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Sicherheitsforschung

Effects of Electronic Avalanche Airbag Systems on Avalanche Transceivers

DAV Sicherheitsforschung, May 2023

Content

Introduction

The influence of electronic sources of interference (e.g. cell phones, radios) on avalanche transceivers has been studied several times in the last ten years (Barkhausen 2012; Genswein 2013; Meister & Dammert 2014; Troeger et al. 2022). Among other things, faster discharge of the battery, range reduction or unclear direction of signal and doubtful distance indication are mentioned as possible effects. Based on these study results, a rule has been established in practice to carry potential sources of interference at least 20 cm away from the avalanche beacon in transmit mode and at least 50 cm away in search mode. This can also apply to devices that are switched off or put into standby or flight mode!

Since the market launch of the first electronically triggered avalanche airbag system from the company Pieps ("JetForce"), currently three different systems exist: Pieps/Black Diamond JetForce BT, Alpride E1/E2 and Ortovox/Arc'teryx Litric. Alpride, in contrast to the other two systems, appears primarily as a system supplier for other backpack manufacturers (including BCA, Deuter, Scott). Due to some of the advantages of electronic systems (elimination of the airplane problem of cartridge systems; multiple deployment/testing possible shortly before an emergency) on the one hand, and the positioning of the manufacturers on the other, it can be assumed that electronic airbags will be much more common in the near future than at the present time.

In the winter of 2021/22, DAV safety research received reports of sometimes significant effects on electronically triggered airbag systems, especially on searching avalanche transceivers. In an open letter from the Canadian Avalanche Association (CAA) to the manufacturers of avalanche transceivers and avalanche airbags, the demands were made to communicate the possible interference effects more strongly to the users as well as to investigate them more closely. On the other hand, that manufacturers should agree on a maximum value for allowed interference as well as to take measures to minimize interference when using electronically triggered airbag systems and avalanche beacons at the same time. Currently, a revision of the standard for avalanche airbags EN 16716:2016 is underway.

To the best of our knowledge, the electrical avalanche airbag manufacturers have since carried out investigations and issued software updates in 2022 that are intended to improve the problems addressed, as well as partially adapting the manuals regarding interference.

To date, however, there has been no independent, systematic study on this topic that quantifies the influence of electronic airbag systems on avalanche transceivers.

We would like to answer the question "How do electronic airbag systems affect searching and being found with the avalanche transceiver?" with this study and contribute to the fact that both users and device manufacturers continue to think about the influence of interference sources on their avalanche transceivers in an emergency.

Methods

For the following series of tests, one current avalanche transceiver per manufacturer was selected:

- Arva Neo BT Pro
- Pieps Pro BT
- Mammut Barryvox S
- Ortovox Diract Voice
- BCA Tracker 4

The potential interference impact of the following electronic airbag backpack systems was investigated:

- Alpride E1 (Software E1.11)
- Alpride E2 (Software E2.24)
- Litric (January 2023)
- Jetforce BT (Software 2.1)
- Jetforce BT (Software 1.7)

In addition, tests were made with other sources of interference, including smartphone, GPS sports watch, heated gloves, and digital radio. To quantitatively determine the different effects in the processing of the signals and the influence of the interference sources, each of the selected avalanche transceivers was tested several times with each interference source in each selected scenario. In total, more than 1000 measurement runs were carried out in a field test in February 2023.

In the following, we will explain the procedure of the field tests with the electronic airbag systems:

The test person has the backpack on his back in a normal position, the airbag system is activated so that the airbag can be triggered. To obtain a realistic search scenario, distances between the avalanche transceiver and the source of interference were chosen that could also occur in practice:

- Position 1: the avalanche transceiver was held close to the body at abdominal level.
- Position 2: the avalanche transceiver was held with the arm almost extended - not hyperextended, so that an orthogonal line could be drawn between the elbow and the abdomen.

Position 1 Position 2

We considered even further stretching of the arms to be unrealistic, since in the emergency case of a burial search this would hardly be endured by anyone, as it would be strenuous, and would also make the display difficult to read.

The arm position was checked regularly, and the walking speed was low. However, minimal fluctuations in the distances cannot permanently be ruled out.

The following distances between the main electrical units of the airbags as well as the release handles and the avalanche transceivers were determined:

Distance (shortest) *in cm*	Position 1 transceiver – main electric unit	Position 2 transceiver – main electric unit	Position 1 transceiver – trigger handle	Position 2 transceiver - trigger handle
Alpride	30	50	40	55
Jetforce	30	50	31	46
Litric	40	60	33	45

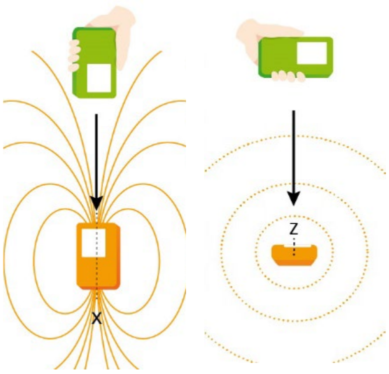
Note that these are the projected distances and the body as a dampening element was in between in any case.

Signal Search (Reception Range)

Influence on the searching transceiver

The maximum reception range where a constant and stable signal was present (10 pulses) were measured. Earlier individual pulses do not increase the stable reception range. The real distance at first reception and at stable reception as well as the display values were noted in each case. Three measurement runs were performed for each scenario and the mean average was calculated.

