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Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Tests on the immunity of Wind Profiler Radar to transmissions from RFID, ALDs and GSM

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document includes necessary information to support the co-operation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT).

The present document was prepared with the assistance of the UK Met Office without whose support the present document would not have been possible.

Introduction

Recently ETSI made a request to CEPT for use by SRDs and RFID of the band 915 MHz to 921 MHz. Since this band was already allocated to the railways and to government services, SE24 was asked to investigate if sharing in these bands by SRDs and RFID with the primary services would be possible. In the course of their compatibility studies SE24 has learnt that two sites exist in the UK where Wind Profiler Radar (WPR) are in use operating within the band 915 MHz to 917 MHz. It was decided that some practical tests should be made at one of these sites to find out if SRDs and RFID caused unacceptable levels of interference.

Further technical information on the Wind Profiler Radar is provided in annex A.

The UK Met Office kindly agreed to make their site and facilities at Camborne available in order to perform practical tests. The tests took place on 14th and 15th February and involved personnel from the Met Office who operated the WPR and recorded data and ETSI ERM TG 34/17 who operated the interferers. Two items of equipment were made available as interferers for the tests. One of these was a prototype Assisted Listening Device (ALD) operating at 10 dBm and the other was an RFID interrogator transmitting at levels up to 36 dBm in free space (It should be noted that this equipment is normally mounted in a shielded portal, which contains the RF). The actual ERP at a distance of 10 m from a distribution centre where RFID is installed is in the region of -36 dBm. See annex C for typical use cases. In addition it was also possible to generate signals that emulated the transmissions from 3G and UMTS.

The Met Office had previously carried out testing on a similar WPR operating at 1 290 MHz and considered the results would echo the testing on the 915 MHz unit.

1 Scope

The present document gives a report on compatibility tests between the Wind Profiler Radar at the Met Office site in Camborne UK, a prototype ALD device and a RFID interrogator. In addition the report also provides results on the compatibility between WPR and simulated transmissions of GSM and UMTS.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] OFCOM Report SES/10/12: "Wind Profiler Radar Measurements Camborne".

[i.2] ETSI TR 102 791: "Electromagnetic compatibility and Radio spectrum Matters (ERM); System Reference Document; Short Range Devices; Technical characteristics of wireless aids for hearing impaired people operating in the VHF and UHF frequency range".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Assistive Listening Devices (ALD): systems utilizing electromagnetic, radio or light waves or a combination of these, to transmit the acoustic signal from the sound source (a loudspeaker or a person talking) directly to the hearing impaired person

interrogator: fixed or mobile data capture and identification device using a radio frequency electromagnetic field to stimulate and affect a modulated data response from a transponder or group of transponders in its vicinity

Telecoil: Audio Induction Loop systems, also called audio-frequency induction loops (AFILs) or hearing loops are an aid for the hard of hearing

NOTE: They is a loop of cable around a designated area, usually a room or a building, which generates a magnetic field picked up by a hearing aid. The benefit is that it allows the sound source of interest - whether a musical performance or a ticket taker's side of the conversation - to be transmitted to the hearing-impaired listener clearly and free of other distracting noise in the environment. Typical installation sites would include concert halls, ticket kiosks, high-traffic public buildings (for PA announcements), auditoriums, places of worship, and homes. In the United Kingdom, as an aid for disability, their provision where reasonably possible is required by the Disability Discrimination Act 1995, and they are available in the back seats of all London taxis, which have a little microphone embedded in the dashboard in front of the driver; at 18 000 post offices in the U.K.; at most churches and cathedrals.

