The effects on trees of pulsed digitally modulated high-frequency electromagnetic fields produced by EM transmitters

Section: Bio-potential measurements

Location: Wageningen University, Netherlands, 2011-2012

October 2013

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Introduction

Scoping research was first carried out in 2010 by Wageningen University and Research Center (WUR) into the effects upon trees of pulsed digitally-modulated high-frequency electromagnetic signals from EM transmitters (henceforth, 'EM fields'). This research threw up the need for further research. Accordingly, the Municipality of Alphen aan den Rijn and the Horticultural Production Board (Productschap Tuinbouw) commissioned scientifically-based follow-up research in 2011 into the effect of EM fields. The Council commissioned WUR to carry out the bio-potential measurements.

WUR performed this research in the period 2010 - 2012. Specifically, what was determined was whether or not the viability of a tree can be impacted by EM fields. Also recorded and described were the effects that EM fields had upon the outward structure and shape of various parts of a tree.

Bio-potential measurements were conducted and calculated by a team that included electrotechnical engineers and that drew upon the expertise of electrotechnical companies and of Alphen aan den Rijn municipal employees. To the best of our knowledge, this new technique had never before been used. This document validates the apparatus, testing model, conduct and results of the bio-potential measurements taken.

Aim

Occasioned by the increasing number of damaged trees observed, the research, by means of measuring bio-potentials, covered the issue of whether EM fields have an effect on trees. External factors can influence the health of trees. The outward structure and shape can be influenced by the interplay between genotype and environment.

What are bio-potentials?

Andrew Goldsworthy BSc PhD, a retired lecturer of Imperial College, London, has for years been researching how living organisms generate their own electrical currents. He researches how trees use such electrical currents in ways such as growth or daily metabolic processes. A hypothesis of Dr Goldsworthy is that:

"The electrical (bio-)potential in a tree is in equilibrium. The sum of the total direct current produced by the cells is a reasonable guide to the physiological activity of the tree."

Bio-potential is the potential difference measured between two electrodes in the stem of a plant or tree. It is expressed in millivolts (mV). Typically, the value of this PD is in the tens of millivolts, i.e., a couple of hundredths of a single volt. Data loggers were used to record the bio-potential measurements. For further information about electrical potentials, including bio-potentials, the reader is referred to Dr Goldsworthy's paper delivered at the symposium "Het effect van elektromagnetische straling op bomen, februari 2011" held at Baarn in the Netherlands, in the "Plant Electrophysiology" section. It can be viewed at http://vimeo.com/user7485983

It is known that trees have a network antenna effect in receiving radio signals. These signal strengths can easily be measured from within a tree. Present-day knowledge and insights suggest that trees are not able to convert these radio signals to direct current. In addition, the apparatus and the calibration of measurements currently used have proven not to be sensitive to EM fields (see Sectional Appendices 1 - 3).

Taking bio-potential measurements

From 2006 onwards, a method has been developed to measure electrical potential in trees, including bio-potential. Between 2006 and 2012, hundreds of such measurements were carried out and interpreted. Measurements were taken of the equilibrium generated by the cells. The apparatus and testing model are described and validated in the below sectional appendices.

- *For a description of the bio-potential data logger, see Sectional Appendix 1.*
- *For the bio-potential logger test report, see Sectional Appendix 2.*
- *For a susceptibility test of a DC data logger, see Sectional Appendix 3.*
- *For EMF measurements on trees in climate chambers of Wageningen University in 2011, Canrinus Consultancy, 19 - 20 July 2011, see Sectional Appendix 4.*

Results of bio-potential measurements 2011 and 2012

During the research in 2011 - 2012, it became clear that bio-potentials in trees do change as a result of exposure to EM fields. However, it was also found that other aspects of trees, such as their day/night (Circadian) rhythm, can be measured.

Below is an overview of the circumstances in which measurements were taken. Throughout the research period, WUR bore responsibility for conditioning the environmental factors in the climate chambers used, in particular the temperature regimens, light intensity and air humidity.

2011 Climate chamber	A1	A2	C8
Begin End	1 July 2011 26 October 2011	1 July 2011 26 October 2011	1 July 2011 December 2011
Light	04 → 05 hours: On 19 → 20 hours: Off Intensity: 53.64 μmol	04 → 05 hours: On 19 → 20 hours: Off Intensity: 55.01 μmol	04 → 05 hours: On 19 → 20 hours: Off Intensity: 68.27 μmol
Temperature	13 - 23 °Celsius	13 - 23 °Celsius	13 - 23 °Celsius
EM emitters	6 WiFi access points + dummy load	--	6 WiFi access points UMTS DVB-T
Electrodes	Fraxinus (Ash): 1 - 3 Aesculus (Horse chestnut): 4	--	Fraxinus (Ash): 1 - 3 Aesculus (Horse chestnut): 4

Three ash trees and one horse chestnut tree were fitted with electrodes in climate chambers A1 and C8 in 2011. Bio-potential measurements were taken. In total, then, 8 electrodes were connected.

2012 Climate chamber	A1	A4	C8 (half-chamber)
Begin End	June 2012 November 2012	June 2012 7 November 2012	June 2012 26 November 2012
Light	04 → 05 hours: On 19 → 20 hours: Off	04 → 05 hours: On 19 → 20 hours: Off	04 → 05 hours: On 19 → 20 hours: Off
Temperature	18 - 23 °Celsius	18 - 23 °Celsius	18 - 23 °Celsius
EM emitters	None	6 WiFi access points UMTS	6 WiFi access points UMTS
Electrodes		Fraxinus (Ash): 1 and 4 Aesculus (Horse chestnut): 2 Salix (Willow): 3	Fraxinus (Ash): 1 and 4 Aesculus (Horse chestnut): 2 Salix (Willow): 3

Two ash trees, one horse chestnut tree and one willow tree were fitted with electrodes in 2012. Bio-potential measurements were taken.

EM-emitters

	DBV-T	UMTS	WiFi
2010			2 access points 2442 Mhz field strength 0.2-1.4 V/m *
2011	Transmitter 714 Mhz field strength 0.05-0.13 V/m	GPRS modem 1920-1980 Mhz field strength 0.08-0.23 V/m **	6 access points 2412-2472 Mhz field strength 0.13-0.16 V/m **
2012		GPRS modem 1920-1980 Mhz field strength 0.08-0.23 V/m **	6 access points 2412-2472 Mhz field strength 0.13-0.16 V/m **

* field strength varies on distances from 0,2 – 3,20 meters
** field strength measured in the front, the middle, and the back

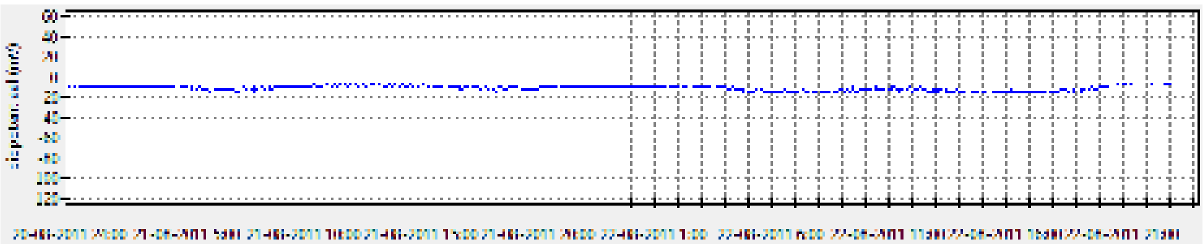
Results 2011

In the research, a range of different periods was used (replication study) in which WiFi routers or other EM emitters present were switched on and off in the climate chambers. Representative examples are given below of the effect upon the bio-potential of trees measured.

Period		EM emitters
1	23 August 2011 12:00 – 16:00 hours	Off
2	24 August 2011 12:00 – 16:00 hours	Off
3	30 August 2011 12:00 – 31 August 12:00 hours	Off
4	10 October 2011 12:00 – 11 October 12:00 hours	Off

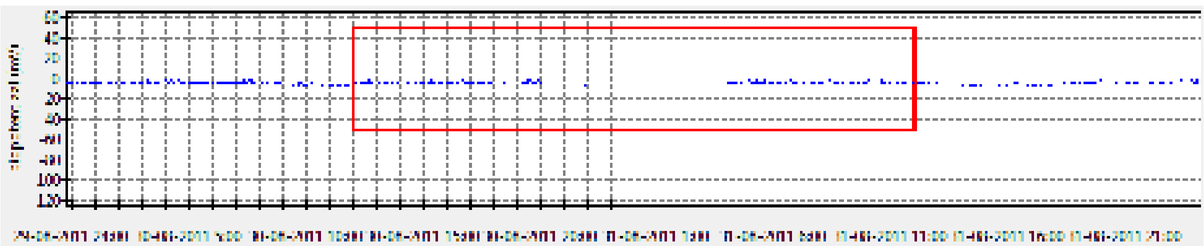
Overview of replication studies

Climate chamber A1



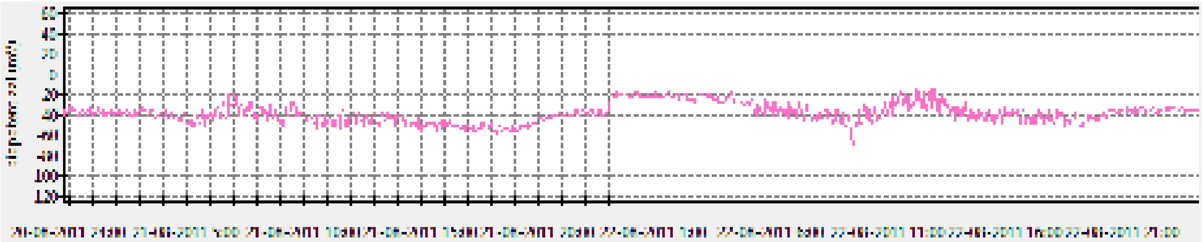
Given above is the bio-potential of an ash tree on 21 and 22 August 2011. In this chamber, EM emitters (WiFi routers in this case) were set up and provided with a dummy load. This is a potential resistance that has the same impedance as an antenna, so that the load on the emitter occurs in the same manner. A dummy load does not emit any EM field. The equipment was switched on.

The day/night (Circadian) rhythm of the ash tree was visibly documented using the bio-potential measured. The nocturnal period can be recognised by its flat plotting.



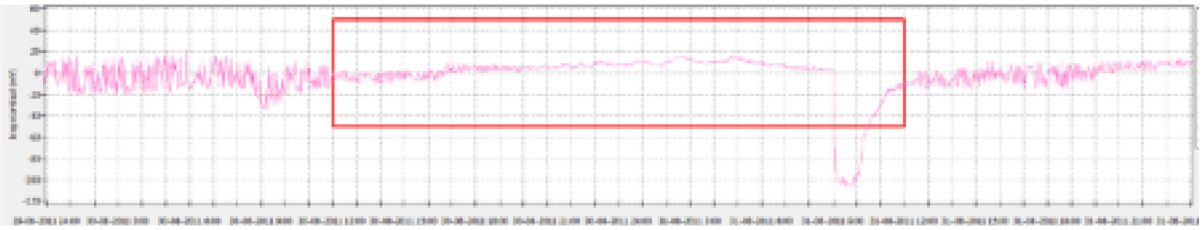
The nocturnal period from 20:00 hours on 30 August 2011 until 4:00 hours on 31 August 2011 is visible. The EM emitters (WiFi routers) present that were provided with a dummy load were switched off from 12:00 hours on 30 August 2012 until 12:00 hours on 31 August 2011. No effect upon the value of the bio-potential of the ash tree as a result of switching off the apparatus can be discerned.

Climate chamber C8



Given above is the bio-potential of a horse chestnut tree on 21 and 22 August 2011. In this chamber, EM emitters (WiFi router, UMTS and DVB-T) were installed and were emitting an EM field. All the equipment was switched on.

The day/night (Circadian) rhythm of the ash tree was visibly documented using the bio-potential measured. The nocturnal period can be recognised by its flat plotting.



The nocturnal period from 20:00 hours on 30 August 2011 until 4:00 hours on 31 August 2011 is visible. All the EM emitters (WiFi router, UMTS and DVB-T) present were switched off from 12:00 hours 30 August 2012 until 12:00 hours on 31 August 2011. An effect upon the value of the bio-potential of the ash tree as a result of switching off the apparatus can in this case be discerned.

Results 2012

In the research, a range of different periods was used (replication study) in which WiFi routers or other EM emitters present were switched on and off in the climate chambers.

