ALD compatibility testing against 2.3GHz LTE, TDD signals at UK Ofcom Baldock June 2014;

SUMMARY OF RESULTS

Copsey Communications Consultants

Edgcott House
Lawn Hill
Edgcott
Buckinghamshire
HP18 0QW
United Kingdom

Tel.: +44 (0) 1296 770 552 Fax: +44 (0) 1296 770 423

Important notice

Individual copies of the present document can be obtained from:
info@copsey-comms.com

The present document may be made available in more than one electronic version or in print. In any case of existing or perceived difference in contents between such versions, the reference version is the Portable Document Format (PDF).

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other Copsey Communications Consultants documents are available from
info@copsey-comms.com

If you find errors in the present document, please send your comment to the following service:
info@copsey-comms.com

Copyright Notification

Contents

Foreword

Europe

Following the identification of the 2.3- 2.4 GHz band for the mobile service on a co-primary basis by the 2007 World Radio Conference (WRC) The European Conference of Postal and Telecommunications Administrations (CEPT) carried out compatibility work and produced ECC Report 172[1] followed CEPT Report 55 (not yet available in its final form) and then by ECC decision (14)02 in June 2014[2].

The band is divided into 5MHz blocks which may be aggregated to obtain new channels, the transmission will be Time Division Duplex (TDD) which means that both base station and mobile use the same frequency Following consultations on the ECC report and further recognition of the interference issues for the adjacent band containing Short Range Devices (SRD) the in block power limit for base stations was reduced to 45dBm/5MHz and 25dBm for user equipment in the 2390-2400MHz channels. A maximum in block EIRP of 68dBm/5MHz is recommended between 2300-2390MHz

UK

Ofcom UK published its proposals in February 2014[3] for the auction of the 2.3GHz band and its accompanying report, showed interference to Short Range Devices (SRD) in the 2.4-2.483GHz band, the report also contained an invitation for Stake holders to use an Ofcom test bed at Baldock to identify any issues with their equipment. ALD manufacturers took up the invitation and tested equipment in June 2014.

It should be noted that in the UK only the band 2350-2390MHz will be auctioned for mobile use with in Block power limits of 61dBm/5MHz for base stations and 25dBm for user equipment

1 Executive Summary

A number of caveats are needed when considering the results in this report and comparing these results with the implementation of the CEPT band plan for the rest of Europe these are:

[1] http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP172.PDF

[2] http://www.erodocdb.dk/doks/filedownload.aspx?fileid=4082&fileurl=http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCDEC1402.PDF

[3] http://stakeholders.ofcom.org.uk/consultations/pssr-2014/

- Testing has been carried out with a 10MHz guard band due to the UK implementation.
- Full base station power shown in the ECC Decision was not used
- Impact of UE (user equipment)OOB(Out of Band) energy from actual equipment is likely to be higher than the test signals in use for these tests
- Tests carried out with a single UE, multiple UE will raise the noise floor beyond the results in the current tests
- No work has been undertaken on use of the 2.3-2.4GHz LTE band simultaneously with LTE bands above 2.5, which if used in close proximity to ALD may increase the interference potential.

The results of this testing are in line with the previous Ofcom and CEPT work in that interference will be caused to SRDs in the adjacent band however in the case of ALDs users, interference and loss of range will impact the quality of their lives, especially children with hearing impairment.

Recent UK Legislation states

"All[4] children and young people are entitled to an education that enables them to make progress so that they: achieve their best, become confident individuals living fulfilling lives and make a successful transition into adulthood, whether into employment, further or higher education."

It should be noted that children from the age of six weeks are fitted with ALDs and schools and other places of education have a legal responsibility to provide facilities for hard of hearing pupils. In the case of cochlear implants some 1000 operations a year are performed with a user base in the region of at least 14000.

The results show that the form and bandwidth of the LTE signal is not critical to the interference, leading to the conclusion that blocking is likely to be the major interference mechanism which will become more pronounced as the frequency of LTE transmissions approach the 2.4GHz band edge of the CEPT bandplan. Dependent on ALD model blocking takes place from 15cm to 4 m from a UE and base stations can affect indoor use of ALD via windows. Given the physical size and single cell power source of the ALDs the practical issues of filtering will be extremely difficult if not impossible to implement. The best hope is that Bluetooth chip manufacturers can implement better filtering starting above the current 2350 MHz, along with other recommendations contained in the Bluetooth Sigs "Filter Recommendations for coexistence with LTE and WIMAX"

A number of effects where observed which we were unable to clearly identify the causes, these included loss of pairing between devices and an increase in latency near the bounds of the loss of signal. Observation of the Bluetooth signal will be required to identify these issues. If these latter effects are caused by LTE OOB energy it is difficult to see a satisfactory technical solution for ALDs

In addition to the 2.4GHz ALD equipment two types of VHF (174MHz) systems were tested, no interference was experienced.

---

4 From the new *Special Educational Needs and Disabilities (SEND) Code of Practice*

(relating to part 3 of the Children and Families Act 2014), paragraph 6.1:

www.gov.uk/government/publications/send-code-of-practice-0-to-25.

2 Introduction

I believe this is the first time radiated compatibility testing has been carried out on ALDs and I wish to thank the Ofcom staff for their help in arriving at a test method which gave repeatable and consistent results. Further testing can help refine these test methods

The current compatibility testing was carried out using the UK band plan at Baldock Radio Station using the Ofcom Test Bed, by kind invitation of Ofcom UK

Broadband Wireless Access using LTE equipment in the UK will operate between 2.350 and 2.390 MHz with the remaining 10MHz being retained by the present user. Within CEPT countries the band plan covers goes up to the 2.4 GHz band edge[5]

3 Manufacturers

Some four manufacturers carried out testing in the first phase, equipment varied from experimental units to current production. An additional five manufacturers plus a cochlear implant company wish to test.