Wind Profiler Radar (WPR): instrument that uses radar to measure the wind velocity at different altitudes

3.2 Symbols

For the purposes of the present document, the following symbols apply:

dB	decibel
kHz	kilohertz
km	kilometre
s	seconds
m	metre
MHz	Megahertz
min	minute
ns	nano second

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AFIL	Audio-Frequency Induction Loops
ALD	Assisted Listening Device
CW	Carrier Wave
ECC	Electronic Communications Committee
ERP	Effective Radiated Power
GMSK	Gaussian Minimum Shift Keying
GSM	Global System for Mobile communication
HQ	HeadQuarters
LTE	Long Term Evolution
MFCN	Mobile/Fixed Communications Networks
NE	North East
NW	North West
NWP	Numerical Weather Prediction
PR ASK	Phase Reversal Amplitude Shift Keying
PR	Phase Reversal
PRF	Pulse Repetition Frequency
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RFID	Radio Frequency Identification
RMS	Root Mean Square
SE	South East
SRD	Short Range Device
SW	South West
TRS	Telecoil Replacement System
UHF	Ultra High Frequency
UMTS	Universal Mobile Telecommunications System
VAC	Volts Alternating Current

WCDMA Wideband Code Division Multiple Access
WPR Wind Profiler Radar

4 Description of equipment

4.1 Facilities at Camborne

The Met Office site at Camborne is located in a grass field of approximately 170 metres square surrounded by open farmland. The wind profiler radar on site provides important information on the state of the atmosphere that is used to drive NWP (Numerical Weather Prediction) models and inform forecasts - this particular location in the west of the UK is notably important in respect of this being the prevailing direction from which weather approaches the UK.

The antennas for the Wind Profiler Radar have been installed inside a fibreglass container positioned approximately in the centre of the site. The equipment was controlled from a building, adjacent to the antennas. The site is shown in figure 1.