EM emitters OFF	EM emitters ON
3 October 2012 at approx. 13:00pm	4 October 2012 at approx. 15:00pm
9 October 2012 at approx. 13:00pm	10 October 2012 at approx. 13:00pm

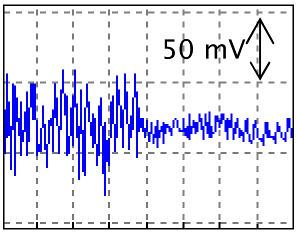
Overview of replication studies

Figures are given below that indicate the forced transitions of the effect of the bio-potential upon trees. Both the forced transition from diurnal to nocturnal state and the forced switching-off of the EM emitters have an effect.

Climate chamber A4

Change in bio-potential

Forced transition from diurnal to nocturnal state (between 19:00 and 20:00 hours) Horse chestnut tree in climate chamber A4 — EM emitters switched ON

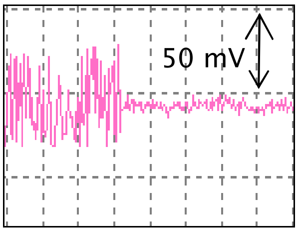


16:00 24:00 hours
7 October 2012

Given above is *the bio-potential of a horse chestnut tree on 7 October 2012. In this chamber, EM emitters (WiFi router and UMTS) were installed that emitted an EM field. All the equipment was switched on. There was an effect upon the value of bio-potential.*

Change in bio-potential

Forced transition by switching off the EM emitters at 13:00 hours on the ash tree in climate chamber A4



10:00 18:00 hours
9 October 2012

On 9 October 2012, all the EM emitters present (WiFi router and UMTS) were switched off at 13:00 hours. There was a visible effect upon the value of bio-potential.

Conclusions

With this research into the effect of pulsed digitally-modulated high-frequency electromagnetic signals from EM-emitters upon trees, it has become clear that these signals do have an effect upon the level of electrical potential, including bio-potential, produced by the cells of a tree. Significant proof was established of interruptions to the exposure to EM fields. Wageningen University and Research Center were able to ascertain that the correct timings of switching the equipment on and off were carried out doubly-blind by municipal staff of Alphen aan den Rijn.

Recommendations

More research will be necessary to determine what consequences are entailed by such changes to the current equilibrium generated by plant cells. For instance, does this biological effect have consequences for the physiological activity of a tree or for its resistance to pathogens, or can such changes cause cell death in plant tissues?

This research into the effect of electromagnetic fields (regarding bio-potential) must be regarded as merely indicative in nature. Repetition and scaling-up of this research should serve to increase the insights it gives and to corroborate its significance.

Sectional Appendices

The appendices to this document were written between 2010 and 2012 by specialists in electrotechnology and by the Municipality of Alphen aan de Rijn.

These tests were carried out at the same time and in the same climate chambers that Wageningen University and Research Center were conducting research into the effects of EM fields upon trees, commissioned by the Horticultural Production Board (Productschap Tuinbouw) and the Municipality of Alphen aan den Rijn.

Sectional Appendix 1

Biopotential Logger Version 4, H. Luik and N. van ’t Wout,

30 November 2012

(11 pages)

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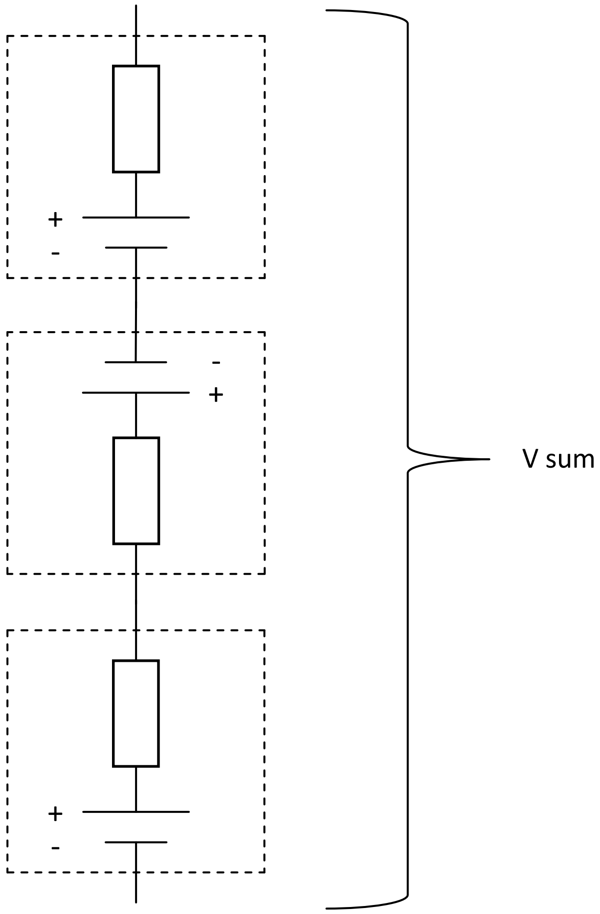
Introduction

The bio-potential logger version 4 is a logger that is special designed for the measurements of bio-potentials in trees. The main purpose for this logger is to monitor the DC potential in the bark of trees for a longer period of time when those trees are exposed to various levels of digital modulated high frequency electromagnetic fields.

We would like to emphasis the term DC (direct current) in this chapter. It is known that cells of trees generate electrical levels in the millivolt range due to the pump action of ions through the cell membrane.



The drawing on the left shows the mechanism how electrodes which are placed in the bark of a tree can pick up DC voltages reaching from several millivolts to hundreds of millivolts.

The drawing represent the electrical modeling of 3 cells of which 1 is connected in reversed mode. That means that cell voltages can add up but they can also subtract from each other.

This is a hypothesis on how the mechanism of adding and subtracting cell potentials work. We cannot proof that this is the reality.

Figure 1 Cell modeling

To summarize this chapter: The measurements done with the bio-potential logger version 4 are not about measuring high frequency signals picked up by the tree. The goal is to measure the DC bio-potential level changes due to the exposure of the tree to electromagnetic fields.

Electrodes

To be able to pick up these low level DC signals from the trees, various types of electrodes can be used. We selected a small flash-gold plated pin that is frequently used in the electronics industry. It is cheap and proved to deliver a constant quality signal over a long period of time.

These electrodes are pressed into the bark of the tree by means of a pair of pliers. The holes are not pre-drilled to make sure that there is a tight fit contact. There will be a chemical reaction between the fluid of the tree and the metal of the electrode, causing a voltage level. However, this reaction is of a fairly constant type and since it happens on both electrodes the nature of the differential measurement will cancel that voltage level out. We noted that for a good result it is essential that the pins are pressed into the bark under an angle of almost 180 degrees to ensure an large surface contact just under the bark.

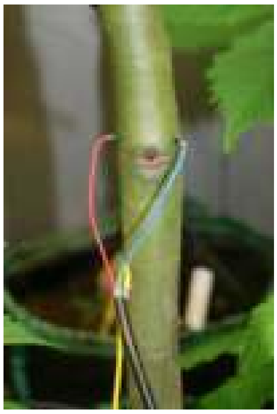


Figure 2 Flash-gold plated electrodes

Experience learned that the distance between the electrodes is not really critical.
2 to 10cm has always been sufficient to pick up the DC voltage levels.

Differential Measurements

Measuring bio-potentials is not new, the technology is known for decades. When measuring the electrical activity of the human heart (ECG) a differential amplifier is used to pick up the signals. Those signals are far more smaller than the type of signals we are after when measuring trees. Still, the mechanism is the same.

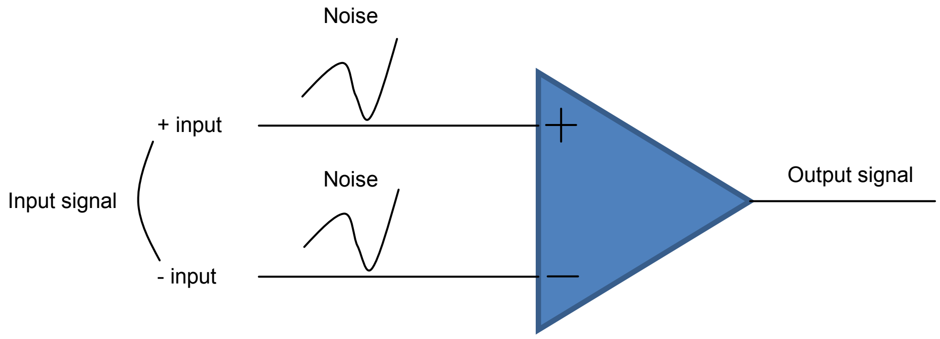


Figure 3 Principle of differential measurement

The drawing above shows the principle of differential measurement. Potentials that exists between the plus and min input of the amplifier cause a “difference” between the inputs. That potential is amplified. The noise signal coming from outside is present on both inputs and has the same phase. When the noise signals goes plus on the plus input it also goes plus on the min input. I.e. there is no difference and therefore the noise signal will be canceled out.

Even with differential measurements it is good practice to use wires of the same length, if possible twisted or locked up in the same shielding (microphone cable). The shielding must at least be grounded on the amplifier side of the circuit.

Very often the output of the amplifier is fed into an analog-to-digital converter (A/D) in order to translate the analog signal into numbers that can be handled by the computer.

A/D Conversion

In the bio-potential logger version 4, the stage of amplification is omitted, instead we use an A/D converter with differential inputs. The inputs consists of only two capacitors of 25pF. The impedance is very, very high and the load on the tree very low.

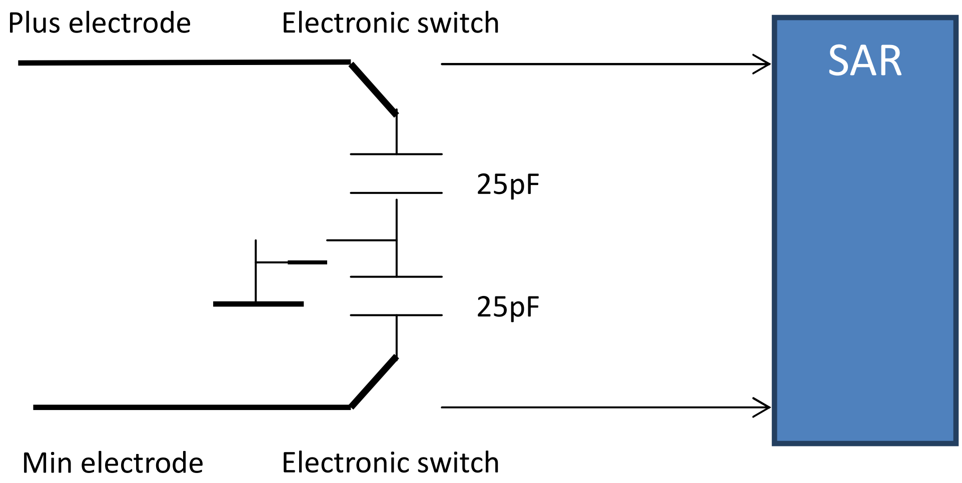


Figure 4 Sampling the signal

When the signal is sampled briefly, the electronic switch in the A/D converter is moved over and then the two capacitors in series represent a copy of the signal that will be converted in the Successive Approximation Register.

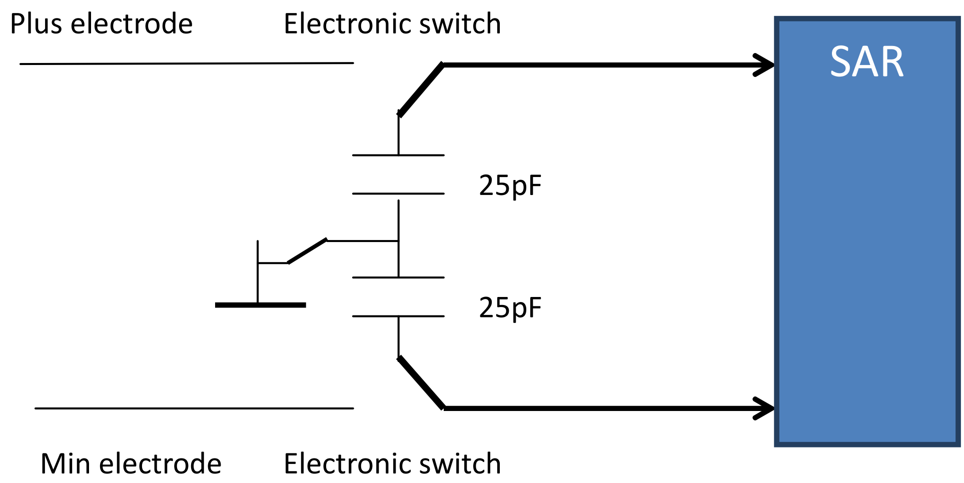


Figure 5 Converting the signal

Electrical Diagram

The used A/D converter is a 13 bits type. It can represent numbers from -4095 to +4096. With a reference voltage of 3.3V it equals a resolution of 0.805mV. The electrical diagram hereunder is the diagram of the bio-potential logger version 4.