- with each transceiver reference runs without interference
- two coupling positions: x- und z-orientation (Best- und Worst-Case)
- two distances to the Source of interference (Position 1, Position 2)



Signal Search: Influence on the transmitter

In this scenario to check the influences of the electrical interference sources on the transmitter, each of the above-mentioned avalanche transceivers acted as a transmitter.

The Black Diamond Guide BT was chosen as the reference device for searching. This range check with stable signal reception was only performed in coaxial coupling position (x-position).

To represent a worst-case scenario in which the interference source and the transmitter come to rest on top of each other due to the force and dynamics of an avalanche, the interference sources were placed directly on the transmitter.

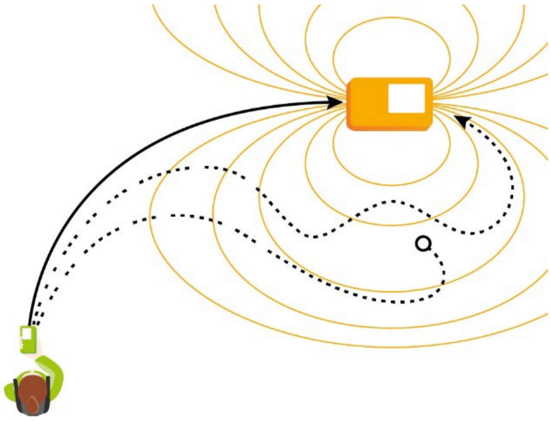
If an influence, i.e., a range reduction, was detected, the distance of the interference source was extended to the recommended 20cm distance.

Coarse Search

In order to investigate the influence of the sources of interference on the area of the coarse search, a test field of 60x30m was set up. The approach was made along a 60m measuring line to the baseline from which, at a 90° angle, the transmitters could be positioned at different offsets.

criteria for a successful coarse search are:

- the transmitter is detected
- a clear and unambiguous directional information is given
- the approach is fast and direct (arrow + display values stable)



For each avalanche transceiver, reference runs were made without any interfering influences. These were marked with flags. With the airbag backpacks switched on (activated), runs were then made with avalanche transceiver position 1 as well as 2 (see above).

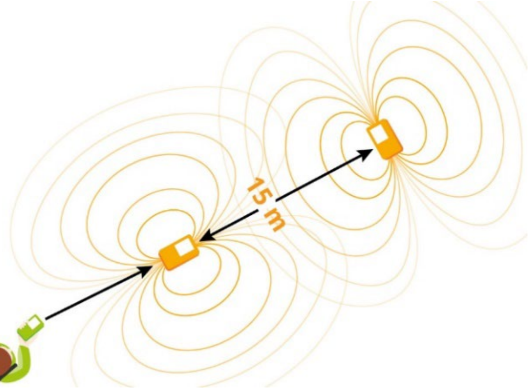
A lateral offset of 20m was chosen. If it was not possible to approach the transmitter, the lateral offset was reduced.

The following points, among others, were checked and noted:

- Initial reception and stable reception
- Approach in relation to reference run
- Behaviour of directional arrow
- Reduction of the distance values
- Indication of interference or multiple burials?
- Maximum lateral offset at which approach was possible.
- Signal loss or other abnormalities

Multi-Person Burial (MB) and Fine Search (FS)

The test setup for multi-person burial and fine search was combined in one scenario. Two transmitters were located on a straight line at 15 m from each other, with the first transmitter in a coaxial position and the second in a 90° position (y) to the search unit. The approach to the first transmitter was from 30 m along the axis. The first was located at the snow surface, the second was placed at a height of 1.5 m to imitate the same burial depth for the fine search. At least 2 runs per scenario (search device: avalanche transceiver A; airbag A) were performed.



The following criteria concerning multi-person burial were evaluated:

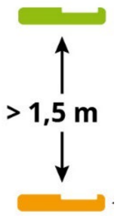
- Is the first transmitter displayed from the beginning?
- At which position is the second transmitter displayed?
- Does the marking of the first transmitter work without problems?
- Is any interference displayed by the device?
- How is the signal tracking to the transmitter?

Excerpt from the evaluation of the avalanche transceiver test to detect the MB in this scenario (15m distance between two transmitters):

- Very good: if MB already displayed more than 5m before first transmitter
- good: if MB is displayed between 5m before or immediately at first transmitter.
- acceptable: if MB is displayed only in fine search (= wait 30 seconds before marking the 1st transmitter)
- problematic: if MB is displayed only after marking.

The following criteria concerning the fine search were evaluated:

- When does the device switch to fine search (real value)?
- Display value above device 1?
- Display value below device 2?
- Is the distance minimum directly below device 2?



For both test setups (MB and FS), any anomalies in the individual runs were noted.

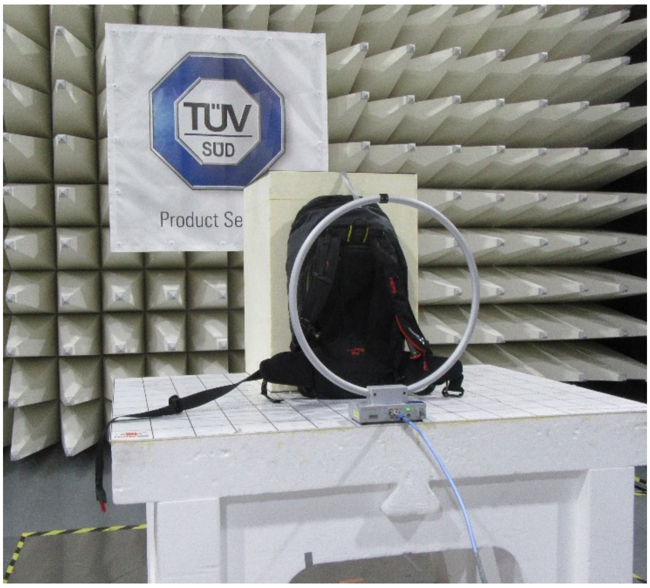
Electromagnetic Emission Measurement

At *TÜV Süd Product Services* in Straubing, the avalanche airbag backpacks were tested for their electromagnetic emissions and thus potentially occurring interference in an EMC measurement laboratory (electromagnetic compatibility) with responsible TÜV experts in accordance with the ETSI EN 300 330 standard.