[5] http://www.erodocdb.dk/Docs/doc98/official/Word/ECCDEC1402.DOCX

4 ALD Equipment

ALD systems are extensively covered in ETSI TR 102-791[6], but the following extracts provide an overview of the extremely compact nature of the equipment in use and its layout on a user, whilst different manufacturers offer a range of options the physical size of the equipment is similar with the FM[7] receiver/transmitter units being under 1cm

1) a. FM Multi-frequency transmitter

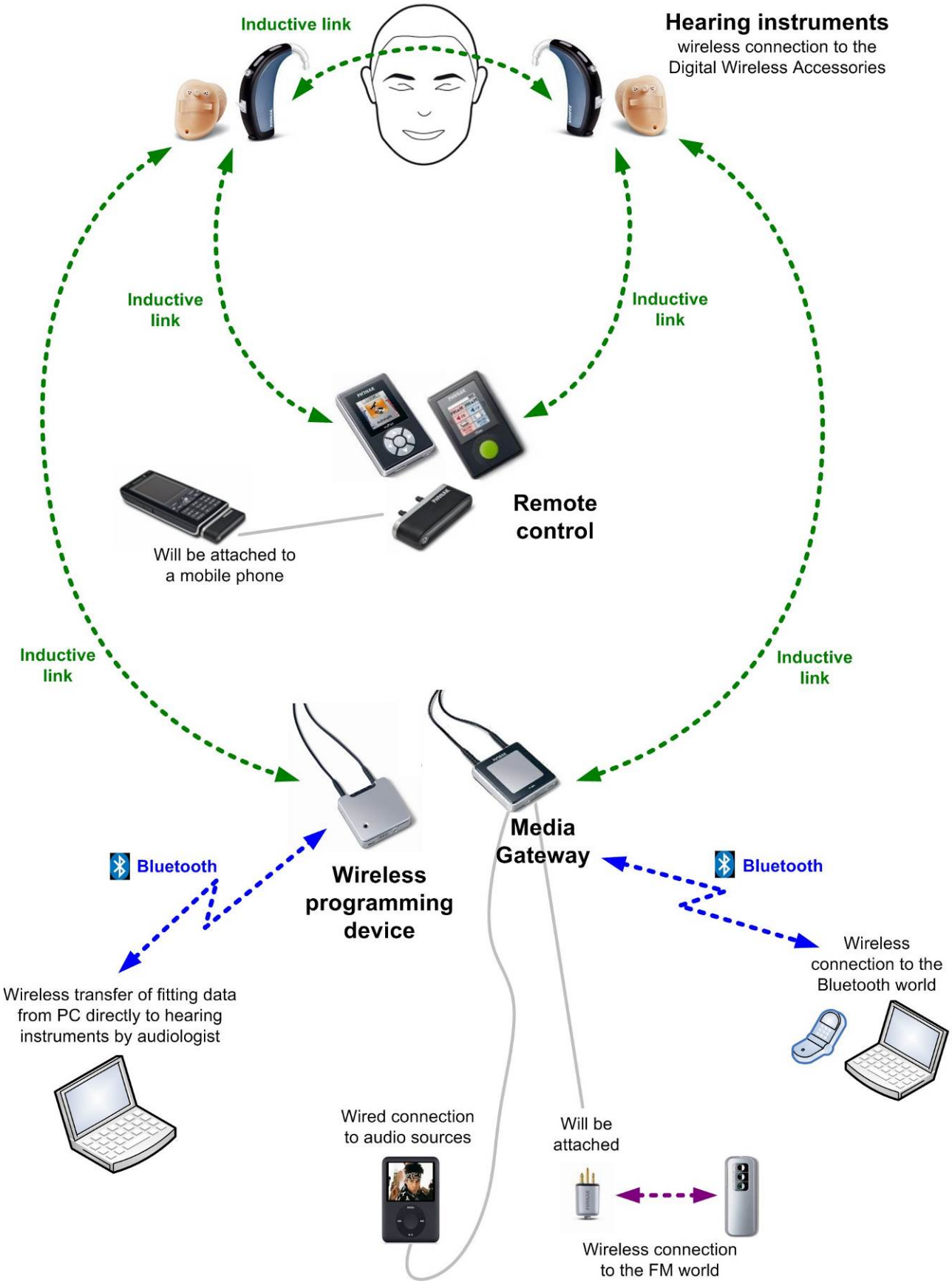
2) b. FM Receiver transmitter

3) c. Has coupled with FM receiver and hearing aid with design integrated FM receiver

4) Figure A.7: Typical components of a Personal FM system

[6] http://webapp.etsi.org/workprogram/Report_WorkItem.asp?WKI_ID=41256

[7] The term "FM" is used to describe any radio aid irrespective of the frequency of use


Inductive link
Hearing instruments
wireless connection to the
Digital Wireless Accessories
Inductive link
Inductive link
Remote control
Will be attached to
a mobile phone
Inductive link
Inductive link
Media Gateway
Bluetooth
Wireless programming device
Bluetooth
Wireless transfer of fitting data
from PC directly to hearing
instruments by audiologist
Wireless connection to the
Bluetooth world
Wired connection
to audio sources
Will be attached
Wireless connection
to the FM world

4.1School Systems

Only teacher has a transmitter

In this mixed situation both teacher and pupils with normal hearing have transmitters

In this situation a pupil uses a hand microphone to communicate with the whole class

5 Test setup & Procedure

5.1 Initial Setup

Compatibility testing of ALD against a radiated signal poses a large number of practical issues very similar to those experienced with radio microphones; prior to arriving at the test site we identified the KEMAR[8] manikin shown in Figure 1 & 2 as a practical method of mounting the ALD and feeding the audio output for analysis via the audacity[9] audio recording program. A 1 KHz tone was the ALD signal source.