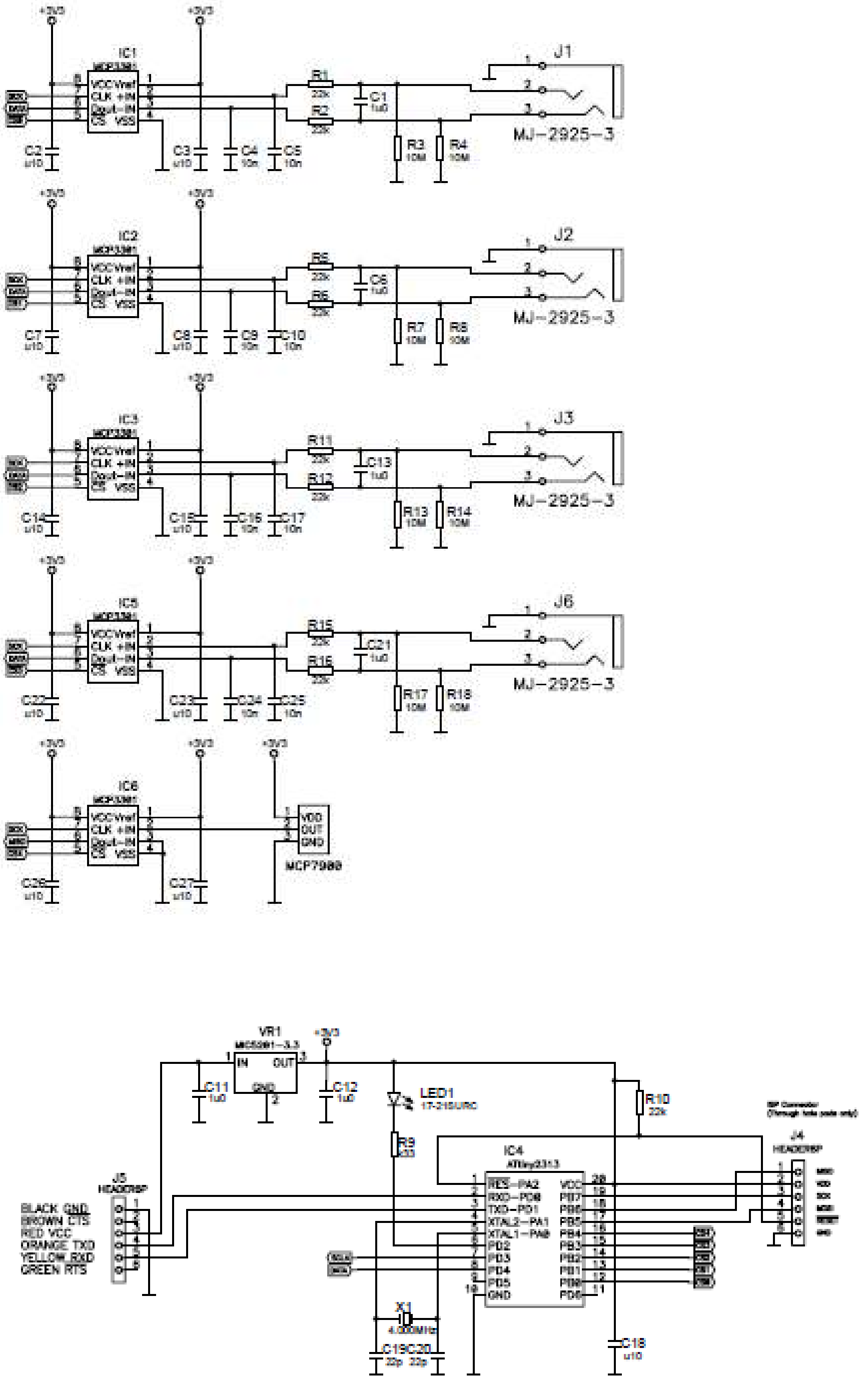


Figure 6 Bio-potential logger version 4 electric diagram

Filtering

The input signal must be absolutely cleared from high frequency signals. For that reason a very low pass RC filter is implemented.

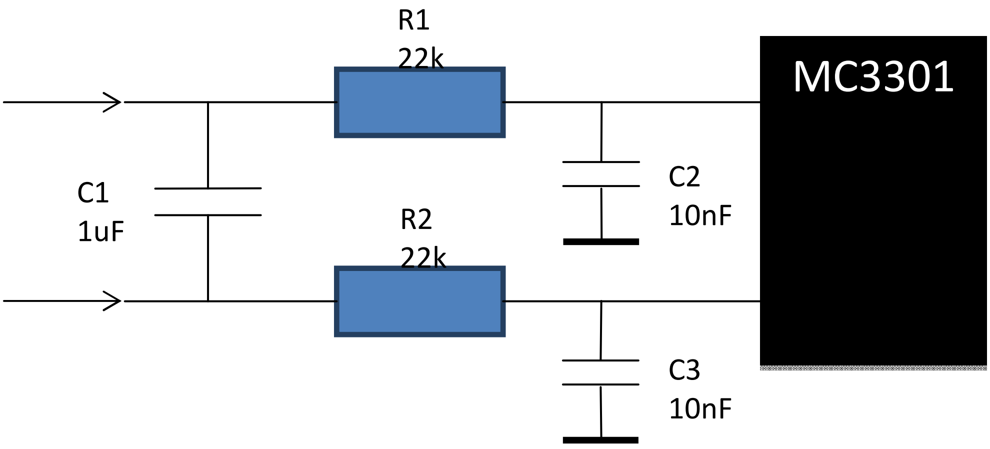


Figure 7 Input filtering

The differential input signal is first buffered and decoupled in C1.Together with the high impedance of the trees bark this capacitor forms a filter with a very low pass band. The -3dB points of the following R1/C2 and R2/C3 combination lies at 720Hz which is well below every radio frequency.

Datasheet Bio-potential logger 4

Number of inputs:	4
Processor:	ATtiny2313 2kB Flash 128 bytes SRAM
A/D Converter:	MC3301 13 bit with differential inputs
Serial connection:	RS-232 1200-8-n-1 to USB (with FTDI interface cable)
Power supply:	5V from USB connection
Current consumption:	< 50mA
Connectors:	6.3mm stereo jack
Cables:	>3m symmetric and shielded microphone cable
Electrodes:	Standard 1mm gold flash pin header
Enclosure:	Black PC-ABS standard "Hammond" box

Figure 8 Bio-potential logger version 4

Software

The picture in the previous chapter shows the bio-potential logger version 4. Two of these units were built and deployed under the 2011 - 2013 experiments at the Wageningen University. The units are connected via USB to a PC. USB is also providing the necessary power. A universal logger program was built to control the logger and store the data. It can be used for loggers with up to 7 sets of electrodes.

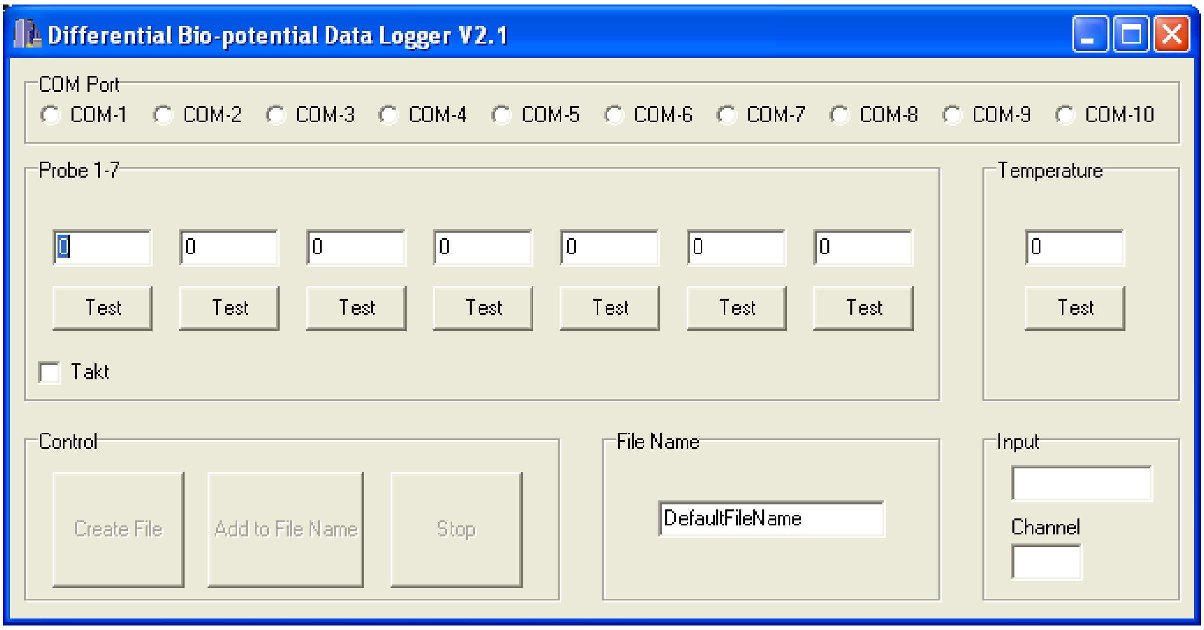


Figure9 PC logger program version 2.1

Origin of Measured Signals

We have built various types of loggers, experimented with different electrodes on different places in the tree bark. Over and over again we asked ourselves the same question: what are we measuring, is this really the bio-potential of the tree? We started out in 2006 and kept on experimenting during these years. With all these various types of loggers and electrodes we now dare to confirm: Yes, the signals we are measuring originate in the tree. We can clearly define day and night rhythms as well as temperature dependencies. We also saw the influence of pulsed high frequency electromagnetic signals.

To be absolutely sure that we are measuring the right thing we frequently ran a “dummy” measurement in a plane piece of timber wood along with our experiments. The next picture shows the outcome of such “dummy” measurements. It looks like there is happening a lot, however, it all happens on a scale from -1 to +5mV. That are 8 steps of the 8192 possible digital values of the A/D converter. I.e. this signal is within the noise and offset area of the system.

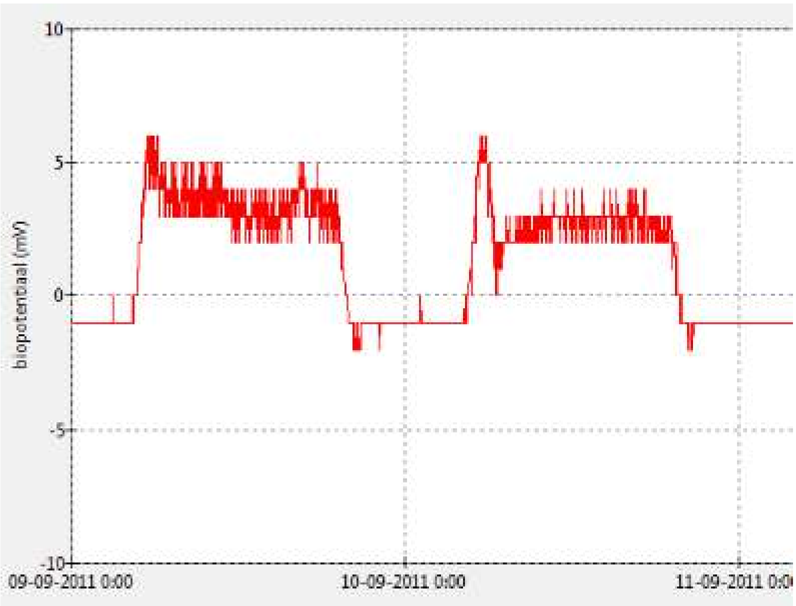


Figure 10 Measurements on plane timber wood with WiFi stations activated

Future Experiments

We only start understanding now how to measure bio-potentials in trees. We already think of better ways to log data with galvanic separated logging devices. This should cancel out noise from light sources that are picked up by the system. Although we clearly showed over and over again that pulsed high frequency signals cause "something" to happen in the bio-potential level of trees we realize that the work is still not finished…..

Conclusion

Since the start of our investigations back in 2006 we learned a lot about the interaction between electromagnetic fields and trees. Some things are still unclear but we learned that with a good setup and careful monitoring we can blindly tell by the outcome of our measurements if an electromagnetic field is switched on or off in a test cell.