Electro-magnetic Emissions at frequencies 9kHz to 30mHz

After no relevant emissions could be measured in the standardized measurement at 3m, the distance was reduced.

To achieve distances between the measuring instrument and the electronics of the backpacks as in the field test, the measurements of all backpacks were carried out at a distance of 30cm and 50cm respectively. The measurement was carried out in the relevant orientation (see photo). The maximum field strength was measured over a period of 15sec.



6 backpacks were tested. In addition to the 5 airbag systems from the field test, a non-updateable older Jetforce Tour Pro model was also checked.

Further measurements were carried out as examples:

- Emissions at 1m distance and 360 degrees
- High resolution measurement in the reduced frequency band of 3kHZ around 457kHZ
- Time continuous measurements at 457kHz
- Measurement of an activated airbag at 50cm distance

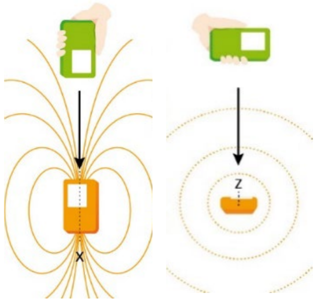
Results

Signal Search: Reception Range

All values - unless otherwise stated - reflect the mean value from at least 3 independent measurements.

Influence on the searching transceiver

Reference Values		
Max. Range (m)	Mean Value (3 measurements, stable signal)	
Coupling orientation	X	Z
Mammut Barryvox S	51,7	30,4
BCA Tracker 4	42,2	12,2
Arva Neo BT Pro	59,8	30,4
Pieps Pro BT	50,0	33,2
Ortovox Diract Voice	28,9	19,9



Position 1

Position 2

Relative **reduction** of the stable reception range to the reference runs averaged over 3 measurements. Range reductions below 5% are indicated as <5%.

Relative reduction of range in %	**Alpride E1**			
Position	Position 1		Position 2	
Coupling orientation	X	Z	X	Z
Mammut Barryvox S	17%	23%	<5%	<5%
BCA Tracker 4	17%	16%	<5%	<5%
Arva Neo BT Pro	15%	<5%	<5%	<5%
Pieps Pro BT	30%	35%	13%	<5%
Ortovox Diract Voice	<5%	<5%	<5%	<5%

Relative reduction of range in %	**Alpride E2**			
Position	Position 1		Position 2	
Coupling orientation	X	Z	X	Z
Mammut Barryvox S	<5%	<5%	<5%	<5%
BCA Tracker 4	<5%	13%	<5%	<5%
Arva Neo BT Pro	5%	<5%	<5%	<5%
Pieps Pro BT	<5%	<5%	<5%	<5%
Ortovox Diract Voice	<5%	<5%	<5%	<5%

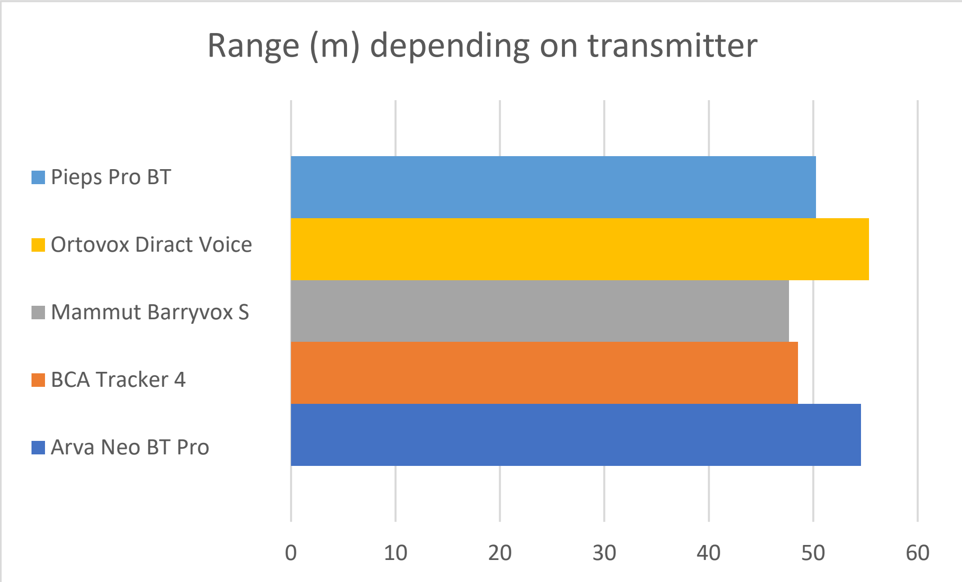
Relative reduction of range in %	**Litric**			
Position	Position 1		Position 2	
Coupling orientation	X	Z	X	Z
Mammut Barryvox S	5%	<5%	<5%	<5%
BCA Tracker 4	<5%	10%	<5%	<5%
Arva Neo BT Pro	5%	<5%	<5%	<5%
Pieps Pro BT	<5%	6%	<5%	<5%
Ortovox Diract Voice	<5%	<5%	<5%	<5%