[8] http://www.gras.dk/products/head-torso-simulators-kemar.html

[9] http://audacity.sourceforge.net/

Figure 1 Kemar

Figure 2 KEMAR ear detail

After initial trails using the Kemar manikin we found:

1. Using the audacity program failed to identify interruptions which could be clearly perceived by a human ear.

2. The 1 KHz tone was difficult to listen to for an extended period and did not easily identify distortion or latency. We replaced the 1 KHz tone with a recorded speech program: ISTS (International Speech Test Signal) which is an internationally recognised test signal that may be used in the technical evaluation of hearing aids, and for probe-microphone measurements. It was created based on the need for a standard test stimulus that included all the relevant properties of speech and allowed for reproducible measurement conditions. It is based on natural recordings of speech which is non-intelligible due to remixing and segmentation. The signal reflects a female speaker for six different languages (American English, Arabic, Chinese, French, German, and Spanish) reading "The north wind and the sun".

   This worked well.

3. On the initial set up we found that the “emitter” used as the LTE user equipment was connected via a fixed cable.

Figure 4 UE Emitter

Leaving us with a physical problem of how to either move the emitter when carrying out blocking and range tests or to move KEMAR.

Figure 5 KEMAR and UE

Neither of the options was practical, therefore for this range of testing we abandoned KEMAR and used Brian Copsey or the manufacturer's representative as a substitute. Unfortunately this means that as with radio microphone testing that the results are subjective.

5.2 LTE Test System

Annex A shows the layout of the Baldock site along with photos showing the base station down tilt aerials located at 10m on a hydraulic working platform and test equipment used. Annex B gives detail of the test signals.

5.2.1 Test signal

The test signals used where from the previous Ofcom compatibility work with an approximate crest factor of:

BS 11.5dB

UE 6.1dB

5.2.2 Frequency

Initially a range of channel frequencies were tested between 2350 and 2390MHz but the results obtained were similar, and for the remaining testing the channel used had a centre frequency of either 2385Mhz for the 10MHz channel or 2380MHz for the 20MHz channel.

As we unable to transmit below 2350MHz the effectiveness of the receiver filtering was not identified.

5.2.3 RF Power

UE 23dBm mean EIRP

BS 53dBm mean EIRP

5.3 Test Procedure

After some experimentation the following procedure was used for all testing.

The variables were:

- Base or UE transmissions
- Idle mode, 50% traffic loading or 100% traffic loading
- 10 or 20MHz signal bandwidth
- Distance from interfering signal source
- Testing any and all functions of the ALD system

5.3.1UE Testing

Base line tests were carried out with no interfering signals present and the ALD transmitter located on the conference room table some two meters from UE to give range and quality of the unit under test.

Pass/Fail Criteria: any change from the base line tests.

Testing started as per figure 6 and then Figure 7 with the ALD transmitter some two meters from the user and each test was carried out for two minutes:

A. If interference was received the ALD receiver was moved away from the UE until interference ceased, or if no interference was received the ALD was moved closer to the UE.

B. The ALD transmitter was moved further from the start position.

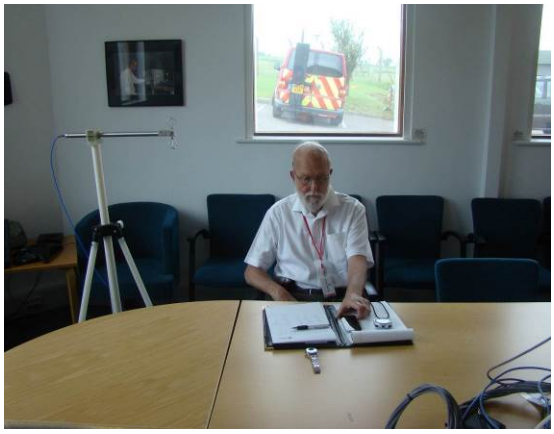


Figure 6 UE Test Start position

Figure 7 UE Test second Start position

The test was repeated for:

- 10MHz idle mode
- 10MHz 50% Loading
- 10MHz 100% loading
- 20MHz idle mode
- 20MHz 50% Loading
- 20MHz 100% loading

5.3.2 Base Station

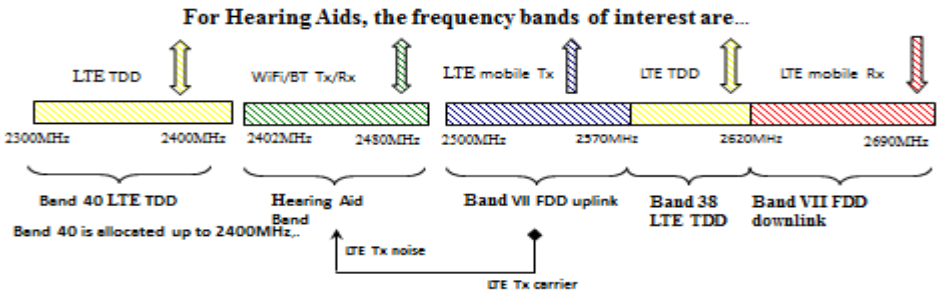
Baseline tests were carried out along the walk shown in Annex 1with no interfering signals present and the ALD transmitter located on the conference room table some two metres from the UE(which was not transmitting) to give range and quality of the unit under test.