Sectional Appendix 2

Electromagnetic Compatibility Test Report (12C01486RPT01),

test results of Biologger, model Biologger 4 ch. USB, D.A.R.E!! Consultancy

20 December 2012

(18 pages)

D.A.R.E!! Consultancy
Test & measurement services

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The Netherlands

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Fax +31 (0)348 430 645
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consultancy@dare.nl

Electromagnetic Compatibility Test Report

Test results of a Bio-logger, model Bio-logger 4 ch USB

Customer	:	Gemeente Alphen aan den Rijn Stadhuisplein 1 2405 SH Alphen aan den Rijn The Netherlands
Customer's representative	:	Mr. N. van 't Wout
In the capacity of	:	Intermediate
Reference number	:	12C01486RPT02
Status test report	:	Final

Test engineer:	Author:	Released:
G.C. Nobel Senior Test engineer	M.J. Rommen Administrative assistant	G.C. Nobel Senior Test engineer

1 Summary

A summary of the test results gained from testing the Bio-logger is shown in the table below.

	Standard	Class / level	Result (Pass/Fail)
Emission	EN 61326-1 (2006)	-	Not requested
Immunity	EN 61326-1 (2006)	Basic & Industrial	Pass, as far as tested
Test plan	Not available		

Note 1: The test results presented in this report relate only to the tested sample(s).

Note 2: The test results are based on the tested mode of operation(s), the applicable performance criteria and the acceptance criteria as described by the customer.

Note 3: At request of the customer, not all required tests as described in the standards are carried out.

This EMC test is performed at special request of the customer. The reason of this EMC test is to rule out, if the bio-logger is susceptible to HF signals like Wi-Fi routers (transmitting at 2,4 GHz).
To investigate this, a standard is chosen out of the EU list of harmonised standards that applies to this type of equipment. The Radiated immunity test of this standard is used to determine if the bio-logger is susceptible of this type of HF signals, or not.
To have a stable output signal of the bio-logger a series of worst case inputs “sensors” were used instead of a pant or tree.
The conclusion after this test is that even with a higher test level (10V/m) the bio-logger is not influenced during this EMC test in the frequency range from 80 MHz till 3000 MHz.

The following table displays an evaluation of the test results, which are carried out to the Bio-logger.

Test sequence	Test Description	Basic standard	EUT Modified during test (yes/no)	Result (Pass/Fail)
--	Conducted emission, test with a LISN	EN 55011 (2009) + A1 (2010)	--	NR
--	Radiated emission up to 1 GHz (SAC)	EN 55011 (2009) + A1 (2010)	--	NR
--	Harmonics	EN 61000-3-2 (2006) + A1 (2009) + A2 (2009)	--	NA
--	Flicker	EN 61000-3-3 (2008)	--	NA
--	ESD	EN 61000-4-2 (2009)	--	NR
1	Radiated Immunity	EN 61000-4-3 (2006) + A1 (2008) + A2 (2010)	No	Basic level: Pass (only one direction) Industrial level: Pass, as far as tested (only one direction)
--	EFT	EN 61000-4-4 (2004) + A1 (2010)	--	NR
--	Surge	EN 61000-4-5 (2006)	--	NR
--	Conducted Immunity	EN 61000-4-6 (2009)	--	NR
--	Voltage Dips and Interruptions[1]	EN 61000-4-11 (2004)	--	NA

[1] Tests are excluded from accreditation.

The table below shows details about tests that are not applicable.

Harmonics	The EUT is not AC supplied (powered by USB).
Flicker	The EUT is not AC supplied (powered by USB).
Voltage Dips and Voltage Variations	The EUT is not AC supplied (powered by USB).

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3 Introduction

At request of the Gemeente Alphen aan den Rijn, the objective of the test was to assess the Bio-logger in accordance with the standards as mentioned in chapter 5 of this report, within the framework of the CE marking process. This report is only to be used for this purpose.

At request of the Gemeente Alphen aan den Rijn, the EMC tests are carried out in order to find out whether the product complies with the harmonised European standards under the EMC Directive 2004/108/EC.

The test sample(s) were received on 2012 December, 20. Testing was performed on 2012 December, 20. The test report is issued on 2013 January, 30.

The tests are carried out at our facilities located in Woerden, The Netherlands.

The test results presented in this report relate only to the product tested.

In this report, the sample tested will be referred to as Equipment Under Test (EUT).

This report is in conformity with ISO 17025.

This report replaces the prior report with D.A.R.E!! Consultancy reference number 12C01486RPT01. The reason for replacing the report is at request of the customer; the customer information is changed, Industrial level is added to the summary in chapter 1 and the requirements in section 11.1.3, the test result of the Radiated Immunity test in the test results table of chapter 1 is updated, the rating frequency is changed in section 7.1, the sentence in section 8.1 is changed, and additional information is added to section 11.1.3. In section 1 additional information is added and the table with details about tests that are not applicable is added.

Opinions or interpretations mentioned in this report are excluded from accreditation.

All tests as described in the applied standard(s) are carried out, unless otherwise specified in this report.

4 Explanation Status Report

- Final : Formally signed report, with a final conclusion. Changes in the report will lead to a new report with a new report number.
- Preliminary : Intermediate unsigned report, with a temporary conclusion. Changes in the report will lead to a new report with a new report number.

5 Standards and test plan

The EUT is assessed against the following requirements.

- Emission : EN 61326-1 (2006)
- Immunity : EN 61326-1 (2006)
- Test plan : Not available

If available, a test plan is used as a supplement.

5.1 Test plan deviations

Not applicable.

5.2 Basic standards

In deviation to the product standards, the latest versions of the basic standards are applied.

6 Measurement Uncertainties

The reported expanded uncertainty of measurement is based on a standard uncertainty of measurement multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%, but excluding the contribution of the EUT. The expanded uncertainty of measurement has been determined in accordance with UKAS publication LAB34.

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7 EUT details

7.1 EUT

The condition of the EUT during reception was undamaged and fully functional.
The details for the EUT supplied for test were as follows.

Description	Sample
Name	Bio-logger
Description	Data logger
Manufacturer	ElektroLuik
Brand	ElektroLuik
Model number	Bio-logger 4 ch USB
Serial number	0011001 & 0011002
Rating voltage	5V DC (by USB)
Rating power	Unknown
Rating amperage	Unknown
Rating frequency	Not applicable
Software release	Not applicable
Hardware release	Unknown
Environment to be used	Laboratory
System description	-

7.2 Cabling

The cable connections to EUT and peripheral equipment during testing are displayed in the table below.

Description	Port Type	Type Of Cable	Cable Length	Fixing shield	Load at port
USB cable	I/O Communication	Shielded	5m	Both sides	Notebook PC
Sensor cable 1	I/O Communication	Shielded	5m	EUT side	Loop antenna
Sensor cable 2	I/O Communication	Shielded	5m	EUT side	Floating
Sensor cable 3	I/O Communication	Shielded	5m	EUT side	1M Ohm load
Sensor cable 4	I/O Communication	Unshielded	30cm	Not applicable	100mV DC source

The highest generated or used frequency of the EUT is Not applicable.
According the information of the customer, the class of emission is B.

The applicable performance criterion for each immunity test depends on the type of operation of the product: Continuous unmonitored operation.

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8 Operating conditions during test

8.1 Test considerations

Two EUT's were tested at the same time and consists out of identical cables and sensors. The EUT with serial number 011001 ferrite cores are applied on the sensor cables at the site of the EUT.

8.2 Mode(s) of operation

The test mode(s) during testing were defined as:

Mode of operation	Description
Mode 1	Logging mode, taking every 5 seconds a sample.
Mode 2	Not applicable
Mode 3	Not applicable
Mode 4	Not applicable

8.3 Acceptance criteria

The criteria for recording a malfunction of operating during the immunity tests are shown in the table below.

Acceptance criterion	Description
Mode 1	Performance criterion A: maximum deviation 5mV.
Mode 2	Not applicable
Mode 3	Not applicable
Mode 4	Not applicable

The applicant's representative was present to witness the testing.

8.4 Test configuration

The EUT is tested as Table top equipment. The Appendixes of this report show pictures of the test configuration during the tests.

9 Possible test case verdicts

• NA or not applicable	:	test does not apply to the EUT
• P(ass)	:	EUT does meet the requirement
• F(ail)	:	EUT does not meet the requirement
• U(ndetermined)	:	Pass or Fail could not be established
• NR or not requested	:	test is not requested by customer

Pass or fail statements exclude the measurement uncertainty.

10 Test equipment

The instruments used to perform the tests are displayed in the Appendix.

11 Test results

11.1 Radiated Immunity

11.1.1 Test method

The radiated immunity tests are carried out in a full anechoic room, in accordance with the applied standard(s) (see chapter 5) and the basic standard EN 61000-4-3 (2006) + A1 (2008) + A2 (2010), where the first standard takes precedence.

11.1.2 Measurement Uncertainty

The measurement uncertainty during testing is displayed in the table below.

Frequency	U
26 MHz – 4 GHz	± 2.4 dB

11.1.3 Requirements

The requirements are laid down in the table below.

Basic requirements:

Frequency	Antenna polarization	Test level	Performance Criterion
80 MHz – 1 GHz	Horizontal	3 V/m	A
80 MHz – 1 GHz	Vertical	3 V/m	A
1,4 GHz – 2 GHz	Horizontal	3 V/m	A
1,4 GHz – 2 GHz	Vertical	3 V/m	A
2 GHz – 2,7 GHz	Horizontal	1 V/m	A
2 GHz – 2,7 GHz	Vertical	1 V/m	A

Industrial requirements:

Frequency	Antenna polarization	Test level	Applied test level	Performance Criterion
80 MHz – 1 GHz	Horizontal	10 V/m	10 V/m	A
80 MHz – 1 GHz	Vertical	10 V/m	-	A
1,4 GHz – 2 GHz	Horizontal	3 V/m	10 V/m	A
1,4 GHz – 2 GHz	Vertical	3 V/m	10 V/m	A
2 GHz – 2,7 GHz	Horizontal	1 V/m	10 V/m	A
2 GHz – 2,7 GHz	Vertical	1 V/m	10 V/m	A

At request of the customer the test level is increased to 10V/m at some frequency bands. Beside the higher test level also the test frequency is increased from 1 – 3 GHz instead of 1,4 – 2,7 GHz.

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Test Results of Radiated Immunity test 80 MHz to 1000 MHz Vertical

PIN number	12C01486
Test ID	1
Mode of operation	Mode 1
Angle, observation and result	Pass, within specifications

Settings

Frequency step	logarithmic step of 1%	Modulation	1000 Hz. 80% AM
Dwell time	5 s	Test level	3 V/m
Distance	3 m		

Test Results of Radiated Immunity test 80 MHz to 1000 MHz Horizontal

PIN number	12C01486
Test ID	2
Mode of operation	Mode 1
Angle, observation and result	Pass, within specifications

Settings

Frequency step	logarithmic step of 1%	Modulation	1000 Hz. 80% AM
Dwell time	5 s	Test level	3 V/m
Distance	3 m		

Test Results of Radiated Immunity test 80 MHz to 1000 MHz Horizontal

PIN number	12C01486
Test ID	9
Mode of operation	Mode 1 - 10V/m
Angle, observation and result	Pass, within specifications

Settings

Frequency step	logarithmic step of 1%	Modulation	1000 Hz. 80% AM
Dwell time	5 s	Test level	10 V/m
Distance	3 m		

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Test Results of Radiated Immunity test 1000 MHz to 3 GHz Vertical

PIN number	12C01486
Test ID	3
Mode of operation	Mode 1
Angle, observation and result	Pass, within specifications

Settings

Frequency step	logarithmic step of 1%	Modulation	1000 Hz. 80% AM
Dwell time	5 s	Test level	3 V/m
Distance	3 m		

Test Results of Radiated Immunity test 1000 MHz to 3 GHz Horizontal

PIN number	12C01486
Test ID	4
Mode of operation	Mode 1
Angle, observation and result	Pass, within specifications

Settings

Frequency step	logarithmic step of 1%	Modulation	1000 Hz. 80% AM
Dwell time	5 s	Test level	3 V/m
Distance	3 m		

Test Results of Radiated Immunity test 1000 MHz to 2 GHz Vertical

PIN number	12C01486
Test ID	7
Mode of operation	Mode 1 - 10V/m
Angle, observation and result	Pass, within specifications

Settings

Frequency step	logarithmic step of 1%	Modulation	1000 Hz. 80% AM
Dwell time	5 s	Test level	10 V/m
Distance	3 m		

Test Results of Radiated Immunity test 1000 MHz to 2 GHz Horizontal

PIN number	12C01486
Test ID	5
Mode of operation	Mode 1 - 10V/m
Angle, observation and result	Pass, within specifications

Settings

Frequency step	logarithmic step of 1%	Modulation	1000 Hz. 80% AM
Dwell time	5 s	Test level	10 V/m
Distance	3 m		

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Test Results of Radiated Immunity test 2 GHz to 3 GHz Vertical

PIN number	12C01486
Test ID	8
Mode of operation	Mode 1 - 10V/m
Angle, observation and result	Pass, within specifications

Settings

Frequency step	logarithmic step of 1%	Modulation	1000 Hz. 80% AM
Dwell time	5 s	Test level	10 V/m
Distance	3 m		

Test Results of Radiated Immunity test 2 GHz to 3 GHz Horizontal

PIN number	12C01486
Test ID	6
Mode of operation	Mode 1 - 10V/m
Angle, observation and result	Pass, within specifications

Settings

Frequency step	logarithmic step of 1%	Modulation	1000 Hz. 80% AM
Dwell time	5 s	Test level	10 V/m
Distance	3 m		

12 Conclusion

As far as tested the Bio-logger meets the basic immunity levels as described in EN 61326-1 (2006). This is based on the tested mode of operation(s), the applicable performance criteria and the acceptance criteria as described by the customer.

