasing, you have reached the interference limit on the approach to transmitter A.

4.3. INTERFERENCE FROM MAGNETS

Slowly move the magnet under investigation along all sides of the transceiver, both in transmit and in search mode. Watch for any change in behavior or mode.

5. CONCLUSIONS

Keep as much distance as possible from other devices. Switch off any other equipment when performing a search. Watch for some interference even when other devices are switched off. Do not position any metal devices or magnets near a transceiver.

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