Then interfering signal was turned on and the same sequence as UE was used:

- 10MHz idle mode
- 10MHz 50% Loading
- 10MHz 100% loading
- 20MHz idle mode
- 20MHz 50% Loading
- 20MHz 100% loading

6 Future LTE Allocations

For band 40, It can be seen that the current band used by ALDs will be bracketed by mobile phone services using LTE modulation with LTE “noise” from above and below.



Page 4

7 Current Bluetooth Situation

Bluetooth is a worldwide communications protocol and has some three pages of RF issues in the standard which is over 2000 pages. RF issues are expected to be specified by Administrations in national or regional regulation.

Within the EC until the publication of the new Radio Equipment Directive the majority of receiver characteristics other than emissions were not in Harmonised Standards. Therefore Chip designers

have concentrated on the known mobile bands which could cause interference to the units (when used within mobile phones) which were below 2350MHz. Current filtering provides protection below this frequency whereas the CEPT bandplan allows LTE transmissions up to 2400MHz.

The Bluetooth White Paper "Filter Recommendations for coexistence with LTE and WIMAX" assumes a guard band of some 20MHz i.e. no mobile transmissions above 2380MHz; however this is not the case for Europe. In addition any filter introduces losses in its host which would make receivers less sensitive and result in a loss of range and probably consume more power.

8 Test results

Some 12 pieces of equipment were tested from four ALD manufacturers; the equipment used Bluetooth Low Energy, standard Bluetooth and company specific protocols. Some equipment can be used in more than one configuration.

In all cases the Ofcom in house WiFi (3) was operating.

The tested equipment can be categorised as:

6.1 Type 1 streamer configuration's: these consist of a base unit powered from the mains .voltage with an audio input (normally a 3.5 jack) which receive audio from a TV, radio or MP3 player communicating either with a necklace unit which in turn transmits to the ALD or directly to an ALD. Normally used in domestic environments. Units used mixture of standard Bluetooth, company specific and BLE.

Four ALD units tested:

Normal use no interfering signal: range 10m to 35m, base unit on conference room table

Base Station:

Range reduction similar (within 1m) for both 10 and 20MHz signals

Idle: reduction of between 10% and 33%

50% loading: reduction of between 10% and 33%

100% loading: reduction of between 10% and 33%

UE:

Once units were more than 1-4m from the UE they functioned normally in all configurations.

Note: Two units also received interference from the base station when passing the windows on the inside of the conference room BLE appeared to suffer more than standard Bluetooth. One effect was an apparent increase in latency near the edge of range, this is extremely disorientating for ALD users. Further investigation of BLE with protocol equipment is needed to determine if the latency issues are caused by blocking of the two lower control channels with possible congestion caused by WiFi.

6.2 Type 2 Microphones**:** for use by teacher or other person: these consist of a battery operated unit which can be hand held, clipped on clothing or left on a table or stand.

Six units tested:

Normal use no interfering signal: range 9m to 15m

Base Station:

Worst case some 20% reduction in range

UE:

Equipment became blocked between 15cm and 4m from UE

Note: BLE appeared to suffer more than standard Bluetooth. One effect was an apparent increase in latency near the edge of range. Further investigation of BLE with protocol equipment is needed to determine if the latency issues are caused by blocking of the two lower control channels with possible congestion caused by WiFi. These effects are worse when multiple ALD devices are in simultaneous use.

6.3 Type 3 Smart Device based systems and Experimental systems: systems uses phone or similar smart device to communicate with ALD.

Normal use no interfering signal: range < 5m

Difficult to determine with these systems if the phone unit or the ALD where affected by the interfering signal, More work required

Base Station:

Due to the short range of these devices no interference was experienced with these systems when in conference room.

UE:

The tested equipment became blocked between 15cm and 2m from UE

Note: These systems had data monitoring facilities, the interference caused the data logging to be intermittent and non-consistent, further work required with more instrumentation

9 Observations

All equipment tested suffered from the LTE transmissions to a greater or lesser extent, as would be expected the proximity to the UE was the major contributor but also some equipment received interference[10] from the base station when passing the windows of the conference room. Given that we were not using the maximum power which will be permitted under Ofcoms or CEPT proposals this raises concern if the base station is located near ALD users such as a school or within close proximity to domestic premises.

[10] The term interference is used to describe and reduction in performance or loss of signal

A number of events involving software of the devices (or possibly test equipment) were noted but require further investigation. These include loss of pairing between the hearing aid and necklace, random data loss or degradation. When testing systems involving mobile phones it is difficult (with the test equipment available in phase 1) to determine if the hearing aid or the phone (or both) are the cause of the loss of the link