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13 Appendix A: General performance criteria

The general principles (performance criteria) for the evaluation of the immunity test results are the following.

Performance criterion A
During testing, normal performance within the specification limits.

Example 1
If electronic equipment is required to work with high reliability, the EUT shall operate without any apparent degradation from the manufacturer's specification.

Performance criterion B
During testing, temporary degradation, or loss of function or performance which is selfrecovering.

Example 1
A data transfer is controlled/checked by parity check or by other means. In the case of malfunctioning, such as caused by a lightning strike, the data transfer will be repeated automatically. The reduced data transfer rate at this time is acceptable.

Example 2
During testing, an analogue function value may deviate. After the test, the deviation vanishes.

Example 3
In the case of a monitor used only for man-machine monitoring, it is acceptable that some degradation takes place for a short time, such as flashes during the burst application.

Performance criterion C
During testing, temporary degradation, or loss of function or performance which requires operator intervention or system reset occurs.

Example 1
In the case of an interruption in the mains longer than the specified buffer time, the power supply unit of the equipment is switched off. The switch-on may be automatic or carried out by the operator.

Example 2
After a program interruption caused by a disturbance, the processor functions of the equipment stops at a defined position and is not left in a "crashed state". The operator's decision prompts may be necessary.

Example 3
The test results in an opening of an over-current protection device that is replaced or reset by the operator.

14 Appendix B: Pictures of EUT

Picture 1: EUT identification label

Picture 2: Radiated immunity (1)


Picture 3: Radiated immunity (2)

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15 Appendix C: Equipment List

Radiated Immunity 80 MHz to 1000 MHz

Device Type	Brand	Type	ID
Amplifier	Prana	AP32MT215	1347
Field sensor 1	D.A.R.E!! Development	RadiSense IV	1349
Signal generator	Rohde & Schwarz	SME 03	1470
Antenna	EMCO	3142	1147
Coupler	Prana	AP32MT215 Coupler	1347
Forward power meter	D.A.R.E!! Development	RPR1018A + RPR1006A	1576/1458
Reflected power meter	D.A.R.E!! Development	RPR1018A + RPR1006A	1576/1459
Cable SG -> amplifier	D.A.R.E!! Development	-	1243
Cable coupler -> antenna	D.A.R.E!! Development	-	1274
Antenna tower	D.A.R.E!! Development	-	1364

Radiated Immunity 1 GHz to 3 GHz

Device Type	Brand	Type	ID
Amplifier	Amplifier Research	25S1G4	1163
Field sensor 1	D.A.R.E!! Development	RadiSense IV	1349
Signal generator	Rohde & Schwarz	SME 03	1470
Antenna	EMCO	3115	1155
Coupler	Narda + Bird	3042B-10 + 10-18A MFN-30	1129+1551
Forward power meter	D.A.R.E!! Development	RPR1018A + RPR1006A	1576/1458
Reflected power meter	D.A.R.E!! Development	RPR1018A + RPR1006A	1576/1459
Cable SG -> amplifier	D.A.R.E!! Development	-	1243
Cable coupler -> antenna	D.A.R.E!! Development	-	1274
Antenna tower	D.A.R.E!! Development	-	1364

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Sectional Appendix 3

Susceptibility test of a DC data logger, Canrinus Consultancy,

5 December 2011

(6 pages)

Susceptibility test of a DC voltage data logger.

This test was performed on December 5, 2011 at Wageningen University and Research (WUR), Radix West, Climate chamber C8.

General information:

The DC data logger is used to log the DC voltage of several trees. The four inputs of the logger are connected to gold plated pins by means of a shielded cable. The shield is only connected at the side of the logger.
Two golden pins are placed in the stem of the tree and connected to the shielded cable.
Goal of this test is to investigate the DC recording under influences of electromagnetic fields. The magnetic fields are generated from Wifi routers and the electronic ballast of fluorescent tubes. The light of the fluorescent tubes is used for generating daylight in the climatic chamber.
Input 1 and 3 are used to perform the susceptibility test. Input 1 is connected to an Ash tree 1 (photo 1) and input 3 is connected to a conductive loop (photo 2). The conductive loop is made out of a solid copper wire with at the end a connector. The dimension of the loop is proximally 20 x 15 cm. To stabilize the loop it is placed on wooden sticks (photo 2). Input 2 is connected to Ash tree 2 and input 4 to a Horse chestnut tree.

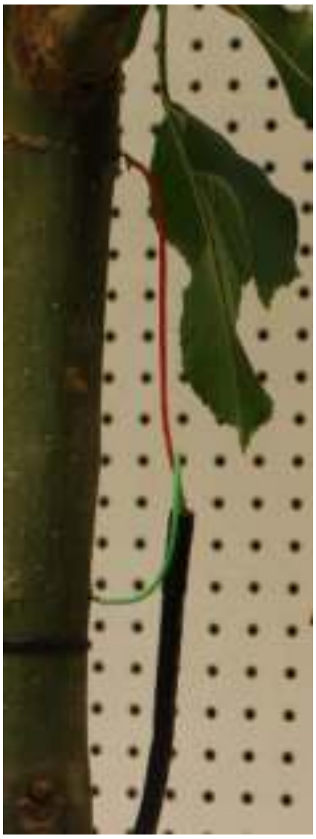


Photo 1: At the right of the tree input 1 is connected to the gold plated pins.

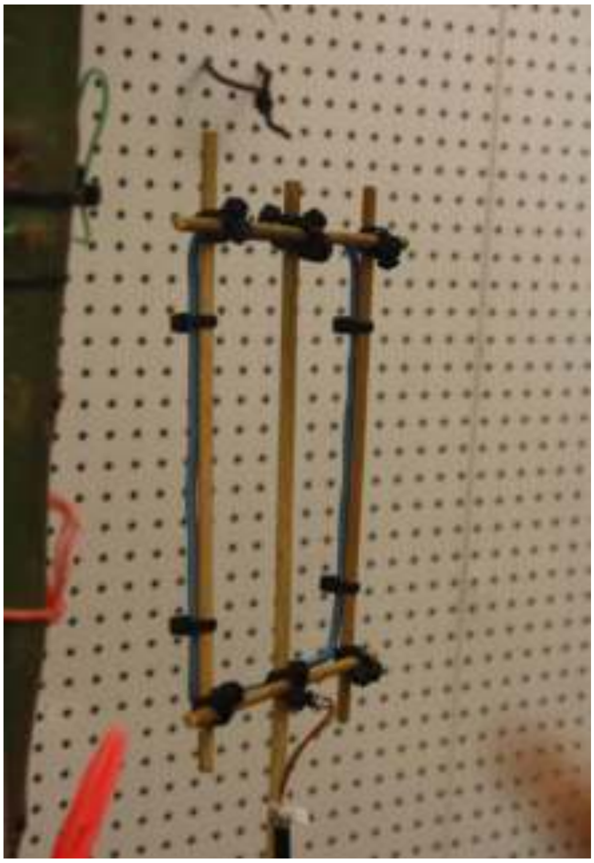
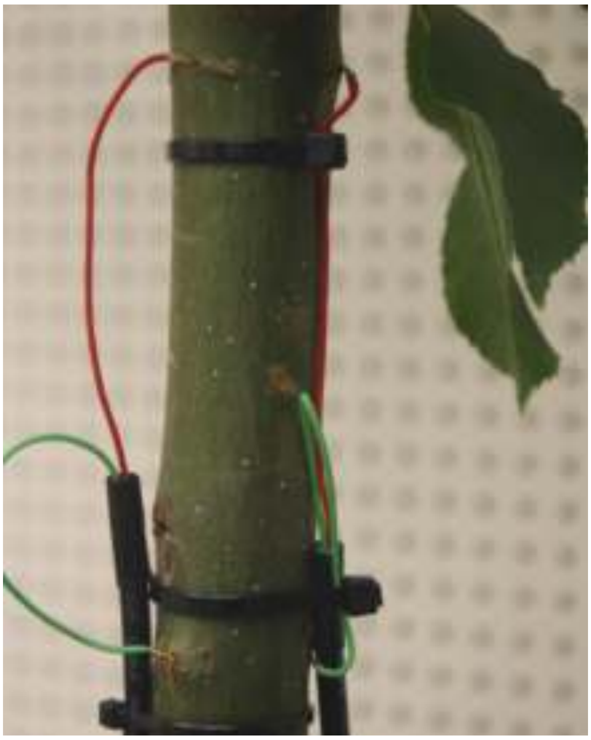


Photo 2: De conductive loop, input 3.



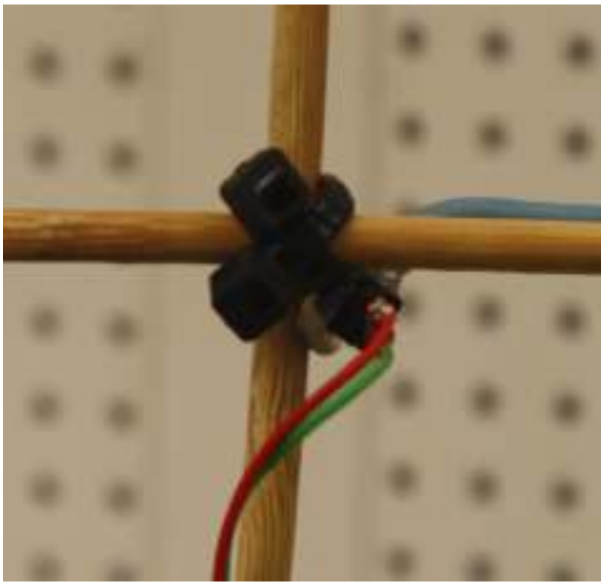


Photo 3: the reduced connection at the tree (right side of the tree)

Photo 4: shorted conductive loop

Test set-up:

A loop of conductive material (solid copper or parts of a wire and a conductive part of a tree) is a receiving antenna if it is placed in a electromagnetic field (this is a combination of electric and magnetic fields for low and high frequencies).

To be sure that this physical law is not disturbing the DC measurements and outcome of the bio potential voltage out of the tree the following test were performed:

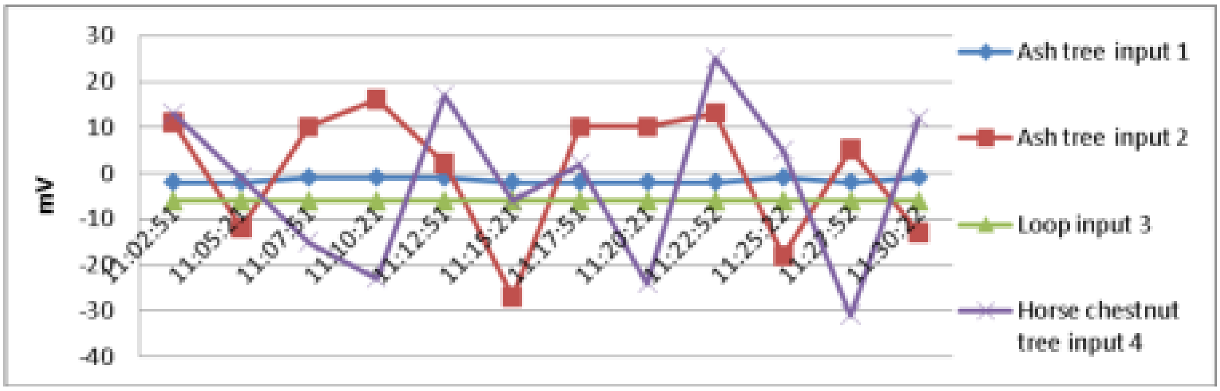
a) Measuring the DC voltages of all four input channels with Wifi and lights on for 30 minutes.
b) Switching off all 6 Wifi routers and keep the lights on and record the next 30 minutes.
c) Switching off all 6 Wifi routers and switching off the light and record 30 minutes.