Relative reduction of range in %	**Jetforce BT 2.1**			
Position	Position 1		Position 2	
Coupling orientation	X	Z	X	Z
Mammut Barryvox S	9%	75%	<5%	36%
BCA Tracker 4	<5%	54%	10%	<5%
Arva Neo BT Pro	17%	32%	<5%	19%
Pieps Pro BT	59%	74%	85%	80%
Ortovox Diract Voice	<5%	13%	<5%	8%

Relative reduction of range in %	**Jetforce BT 1.7**			
Position	Position 1		Position 2	
Coupling orientation	X	Z	X	Z
Mammut Barryvox S	49%	92%	10%	49%
BCA Tracker 4	38%	79%	14%	63%
Arva Neo BT Pro	47%	73%	22%	55%
Pieps Pro BT	42%	75%	13%	49%
Ortovox Diract Voice	55%	81%	30%	10%

Influence on the transmitter

With the same searching device (BD Guide BT), the following maximum stable ranges were found on average as a reference:



Orientation of the transmitter: co-axial (exception Tracker4 turned app. 30° because of different antenna orientation)

Interference Source at the transmitter:

No noticeable reduction in range of more than 10% was observed with any of the systems, even with airbag deployment in progress near the transmitting device.

Coarse Search

For the coarse search, the following ratings for the degree of interference effect were defined:

- *Low* interference effect: signal reception may occur slightly later, but no limitations in the approach compared to the reference runs.
- *Moderate* interference effect: directional arrow not clear, no direct approach especially in the far range
- *Significant* interference effect: More severe effect in the approach such as loss of signal, directional arrow fluctuations, guiding in circles.
- *Very high* interference effect: Approach not possible with an offset of more than 10m. Either no signal until shortly before the transmitter or tracking was characterized by continuous interfering signal or signal loss.

Alpride E1:

With the Alpride E1 system, a reduction in reception of up to about 30% was observed for all beacons in position 1. On the approach of the coarse search, the effects were only slight. Every 10sec interference pulses can occur, which might be irritating but eventually they disturb the process of signal tracking only little (pulse duration was increased from 3 to 10 sec by update).

Alpride E2:

With the Alpride E2 system, no relevant disturbances in the coarse search scenario could be detected in either of the positions tested.

Alpride E1 / E2		
Interference level	*Position 1*	*Position 2*
Arva Neo BT Pro	Low	Low
BCA Tracker 4	Low	Low
Mammut Barryvox S	Low	Low
Ortovox Diract Voice	Low	Low
Pieps Pro BT	Low	Low

Litric:

With the Litric system, no relevant disturbances in the coarse search scenario could be detected in either of the positions tested.

Ortovox Litric		
Interference level	*Position 1*	*Position 2*
Arva Neo BT Pro	Low	Low
BCA Tracker 4	Low	Low
Mammut Barryvox S	Low	Low
Ortovox Diract Voice	Low	Low
Pieps Pro BT	Low	Low

Jetforce 1.7:

The coarse search with the Jetforce BT 1.7 system was characterized by considerable interference with all devices.
In position 1, there were runs with all devices where a signal could only be found at a parallel offset of less than 10m. When an earlier signal was present, the approach was characterized by severe directional arrow changes, especially at long range, and the searcher was often led in circles and serpentines, and the approach was characterized by signal loss. In the case of the Diract Voice, there was also a continuous interfering signal with display value 27 and arrow pointing to the right.
In position 2, the effects were less but still serious in some cases, so there were runs with the Barryvox S and Diract Voice that could only be tracked from an offset below 15m. For the other runs, the signal occurred later, and the approach was characterized by changes in direction.

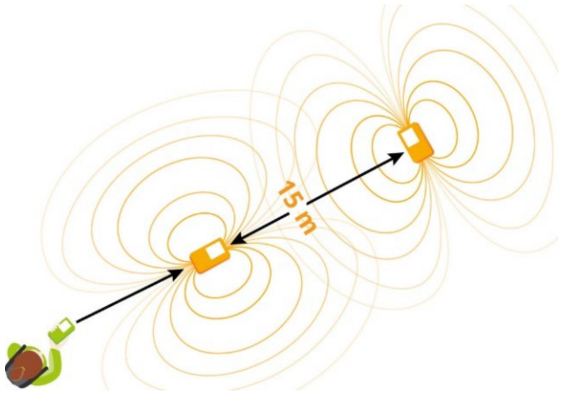
Jetforce BT 1.7		
Interference level	*Position 1*	*Position 2*
Arva Neo BT Pro	Significant/Very High	Moderate/Significant
BCA Tracker 4	Very High	Moderate
Mammut Barryvox S	Very High	Significant
Ortovox Diract Voice	Very High	Significant/Very High
Pieps Pro BT	Significant/Very High	Moderate

Jetforce 2.1

In the coarse search, the Jetforce BT Version 2.1 influenced most avalanche transceivers less than Vers. 1.7. However, a different picture emerged with the Pieps Pro BT transceiver - here, interfering signals with multiple, falsely displayed signals occur permanently in position 1. The display values vary from the beginning around 25 and only start decreasing below 15 m. In position 2, on the other hand, the Pieps Pro BT only received a signal at all at an offset below 10 m.
With all other avalanche transceivers, the approach in position 1 was not straightforward and characterized by serpentine lines in the far range (Arva Neo BT Pro in a circle), but tracking was always possible. In some cases, a second burial symbol was displayed. In position 2, only minor effects were detected.