10 Definitions, symbols and abbreviations

10.1 Symbols

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

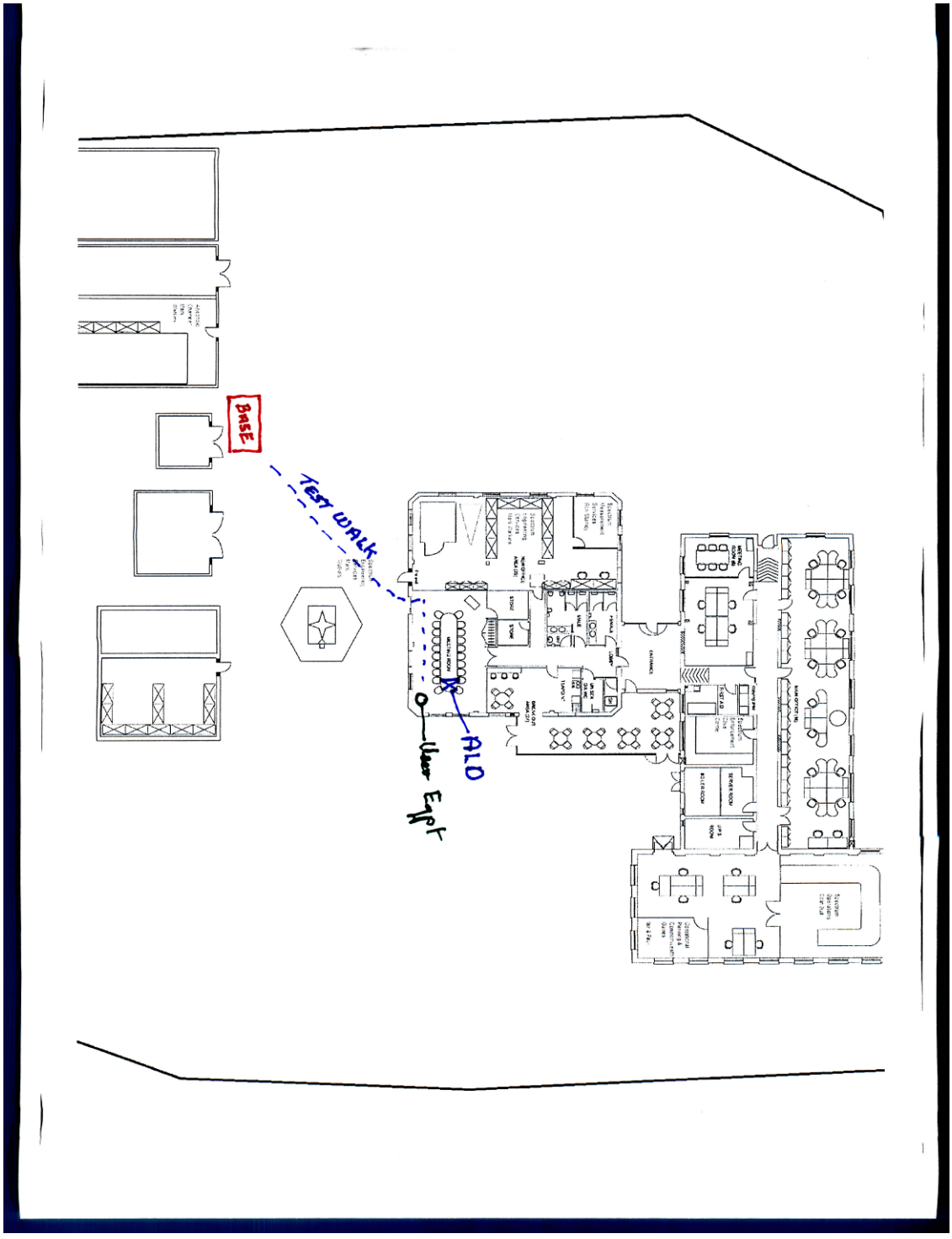
dB	decibel
dBm	power ratio in dB (decibels) referenced to one milliwatt (mW)
kHz	kilohertz – 1 thousand cycles per second
MHz	Megahertz – 1 million cycles per second
mW	milliwatt

10.2 Abbreviations

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

BS	Base Station
CEPT	European Conference of Postal and Telecommunications Administrations
EC	European Commission
ECC	European Communications Committee
ERP	Effective Radiated Power
FM	Frequency Modulation
LTE	Long-Term Evolution
RF	Radio Frequency
UE	User Equipment