After that, the loop area on the tree was reduced in size by placing tire wraps around the tree and the wires (Photo 3 right-hand side), and the solid copper loop was shorted at the connector (Photo 4 lower side):

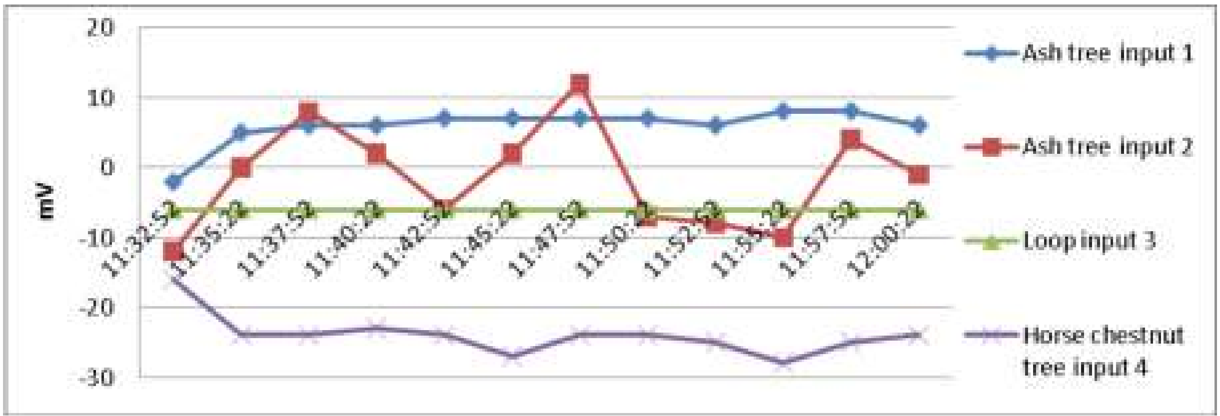
d) Measuring the DC voltages of all four input channels with Wifi and lights on for 30 minutes.
e) Switching off all 6 Wifi routers and keep the lights on and record the next 30 minutes.
f) Switching off all 6 Wifi routers and switching off the light and record 30 minutes.

The measuring results will have the same identification of plot a to f.

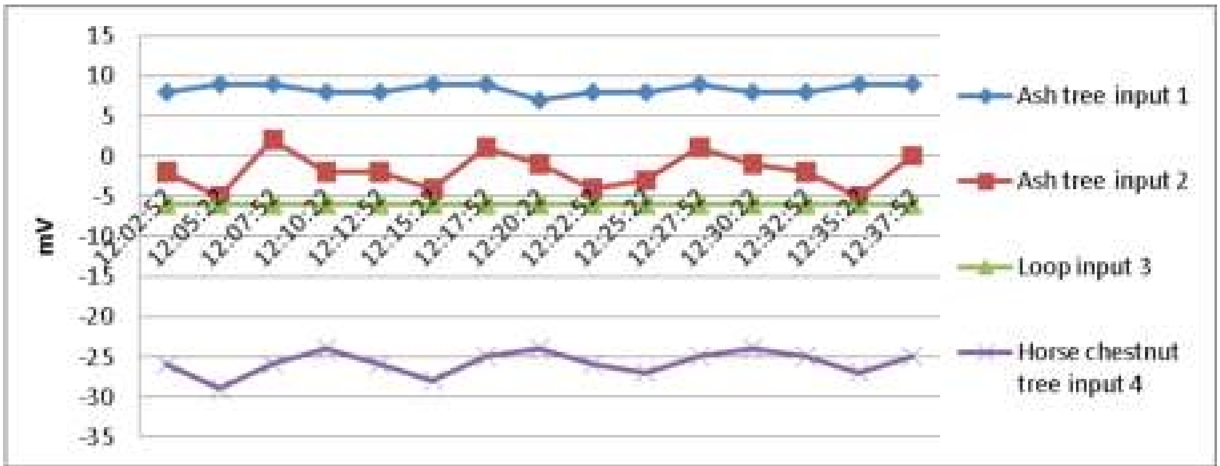
The 30 minutes of DC measuring values are calculated in Excel and the plots are in the table below with the corresponding letters.



Plot a: Wifi on and light on

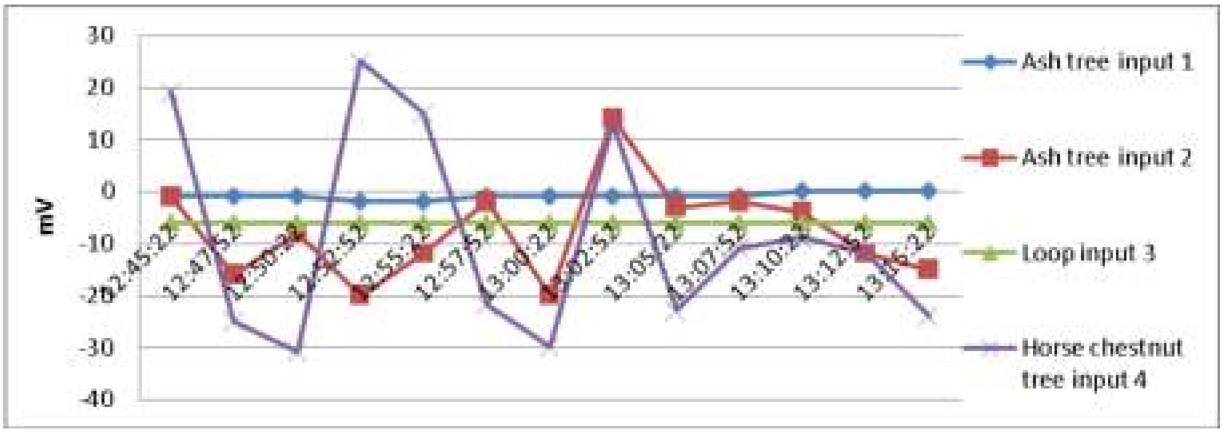


Plot b : Wifi off and light on

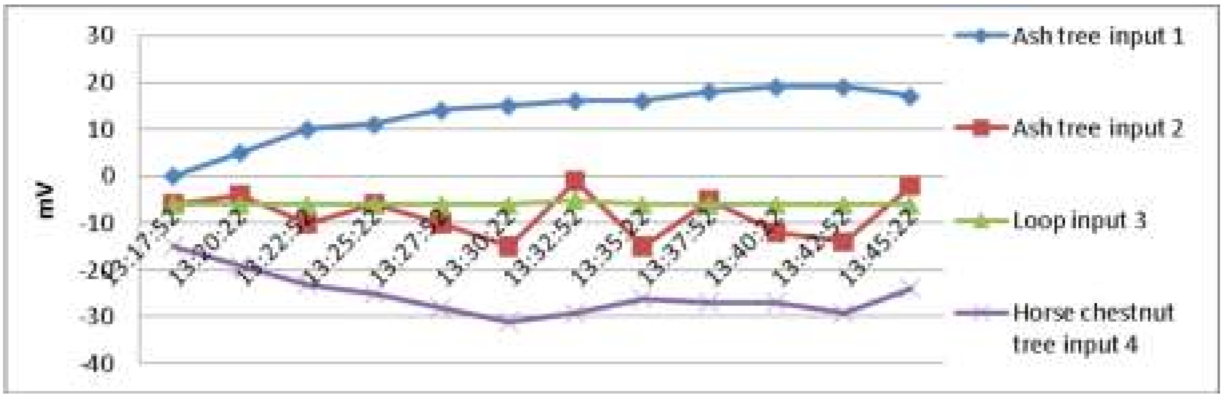


Plot c: Wifi and light off

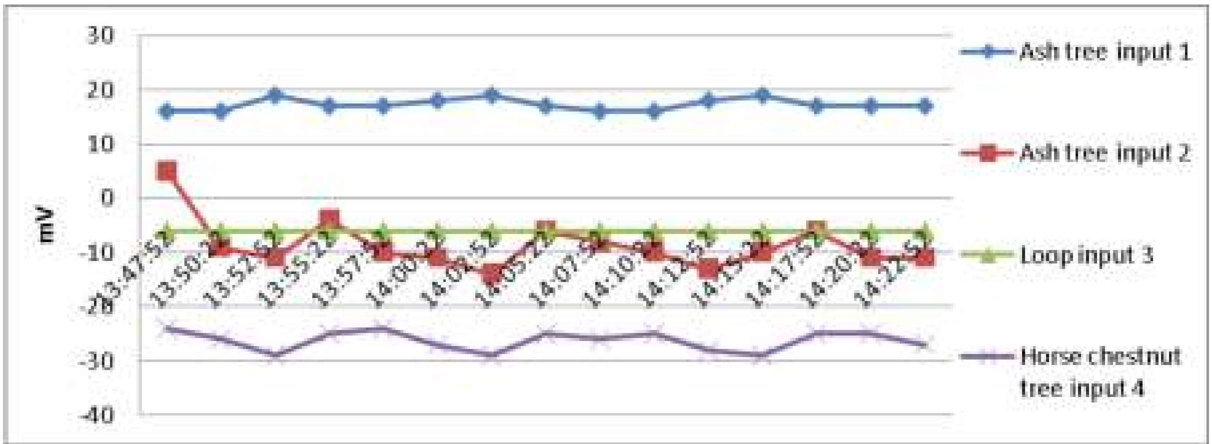
Loop area on the Ash tree (input 1) is made smaller by placing tire wraps around the tree and the wires. The solid cooper loop (input 3) is shorted at the connector.



Plot d : Wifi on and light on.



Plot e: Wifi off and light on



Plot f: Wifi off and light off

Conclusion:

The voltage change of input 1 (Ash tree 1) showed that there is an opposite influence on the the bio potential, the DC value of the Ash tree: If the Wifi routers are switched on, there is almost no voltage measured in Ash ,1and if the Wifi routers are switched off, the voltage is increasing up to 20 mV.

By turning off the Wifi and light, it seems that the voltage of Ash tree 2 (input 2) and the Horse chestnut tree (input 4) is more flattened than when the Wifi and light is on. It seems that beside the light, as we expected, Wifi has influence on the DC value of the plant.
According to the measurement results of plot a to f, there is no change of the measured voltage with a large loop area (input 3).
The measurements with a smaller loop area of plot d on the Ash tree (input 1) also didn't show any change of the measured voltage compared with the measurements of plot a.
Therefore the conclusion can be made that the DC voltage measurements of the data logger is not interfered by the electromagnetic field of the Wifi routers and the electronic ballast of the fluorescent tubes. However the DC value generated in the tree stems seem to be interfered by the generated external electromagnetic fields.

Photo 3: Test set up of the pins in de tree (left) and the loop at the right.

Photo 4: Overall set-up in the climate chamber including the Wifi routers and the antenna's

Sectional Appendix 4

EMF measurements on trees in Wageningen University climate chambers in 2011,

Canrinus Consultancy, 19 and 20 July 2011

(17 pages)

Electromagnetic fields (EMF) in het climate chambers C8, A1 end A2 at the WUR.

Measurements performed on 19 and 20 June 2011.

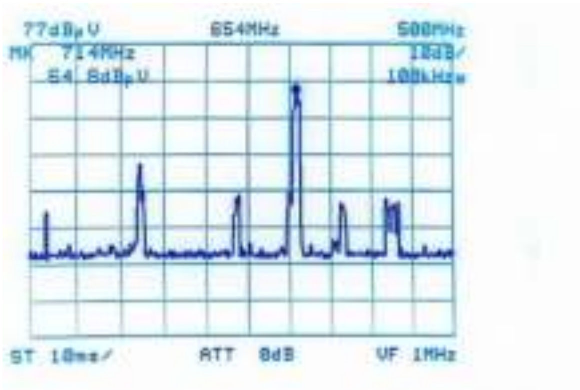
During the preparation of the EMF measurements (DVB-T, WiFi and UMTS signals) fixed antenna positions in the climate chambers are chosen. The three fixed positions are made to perform a good as possible measurement (free space around the antenna). Due to the vertical polarized transmit antennas the receiving antenna are also vertical polarized.

At 3,5 meter distance at the front of climate chamber C8 the first reference emission measurements were performed. Three divered types of antennas were used: Log. Per. (30 – 1000 MHz), Log. Per. PCB (800 – 3000 MHz) and a WiFi antenna (2400 MHz) same that is used as transmit antenna inside the climate chamber C8.