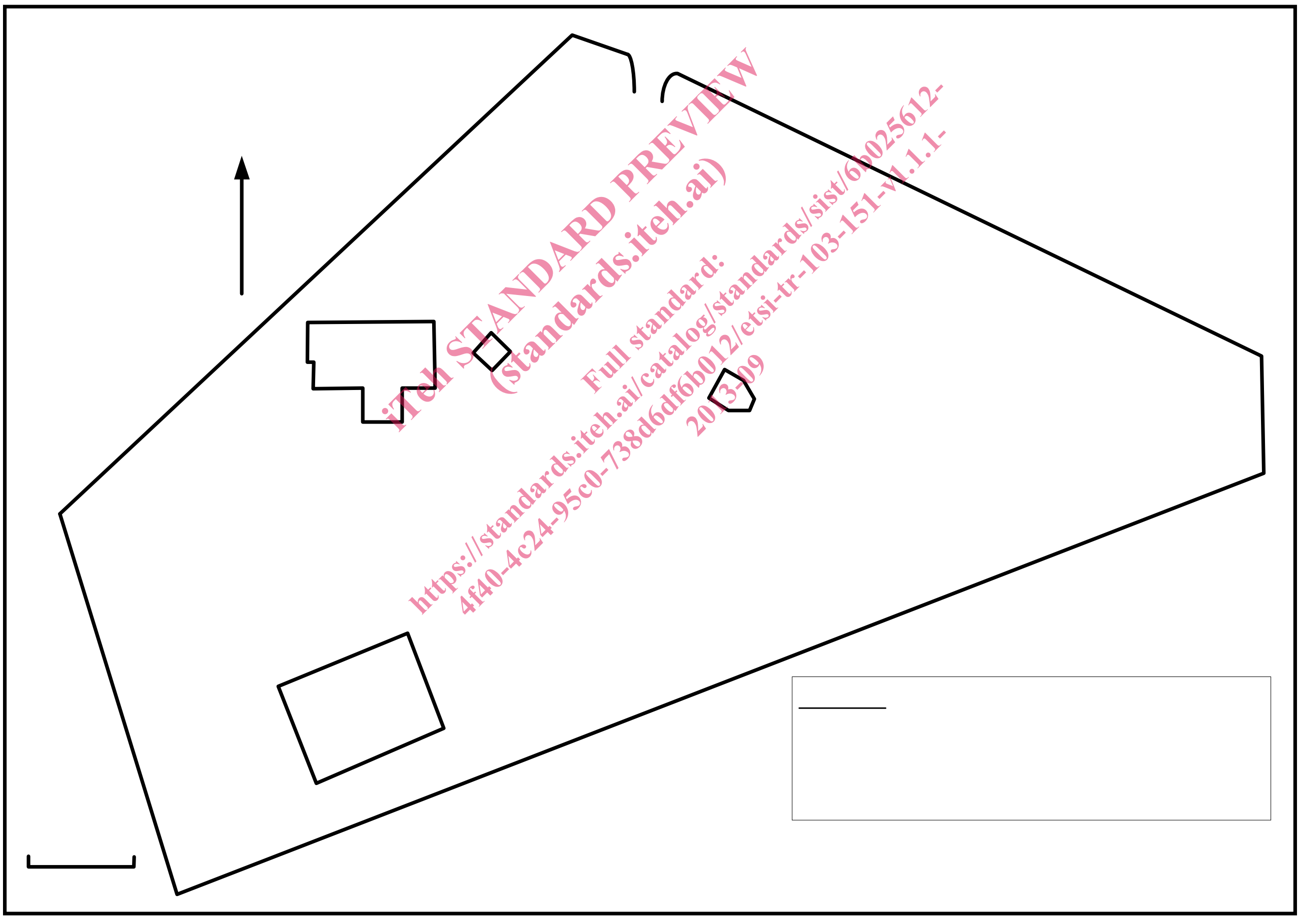

Figure 1: Camborne Meteorological Station

In December 2012 OFCOM made measurements at Camborne of the isolation provided by the container. (See [i.1].) Their measurements showed that at a height of 1,5 m the sidewall attenuation varied between 7,3 dB and 10,6 dB. A picture of the fibreglass container is shown in figure 2.

Figure 2: WPR Antenna housing

In normal operation the four antennas of the WPR are steered electronically to measure reflections from the atmosphere in NE, SE, SW, and NW, directions. After processing, this information gives details of direction and wind-speed at different altitudes, as well as reflectivity data (see annex A for full description of available parameters). Two different pulse lengths and PRFs are used to measure the conditions at low (up to 2 km) and high (up to 8 km) altitudes. For the higher altitudes a radar pulse length of 1 400 ns having a 3 dB bandwidth of 632 kHz is used (High mode). For low altitudes a pulse length of 400 ns is transmitted with a 3 dB bandwidth of 2,5 MHz (Low mode). Each measurement is made over a period of about one minute.

It was believed that the WPR equipment has been operational on the site for some 15 years. During this time it has operated almost continuously to provide valuable information to the Met Office for their weather forecasts.

Further technical information on the Wind Profiler Radar is provided in annex A. However whilst the data sheet refers to the transmitter bandwidth there is no information available on the receiver. From the testing carried out this appears to be considerably wider than the 2,5 MHz shown.

4.2 Description of Interferers

4.2.1 RFID Interrogator

The RFID equipment was provided by a manufacturer and comprised a standard interrogator connected to its patch antenna. The antenna, which had a gain of 7 dBi, was mounted vertically on a post 0,8 m above the ground so that it transmitted in a horizontal direction. The transmission from the antenna was circularly polarized. The interrogator was controlled from an application installed on a laptop. The interrogator was fitted with test firmware, which allowed it to transmit on a fixed frequency with either continuous CW or a continuously modulated signal. The modulation used was PR ASK. It should be noted that in a typical application, such as a distribution centre, an RFID interrogator would only transmit for between 1,5 s and 2 s every 10 s over a period of about 10 min. This might be repeated up to 4 times during a day.

For the purposes of the tests at Camborne, the interrogator was set initially to transmit at a level of 36 dBm at a fixed frequency of 916,25 MHz. Subsequently measurements were also made with the interrogator set to output powers of 8,6 dBm and -2,6 dBm and at a transmit frequency of 917,25 MHz.

4.2.2 ALD Prototype

A prototype system was used providing an output of some 10 mW into a 0 dbi calibrated ½ wave dipole at 915 MHz (see annex E for details) mounted on a wooden tripod some 1,5 m above the ground. The system was programmed with the following parameters:

1) nominal 200 kHz bandwidth 124 kbit/s 4GFSK modulation (BT = 0,5) with 40 kHz deviation (outer symbols), 5 ms packets, 5 ms interval between packets (50 % duty cycle), 0 dBi antenna at 1,5 m above ground level;

2) nominal 600 kHz bandwidth, 360 kbit/s 4GFSK modulation (BT = 0,5) with 162 kHz deviation (outer symbols), continuous PN9 data modulated transmission (100 % duty cycle), 0 dBi antenna at 1,5 m above ground level.