Jetforce BT 2.1		
Interference level	*Position 1*	*Position 2*
Arva Neo BT Pro	Significant	Low
BCA Tracker 4	Moderate	Low
Mammut Barryvox S	Moderate	Low
Ortovox Diract Voice	Moderate	Low
Pieps Pro BT	Very High	Significant/Very High

Multi-Burial



Scenario: 2 transmitters at 15m distance

The tested avalanche beacons show a different behaviour in the MB scenario even without interference, especially regarding the time of displaying the second transmitter. The approach was possible in each case.

MB Scenario Reference	
Transceiver	*Position when transmitter 2 was detected*
Arva Neo BT Pro	2,5m before transmitter 1
BCA Tracker 4	4m after transmitter 1
Mammut Barryvox S	4m before transmitter 1
Ortovox Diract Voice	8m before transmitter 1
Pieps Pro BT	23m before transmitter 1

Effects of Airbag-systems on MB scenario

Alpride E1

With the Neo BT Pro, the 2nd transmitter was only detected in both positions directly after marking the first. When searching with the Diract Voice, the approach to transmitter 2 was sometimes characterized by serpentine lines. The Barryvox S sometimes displayed a 3rd transmitter.

Alpride E2

No major limitations were found in the MB scenario. Only in the case of Diract Voice after marking transmitter 1 the direction arrow alternated and the approach to transmitter 2 was not straight.

Litric

No limitations could be identified in the MB scenario.

Jetforce 1.7

With all devices in position 1 the 2nd transmitter became visible only after marking the 1st transmitter, with some runs only immediately before transmitter 2 (<10m). The approach to transmitter 1 was already characterized by a strongly changing direction arrow and signal losses.
In position 2, only da Pro BT detected the 2nd transmitter before marking the 1st transmitter. The direction arrow fluctuated with all devices at distances >15m, but the approach to the transmitter 2 was mostly possible. The Barryvox S showed display values in the far range that were significantly lower than the real distance and the marking was lost once.

Jetforce 2.1

With the Neo BT Pro, Diract Voice and Barryvox S, the second transmitter only became visible shortly after marking the first. With the Barryvox S, Diract Voice and Tracker 4 devices, the approach to transmitter 2 was also characterized by signal losses and changes in direction, but transmitter 2 could be found. With the Pieps Pro BT, the distance of detecting transmitter 2 was reduced by approx. 50% in both positions. Irritating was the changing of the display of the burial symbols, which varied between 3 and more signals.

Fine Search

In the fine search, there was no noticeable interference effect on the avalanche beacons with any of the systems.

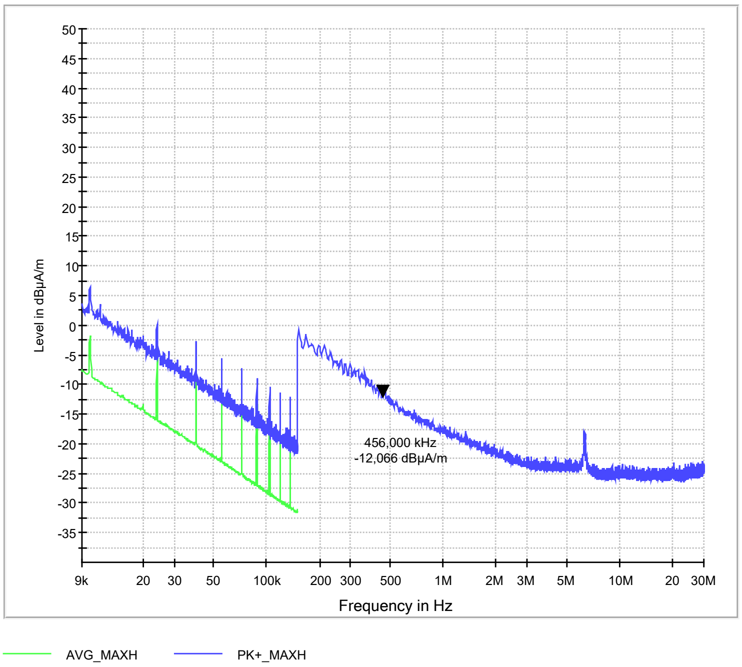
Electromagnetic Emission Measurements
9kHz to 50mHz

Since the emission measurements according to the ETSI standard at a distance of 3 m did not show any detectable field strengths, measurements were carried out at distances of 30 cm and 50 cm analogous to the field test. In general, the following graphs can only ever be viewed and interpreted in relation to the reference measurement.

We refrain from a deeper interpretation at this point and would like to discuss the results in the further course with persons of proven expertise in the electrotechnical field as well as the development departments and the beacon manufacturers.