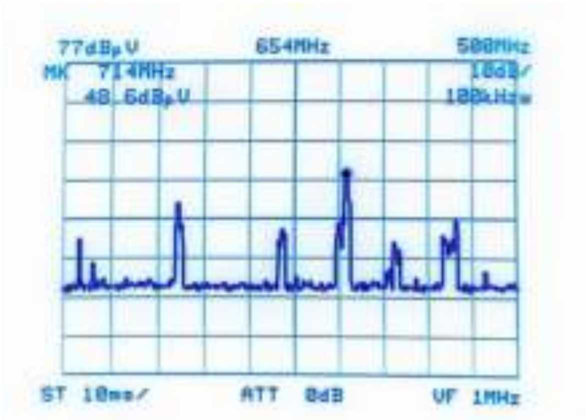
An overview of the measurement results are displayed in the table below. The corresponded frequency plots are laid down after this table. The EMF strength is calculated to V/m including the antenna factor and coax cable losses.

Plot	antenna	DVB-T V/m	GSM 900 V/m	GSM 1800 V/m	UMTS V/m	Wifi V/m	Remarks
1	Log. Per.	0.0331	--	--	--	--	714 MHz, output at set point 8
2	Log. Per.	0.0052	--	--	--	--	714 MHz, output at set point 1
3	Log. Per.	--	0.0083	--	--	--	927 MHz
4	Log. Per.	--	--	0.0023	--	--	1837 MHz
5	Log. Per.	--	--	--	0.0148	--	1933 MHz
6	Log. Per.	--	--	--	--	0.1462	2427 MHz
7	Wifi ant.	--	--	--	--	0.0732	2465 MHz
8	PCB ant.	--	--	--	--	0.1462	2464 MHz
9	PCB ant.	0.0014	--	--	--	--	709 MHz, out of frequency range
10	PCB ant.	--	0.0059	--	--	--	927 MHz
11	PCB ant.	--	--	0.0021	--	--	1836 MHz
12	PCB ant.	--	--	--	0.0023	--	1933 MHz

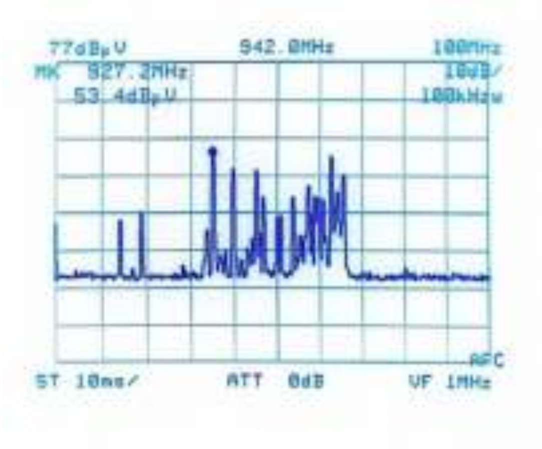
Plot 1



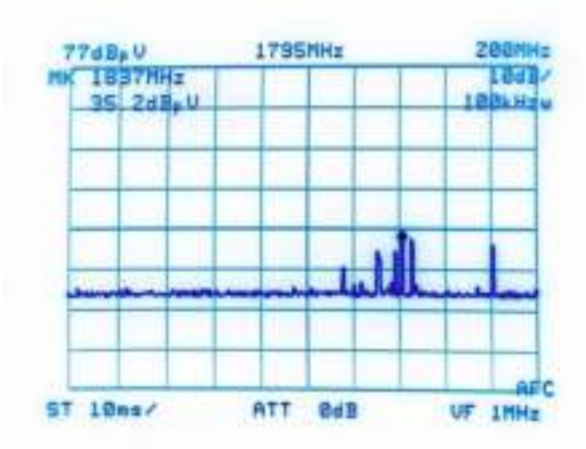
Plot 2



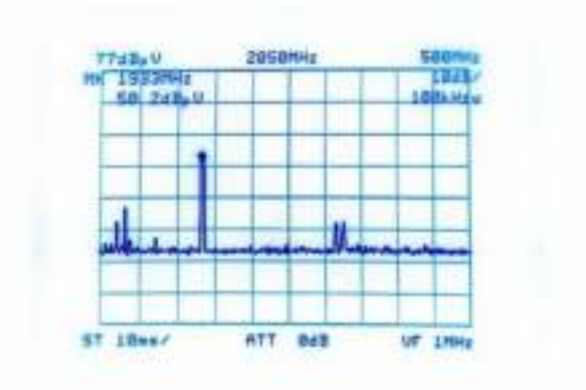
Plot 3



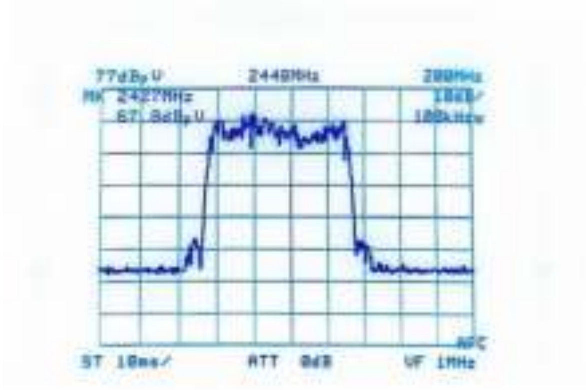
Plot 4



Plot 5

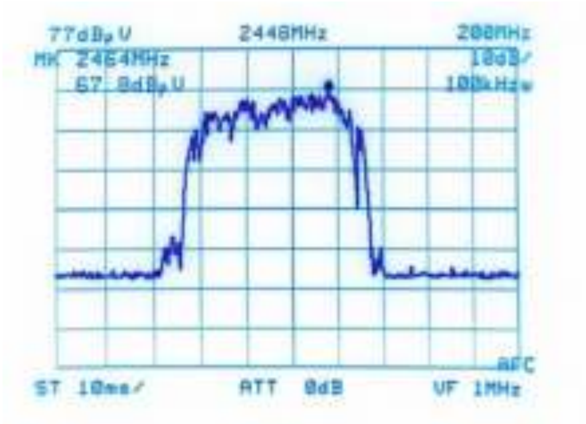


Plot 6

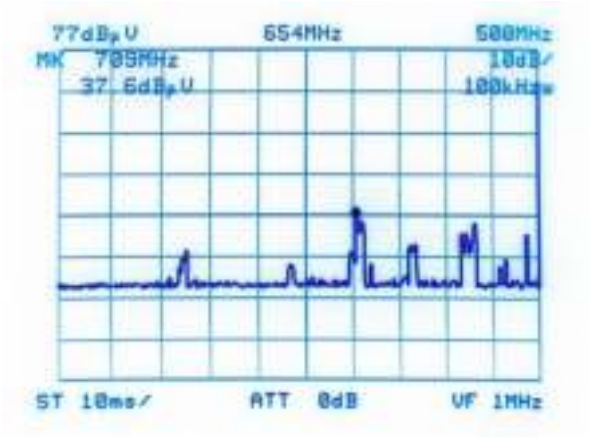


Plot 7

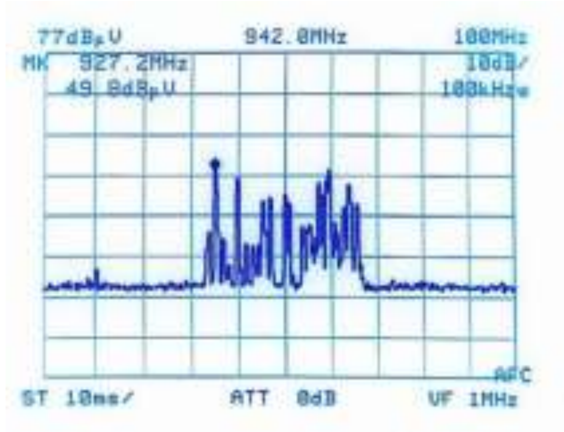
Plot 8



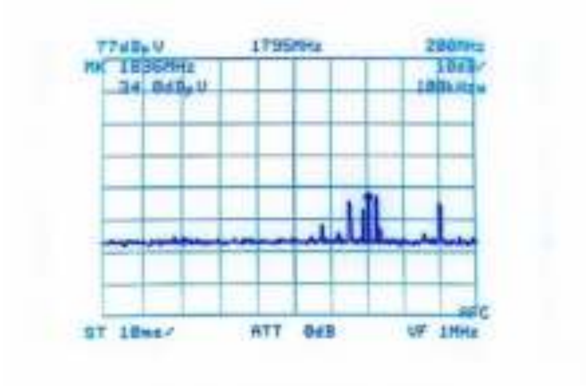
Plot 9



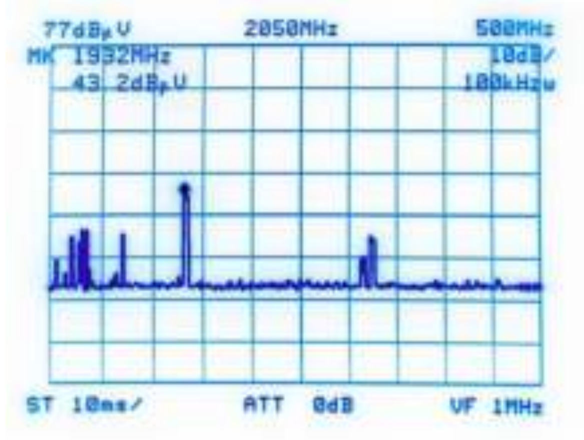
Plot 10



Plot 11



Plot 12



During the first measurements of the DVB-T signals inside the climate chamber the log.per. antenna (30 – 1000 MHz) was in contact with the leafs of the trees. (see picture at the right)

Due to this the measurements are not reproducible and incorrect because there is not enough free space around the antenna.

The measured signal with the standard WiFi antenna (plot 7) is lower because the antenna factor (2 dBi) is lower than both log. per. antennas (6 dBi). Both log. per. antennas have the same measurement result.

Due to the fact that the measurement results of the big log. per. antenna (30 – 1000 MHz) is almost the same (max. 1 dB difference at 714 MHz) than the smaller log. per. PCB antenna (800-3000 MHz).
Because the log. per. PCB is smaller and overall the best frequency range for this measurements, this antenna is used during the rest of the measurements.
The overall antenna factor of 6 dBi is also used around of the DVB-T signal at 714 MHz to calculated the signal to V/m.

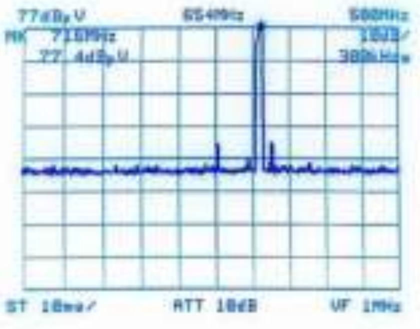
An overview of the measurement inside climate chamber C8 are displayed in the table below. The corresponded frequency plots are laid down after this table.