Other system features not used in tests:

- The system is designed to spectrum sense and frequency hop to minimize interference to other spectrum users.
- Can be pre-programmed to the spectrum available at that site.

4.2.2.1 ALD Use

The ALD system under test is referred to as the Telecoil Replacement System (TRS) designed to take an input such as a railway or airport information service normally provided by a public address system and provide hard of hearing customers with a direct input to their hearing aids. The problem for the majority of hard of hearing is not volume but clarity. The system is designed to replace the inductive telecoil system (see definitions for description) currently used in some religious buildings, theatres and similar locations. TR 102 791 [i.2] provides full information on these issues but briefly the telecoil only has one channel and cannot be used in large areas such as railway stations and airports and is extremely difficult to retrofit to existing buildings whereas the TRS can provide multiple channels for translation services, school and theatre use and is simple to install and run.

The vast majority of systems will be indoor.

4.2.3 GSM and UMTS emulation

A Rhode and Schwarz SMIQ generator was fed into the 0 dBi cable-mounted ½ wave 915 MHz dipole mounted on a wooden tripod some 1,5 m above the ground and set to the following configurations:

R&S SMIQ to transmit a standard GSM GMSK waveform, nominal 200 kHz bandwidth.

This transmission used 100 % duty cycle and a relatively low power level due to limitations of the test equipment. In practice a single mobile device would typically transmit at 1/8 duty cycle (in speech) or less during signalling, but in many locations can be expected to use significantly higher power (up to 2W for typical mobile devices).

Set up R&S SMIQ to transmit a standard WCDMA QPSK waveform, nominal 5 MHz bandwidth.

This transmission used 100 % duty cycle, representative of a phone with a connected channel. The relatively low power level was due to limitations of the test equipment. Mobile devices in this band are understood to be able to transmit at up to +24 dBm, though power control in the system means that this will usually occur only in the outer parts of a cell.

5 Description of Tests

5.1 Tests with RFID

Initially the RFID equipment was mounted on a table about 10 m from the WPR with the RFID antenna directed at the centre of the fibreglass container. The antenna was approximately 1,2 m above the ground. A picture of the set-up is shown at figure 3.

Figure 3: Initial RFID test setup

With the interrogator transmitting at 916,25 MHz and an output of 36 dBm, measurements were made at the monitor of the WPR. For both CW and continuous modulated transmissions, significant levels of interference were evident in both the high and low modes of the WPR. The measurements were made in all four orientations of the WPR. The results together with a control measurement are shown at figures B.1 to B.9.

The RFID equipment was then moved to the perimeter of the site, which put it at a distance of 85 m from the fibreglass container. Measurements were again made at 916,25 MHz and 36 dBm (see annex C for real site calculations where a typical figure of -52 dBm e.r.p. would be experienced at this distance) with both CW and continuous modulation. Examination of the results from the monitor of the WPR showed that in the low mode RFID was still causing levels of interference. In the high mode interference from RFID was not immediately apparent. However any possible harmful effects will need to be confirmed by the team in Exeter who interpret the output.

Figure 4: Setup of RFID and ALD at perimeter of site

The WPR can be seen at to the right of the building.

By the insertion of attenuators in the feeder cable to the RFID antenna, the transmitted power was reduced first to -2,6 dBm and then 8,6 dBm. The interrogator was set to transmit a continuously modulated transmission (from previous measurements this represented the worst case condition). The WPR monitor appeared to show no evidence of interference in the low mode at a transmit level of -2,6 dBm but interference was just evident at 8,6 dBm.

The measurements were repeated with an output power of 8,6 dBm and the interrogator operating at a frequency of 917,25 MHz. In this configuration there was no obvious sign of any interference on the monitor of the WPR.