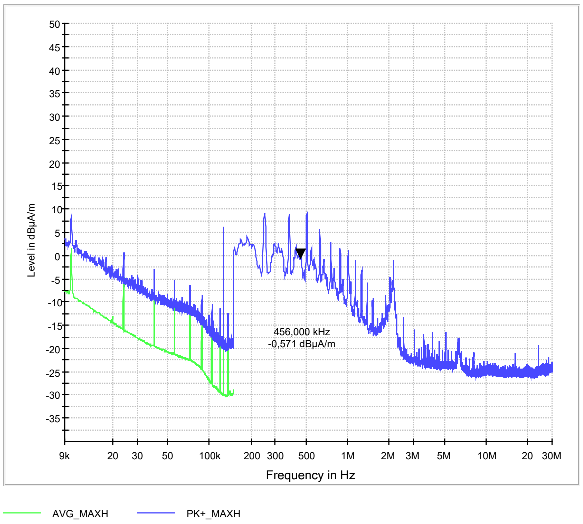
We merely note here that emissions and certain patterns can be identified. Some electronic airbag backpacks tend to emit broadband low-frequency emissions. Sometimes higher emission peaks at a frequency also produce harmonics, which can then also be detected in the range near the 457kHz mark.

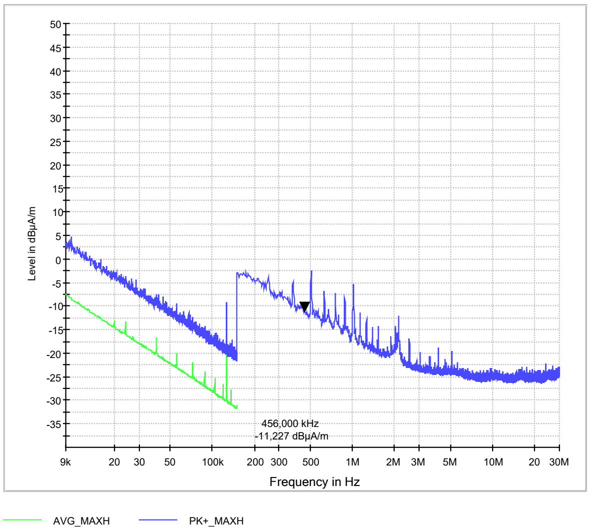
Reference Measurement (Empty Chamber)



Reference measurement in an empty chamber: inherent noise of the system. All measurements must be considered in relation to this measurement.