Annex 1 Test equipment Location



A 1.1 Base Station

From Meeting Room

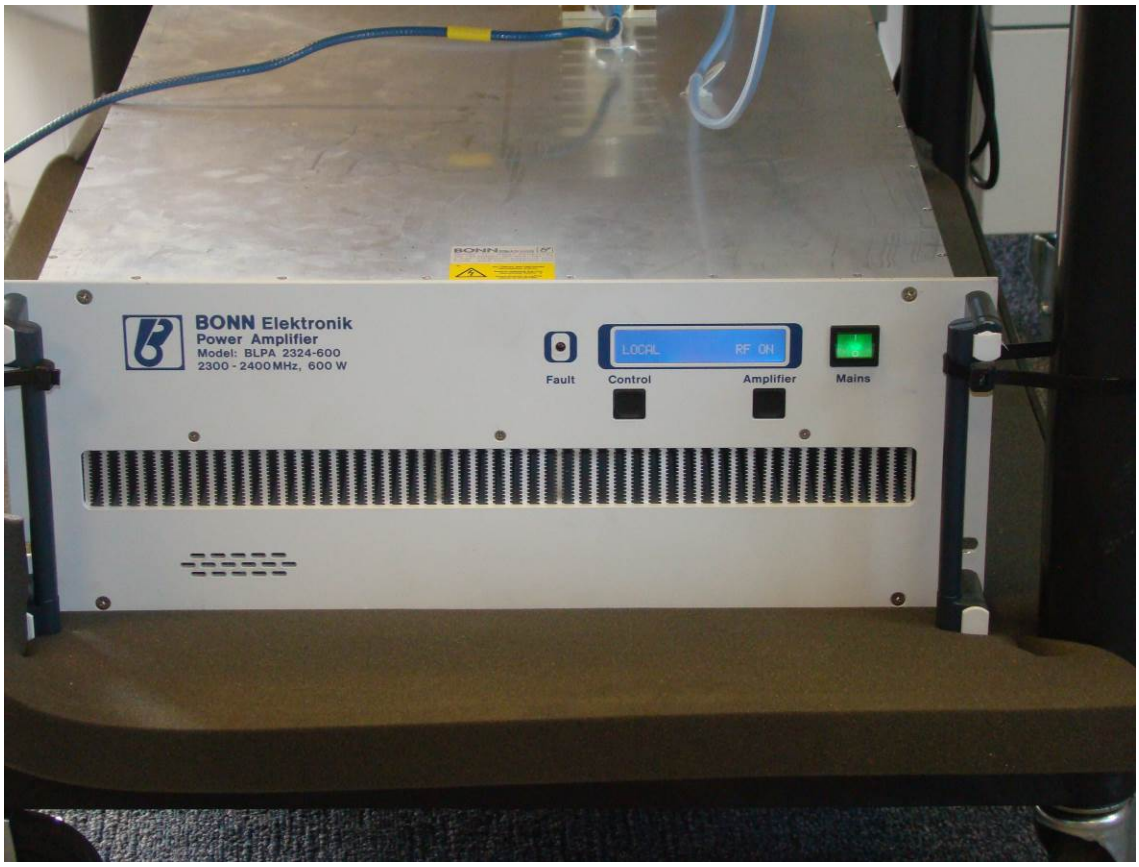
From base of antenna

A1.2 Base Station Antenna

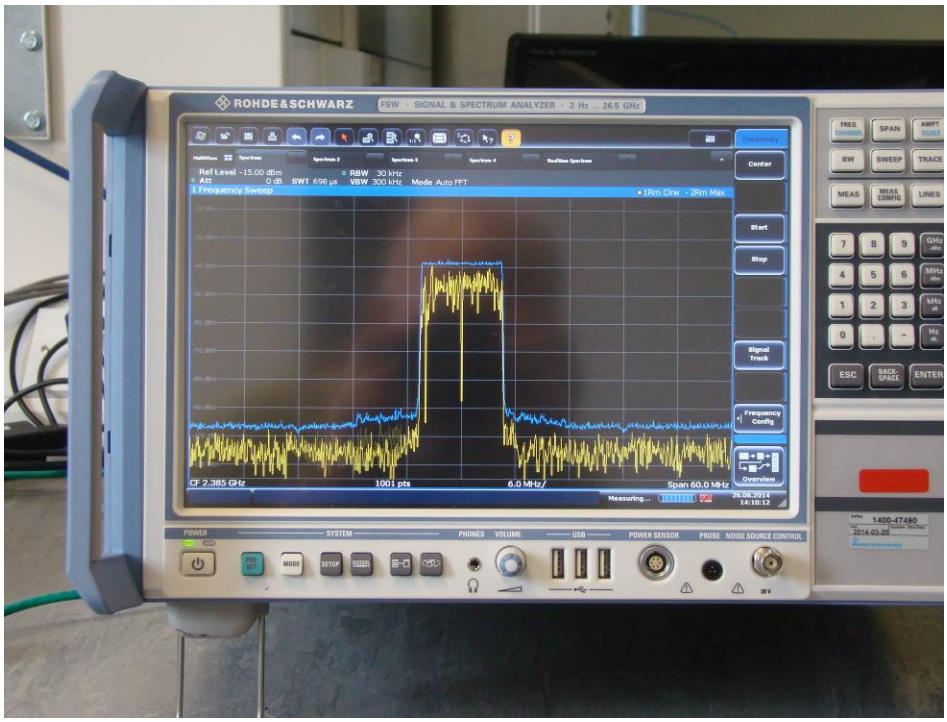
A 1.3 Base Station Equipment

General Overview

Signal Source: R&S SMBV 100A Vector Signal Generator