In a final test the RFID system was set-up in the conference room of the site office with its antenna directed at the fibreglass container. Although the RFID equipment was probably no more than 20 m from the fibreglass container, the transmission had to pass through at least three brick walls. With the interrogator again set to 916,25 MHz and 36 dBm transmit power in continuous modulation; an inspection was made of the traces at the monitor. There was no immediate evidence of interference in the high mode but there was clear evidence of interference from RFID in the low mode.

Figure 5: Tests carried out in left hand room of the building

5.2 Tests with ALDs

5.2.1 Measurement Sequence

Power levels for all of the following tests except for WCDMA were measured using the R&S ZVL using input resolution bandwidth at least 3x the signal bandwidth, and the peak detector in max hold mode run for at least 10 s. For WCDMA, because of the waveform's crest factor, power was measured with 10 MHz input bandwidth and the RMS detector. All power levels quoted here are referred to the antenna connector.

The antenna for all of the ALD, GSM and WCDMA tests was a 0 dBi cable-mounted ½ wave 915 MHz dipole from Taoglas (see note), with an omnidirectional response in the horizontal direction. (Datasheet in annex C). For the tests at 1,5 m height, this antenna was mounted on a non-metallic antenna stand via a cable. For the indoor tests the antenna was fitted directly to the ALD prototype. Figures 3 and 4 provide an overview of the test setup.

NOTE: See http://www.taoglas.com/images/product_images/original_images/TI.09.0111%20915MHz%200dBi%20Teminal%20Antenna%20090409.pdf

This antenna has performance typical of professional-grade SRD, ALD and mobile devices - in many consumer devices, antenna gain will be lower than this.

Antenna for RFID tests was a nominal +7 dBi directional patch antenna, Symbol branded. Input power is noted here. In all RFID tests, the antenna centre was directed at the radar.

5.2.2 Test sequence

Thursday 14 February 2013 - measurements at 85 m from WPR:

- Set up ALD1, nominal 200 kHz bandwidth, 124 kbit/s 4GFSK modulation (BT = 0,5) with 40 kHz deviation (outer symbols), 5 ms packets, 5 ms interval between packets (50 % duty cycle), 0 dBi antenna at 1,5 m above ground level
- Baseline (no tx)

- ALD1 915,2 MHz, 9,92 dBm
- ALD1 915,2 MHz, -1,67 dBm
- Baseline
- ALD1 915,2 MHz, 10,40 dBm
- ALD1 916,2 MHz, 9,79 dBm
- ALD1 916,2 MHz, -1,72 dBm
- Baseline
- ALD1 918,0 MHz, 9,65 dBm
- ALD1 918,0 MHz, -1,76 dBm
- Baseline
- Set up ALD2, nominal 600 kHz bandwidth, 360 kbit/s 4GFSK modulation (BT = 0,5) with 162 kHz deviation (outer symbols), continuous PN9 data modulated transmission (100 % duty cycle), 0 dBi antenna at 1,5 m above ground level
- Power level 0x40 used for 10 mW, 0x12 used for 1 mW
- ALD2 915,6 MHz, 10,54 dBm
- ALD2 915,6 MHz, -0,42 dBm
- Baseline
- ALD2 916,2 MHz, -0,58 dBm
- ALD2 916,2 MHz, 10,63 dBm
- Baseline (some measurements were missed first time and were repeated)

Friday 15 February 2013 - measurements at 85 m from WPR:

- Baseline
- Set up ALD2 in the same configuration as before, 0 dBi antenna at 1,5 m above ground level
- ALD2 918,0 MHz, 11,17 dBm
- ALD2 918,0 MHz, -0,50 dBm
- Set up R&S SMIQ to transmit a standard GSM GMSK waveform, nominal 200 kHz bandwidth:
  - Note that this transmission used 100 % duty cycle and a relatively low power level due to limitations of the test equipment. In practice a single mobile device would typically transmit at 1/8 duty cycle (in speech) or less during signalling, but in many locations can be expected to use significantly higher power (up to 2W for typical mobile devices)
  - 0 dBi antenna at 1,5 m above ground level
- GSM 914,8 MHz 14,33 dBm
- GSM 914,8 MHz -0,41 dBm