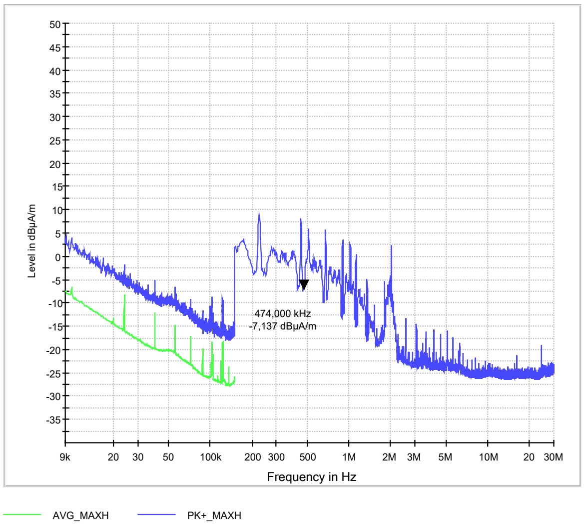
Jetforce BT 1.7

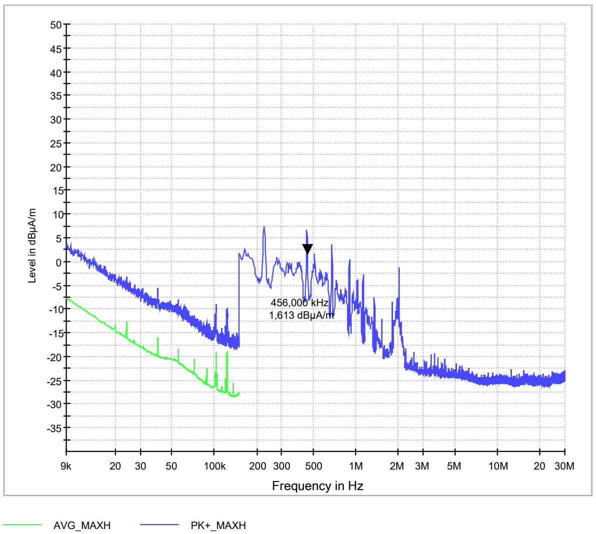




Jetforce 1.7: 30cm 50cm

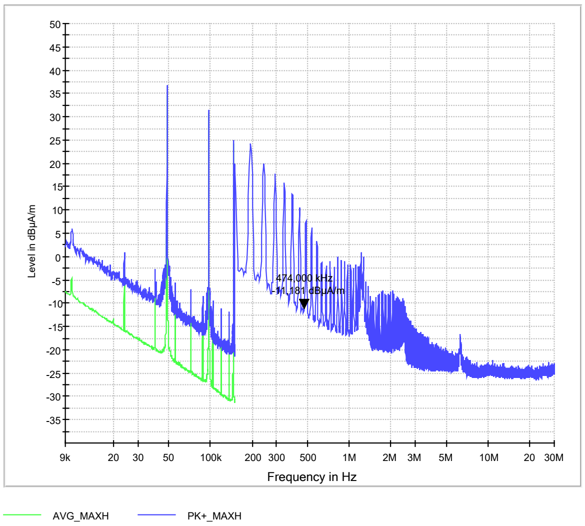
Jetforce BT 2.1

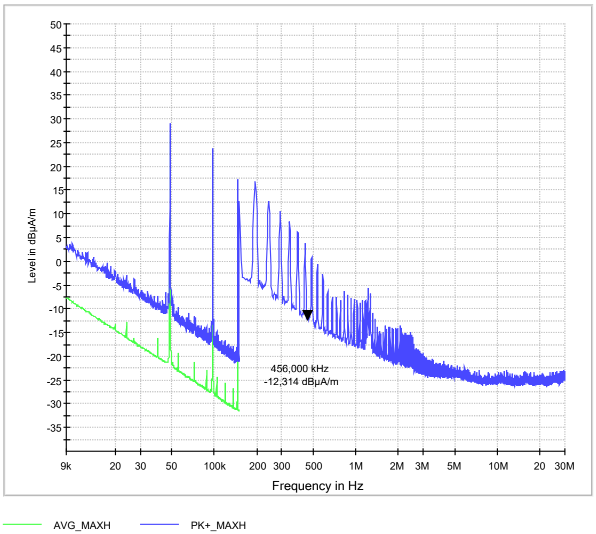




Jetforce 2.1: 30cm 50cm

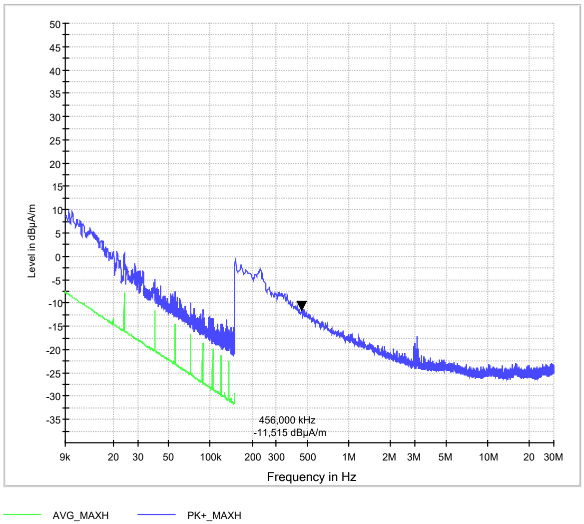
Jetforce Tour Pro

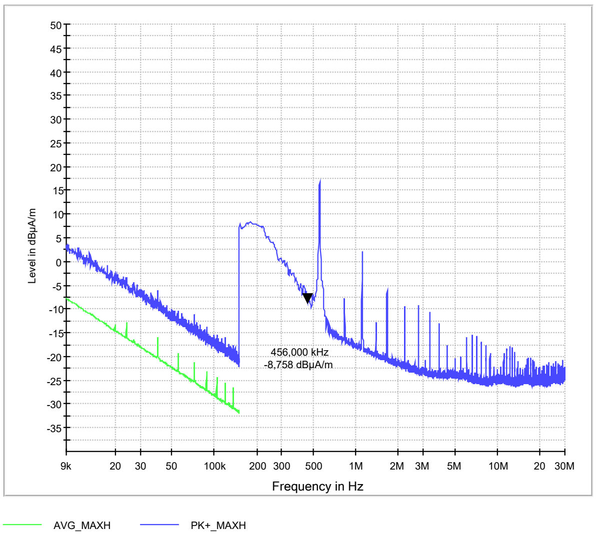




Jetforce Tour: *30cm* *50cm*

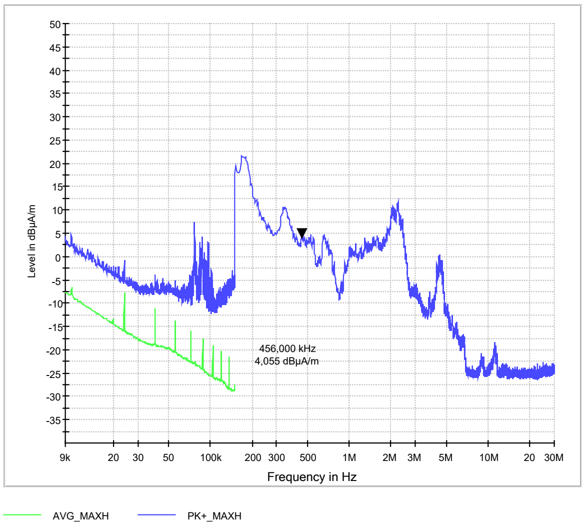
Litric

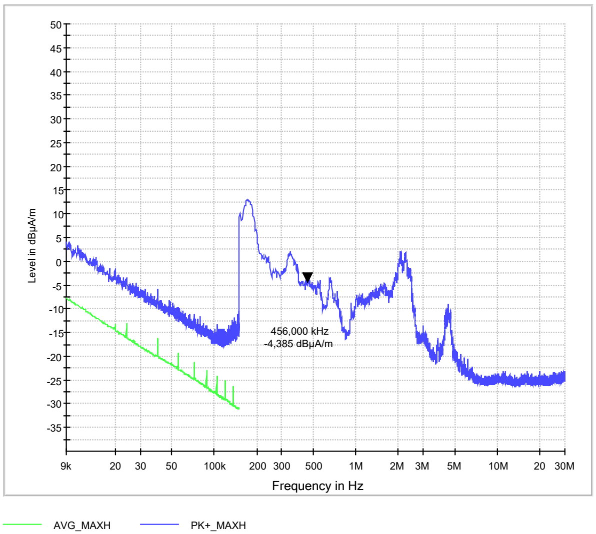




Litric: *30cm* *50cm*

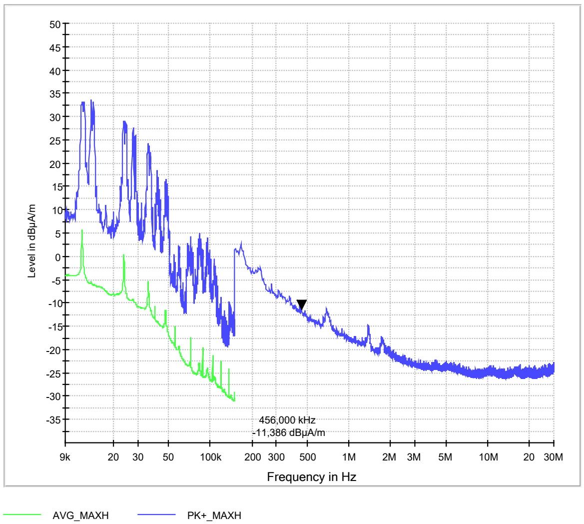
Alpride E1

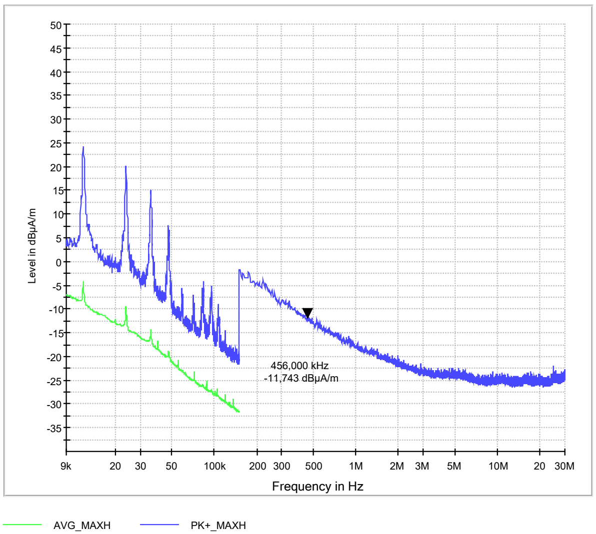




Alpride E1: 30cm 50cm

Alpride E2





Alpride E2: 30cm 50cm

Limitations

Field tests are naturally subject to fluctuations. The measurements were carried out on a large, flat and undisturbed area. Small deviations between individual runs are to be expected and are not relevant for the main conclusions of our investigation; the few larger deviations of individual runs were subsequently re-examined, and the results initially obtained could be verified. For such and further plausibility purposes, at least 3 reference measurements without interference were also performed with each avalanche transceiver before each test scenario.

The specified and selected distance to the backpacks refers to the main electrical unit. This was considered as a black box and individual components were not differentiated in their interference potential. In the case of the Litric system, the distance of the electrical unit is therefore somewhat greater (+ 10 cm) relative to the position of the avalanche transceiver than in the other systems, due to its location in the upper back area.

For the measurements on electromagnetic emission, no standard limit values can be used at this time for the selected distances of 30cm and 50cm since this is far below standardized test arrangements. The minimum distance at which a 360° measurement was possible was 1m (the minimum distance for ETSI EN 300 330 is 3m). At the closer distances, only a linear measurement in the direction of the backpack could be performed with a circular receiving antenna. The position of the backpack or the trigger unit corresponded to that from the field test and represents the most relevant orientation or distance for practice.

Conclusion

Based on the results presented, the cause of the interference problem could also be searched on the side of the sensitivity of the avalanche transceivers. Certainly, the expected increase in the number of electronic sources in the (near) future represents a challenge for the manufacturers of avalanche transceivers. However, due to the relatively narrowly defined transceiver standard, the implementation of new standards and technical solutions in this area, which have yet to be established, can only be expected in the medium term, if at all.