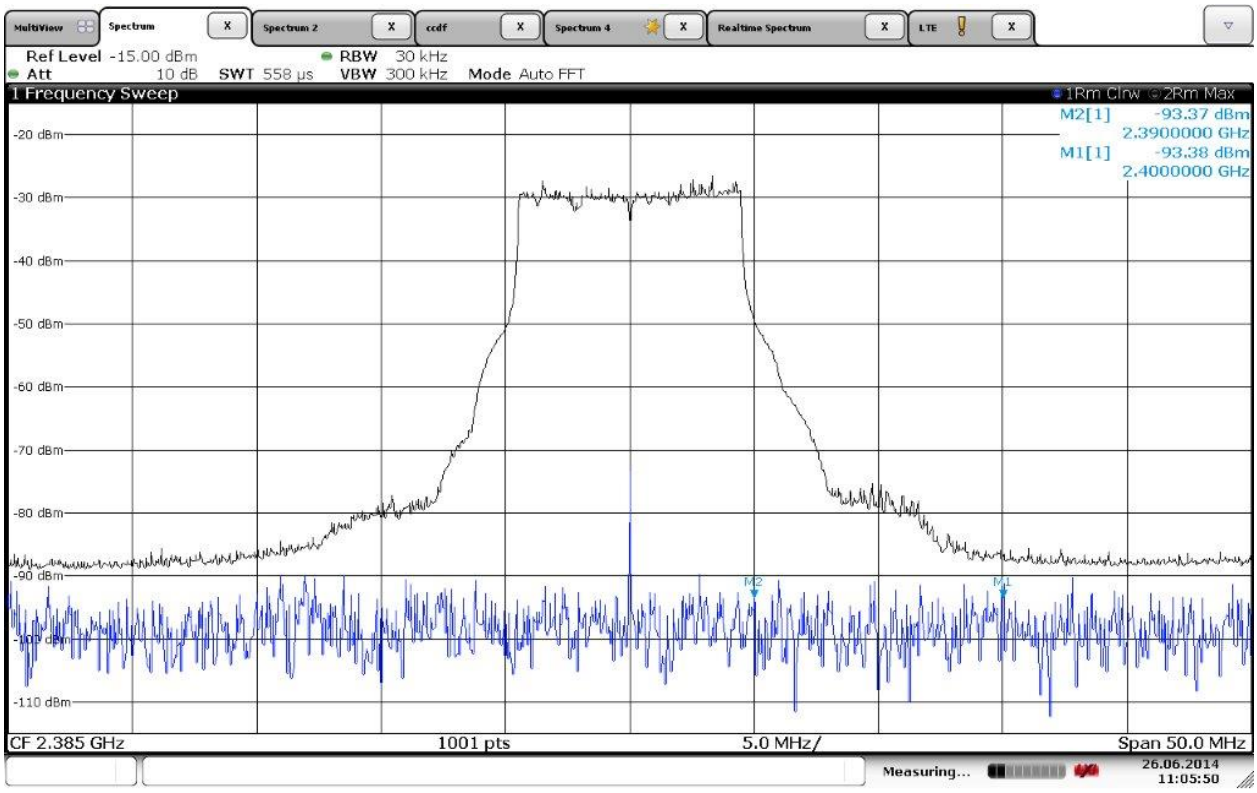


Power Amplifier: Bonn Elektronik BLPA 2324-600



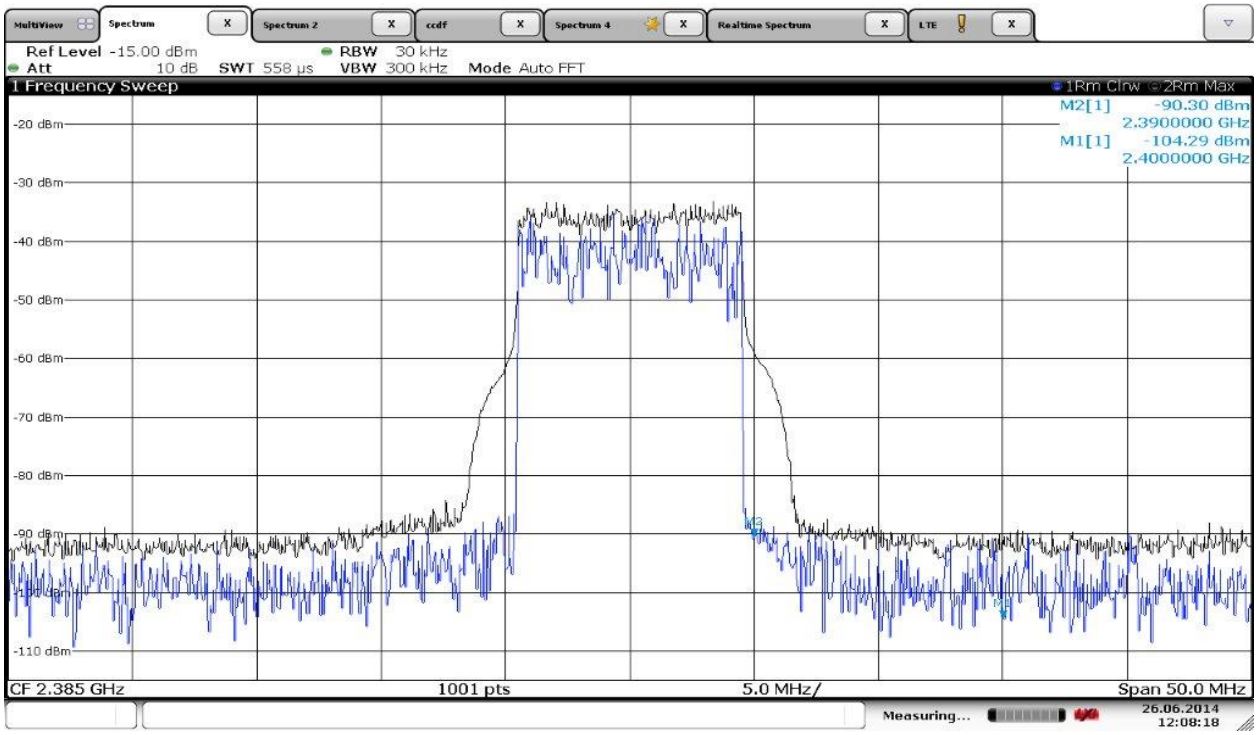
Monitor: R&S FSW

Annex 2 Test Signals



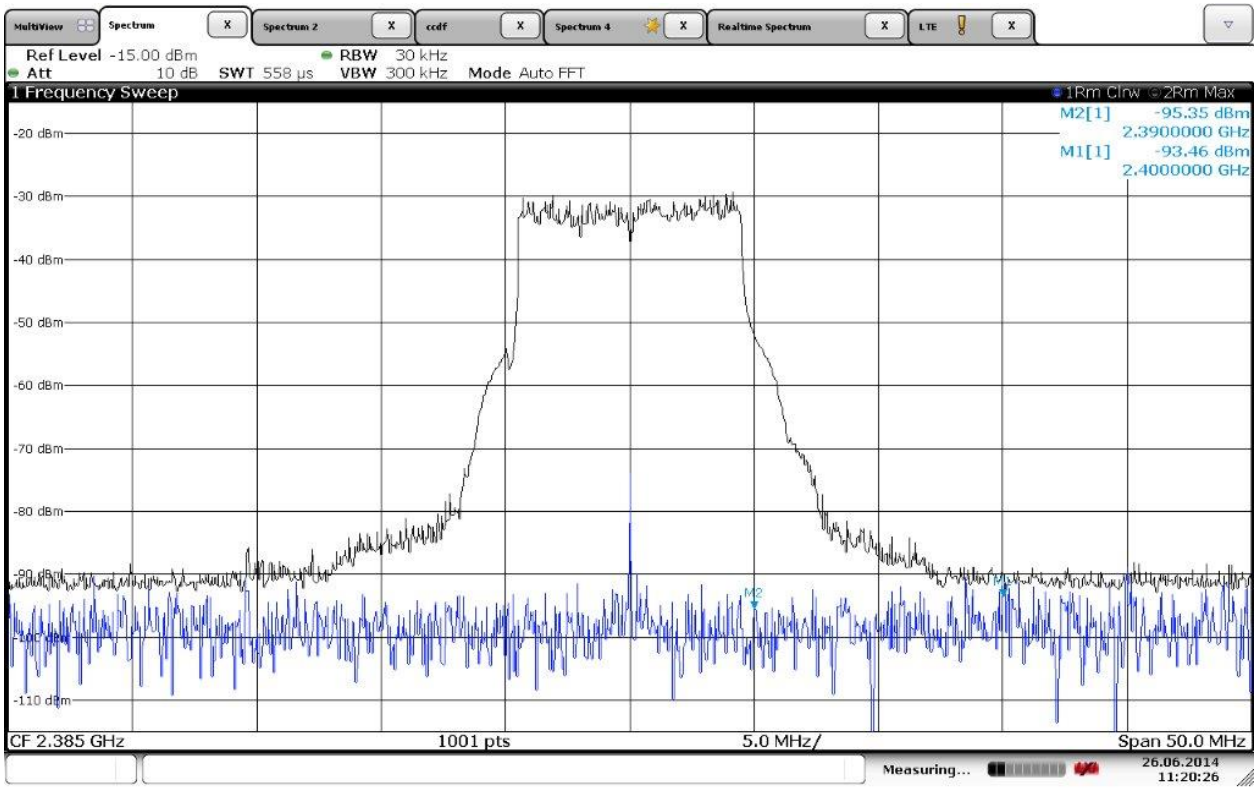
Date: 26.JUN.2014 11:05:50

10 MHz Base Station idle modes



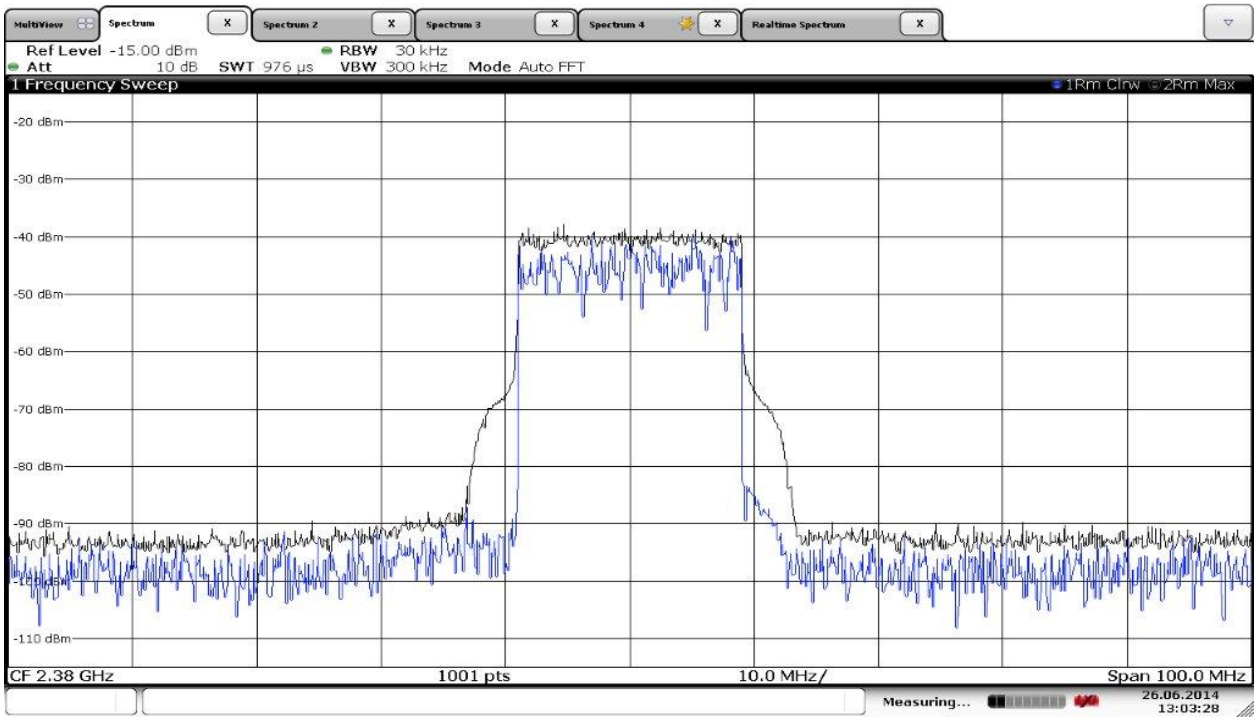
Date: 26.JUN.2014 12:08:17

10MHz Base Station 100% Loading



Date: 26.JUN.2014 11:20:26

10 MHz Base Station 50% Loading



Date: 26.JUN.2014 13:03:28

20MHz Base Station 100% Loading

History

Document history		
V0.1	20 July 2014	Document creation
V0.2	16September 2014	Final after consultation and incorporation of changes