As a result of the available test results, in particular of one airbag system, the conclusion is obvious that it is necessary - and technically possible - taking into account the currently valid avalanche transceiver standard, to design electronic airbag systems in such a way that the search with the avalanche transceiver is not noticeably disturbed in any of the search phases. Manufacturers who market optional avalanche (emergency) equipment that is intended to significantly increase safety in potential avalanche terrain - and not reduce it in certain situations (too short a distance from the searching avalanche transceiver) - should pay the utmost attention to this fact.

Furthermore, we consider it necessary that the manufacturers of electronic airbag systems check the interference effects of their systems even below the generally established limit of 50 cm distance to the avalanche transceiver and, if necessary, reduce them to a level that has no effect on the search with currently available avalanche transceivers. In fact, based on our measurements and observations, we have had to conclude that in an avalanche emergency (and not only there!) it cannot be ruled out that the 50-cm mark can be significantly undercut in some cases when searching with an avalanche transceiver with a backpack on one's back. Some manufacturers knowingly or not already meet this criterion completely at present, others partially, while others only insufficiently.

The reference to possible interference is now also cited in the instructions for use (of both electronic airbag systems and avalanche transceivers). However, the duty of care regarding the problem of interference effects of electronic airbags on avalanche transceivers, which has been proven in practice, field tests and possibly in the laboratory, should not primarily be passed on to the users. As an association representing more than 1.4 million potential users of airbag systems in Germany, we believe it is the responsibility of the manufacturers to ensure that the issue is adequately investigated internally and externally, better communicated and, at best, eliminated through appropriate measures.

Future software updates of electronic airbag systems also must be examined again and again regarding their possible interference effects, since even minor changes - for example, those to the control system - can potentially have negative effects on the search with the avalanche beacon.

With the EMC measurements presented, we hope to encourage avalanche device and airbag system manufacturers to exchange information about problematic interference areas, get to the bottom of them, and propose solutions based on this information. It would be desirable if a test procedure for a future standard could be derived from this.