Plot	Location	DVB-T V/m	GSM 900 V/m	GSM 1800 V/m	UMTS V/m	WiFi V/m	Remarks
13	Door	0.1318	--	--	--	--	716 MHz
14	Centre	0.0468	--	--	--	--	714 MHz
15	Rear	0.0525	--	--	--	--	714 MHz
16	Door	--	0.0007	--	--	--	958 MHz
17	Centre	--	0.0010	--	--	--	927 MHz
18	Rear	--	0.0005	--	--	--	950 MHz
19	Door	--	--	0.0004	--	--	Ruis
20	Centre	--	--	0.0005	--	--	Ruis
21	Rear	--	--	0.0004	--	--	Ruis
22	Door	--	--	--	0.0933	--	1935 MHz
23	Centre	--	--	--	0.2344	--	1934 MHz
24	Rear	--	--	--	0.0832	--	1935 MHz
25	Door	--	--	--	--	0.1303	2440 MHz
26	Centre	--	--	--	--	0.1161	2473 MHz
27	Rear	--	--	--	--	0.1641	2423 MHz

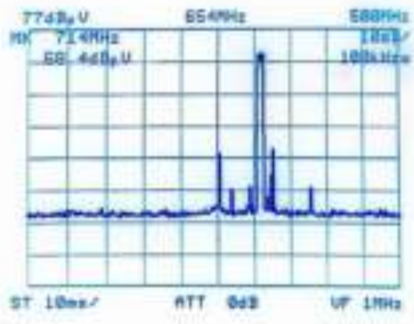
Set -up in C8

Set -up in C8

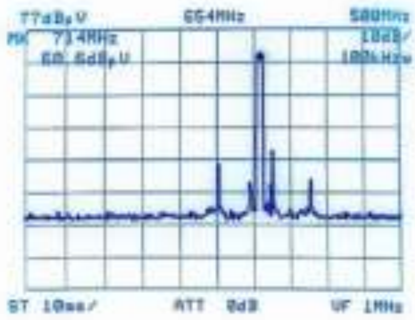
Plot 13



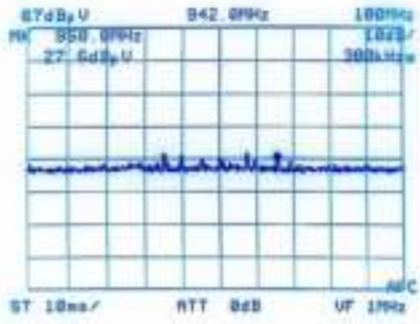
Plot 14



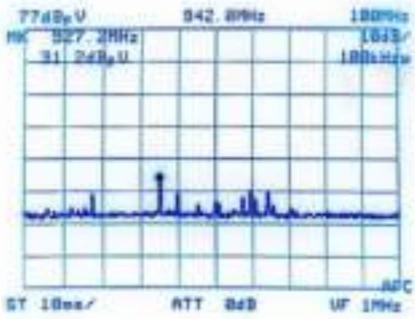
Plot 15



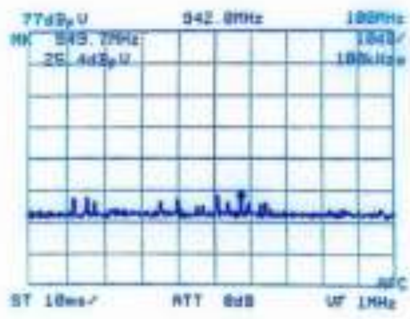
Plot 16



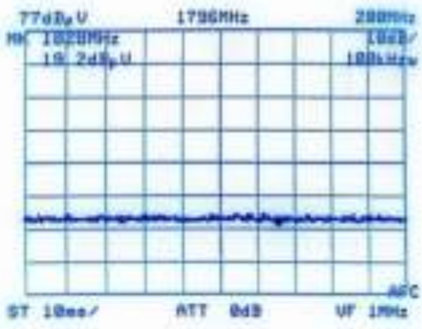
Plot 17



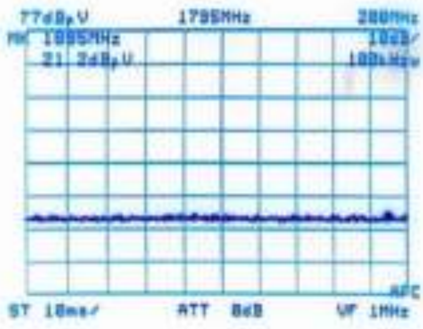
Plot 18



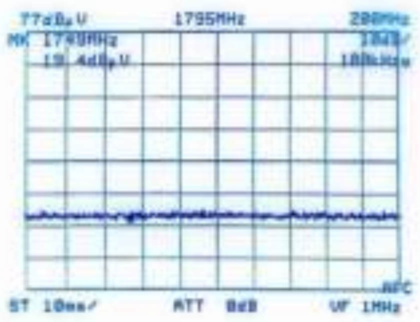
Plot 19



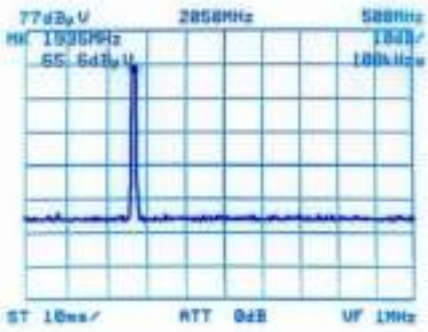
Plot 20



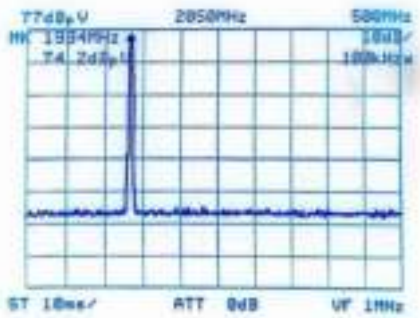
Plot 21



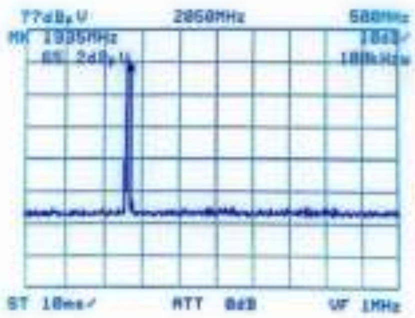
Plot 22



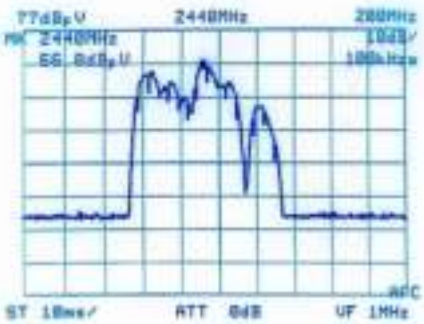
Plot 23



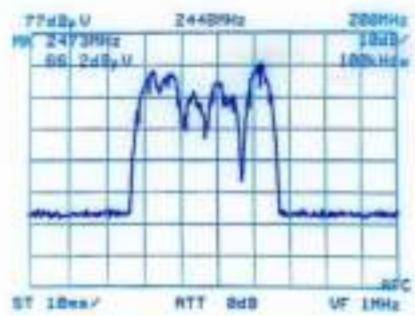
Plot 24



Plot 25



Plot 26



Plot 27

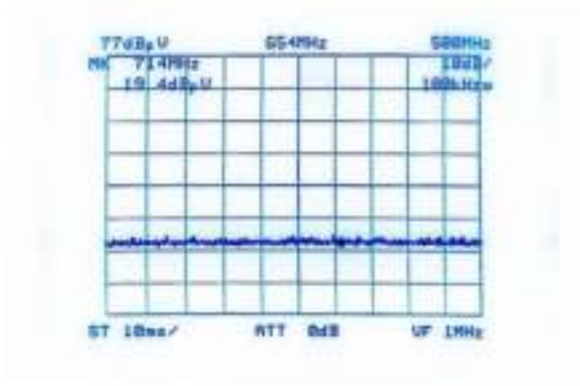
An overview of the measurement inside climate chamber A1 are displayed in the table below. The corresponded frequency plots are laid down after this table.

Plot	Location	DVB-T V/m	GSM 900 V/m	GSM 1800 V/m	UMTS V/m	WiFi V/m	Remarks
28	Door	0.0002	--	--	--	--	Noise
29	Centre	0.0002	--	--	--	--	Noise
30	Rear	0.0002	--	--	--	--	Noise
31	Door	--	0.0005	--	--	--	926 MHz
32	Centre	--	0.0008	--	--	--	926 MHz
33	Rear	--	0.0005	--	--	--	928 MHz
34	Door	--	--	0.0005	--	--	Noise
35	Centre	--	--	0.0005	--	--	Noise
36	Rear	--	--	0.0006	--	--	Noise
37	Door	--	--	--	0.0007	--	Noise
38	Centre	--	--	--	0.0006	--	Noise
39	Rear	--	--	--	0.0006	--	Noise
40	Door	--	--	--	--	0.0013	2452 MHz
41	Centre	--	--	--	--	0.0016	2453 MHz
42	Rear	--	--	--	--	0.0010	2473 MHz

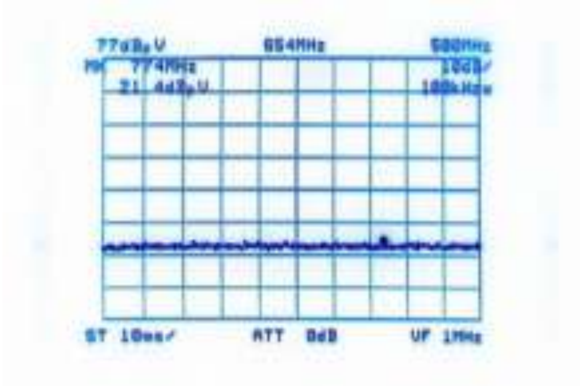
Set-up in A1

Set-up in A1

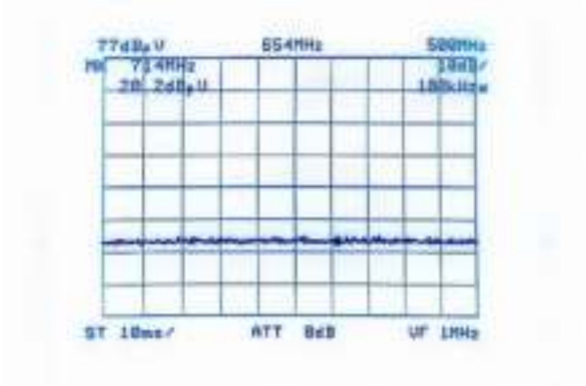
Plot 28



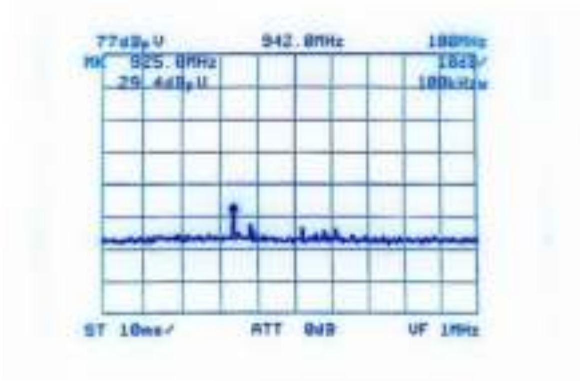
Plot 29



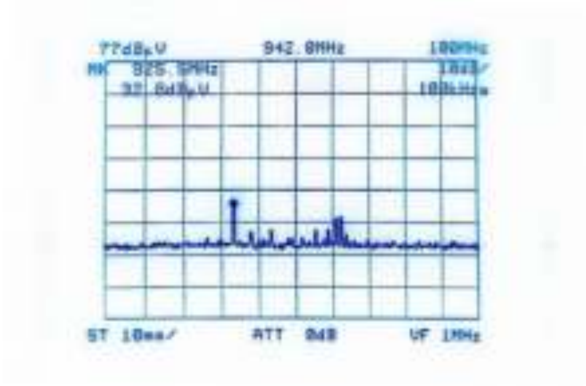
Plot 30



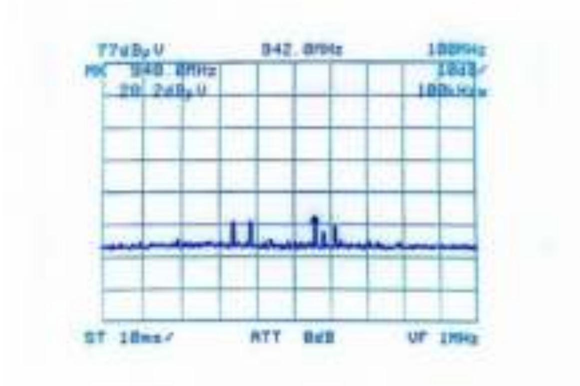
Plot 31



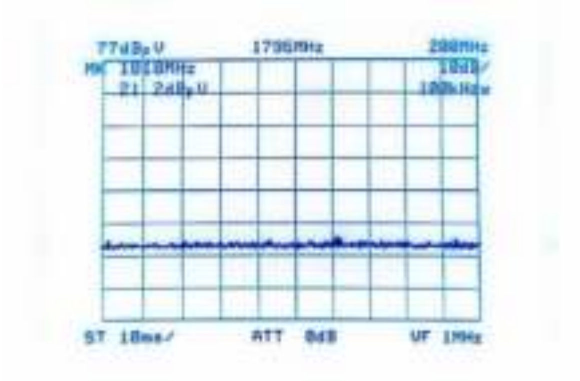
Plot 32



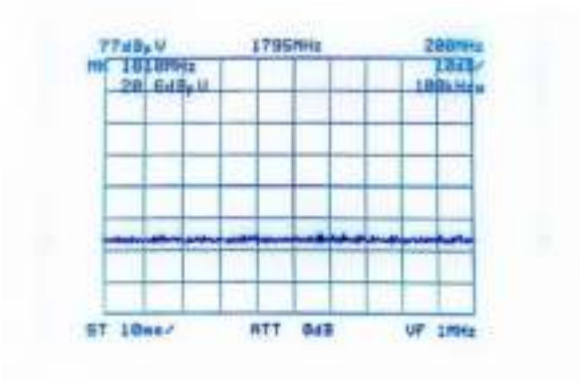
Plot 33



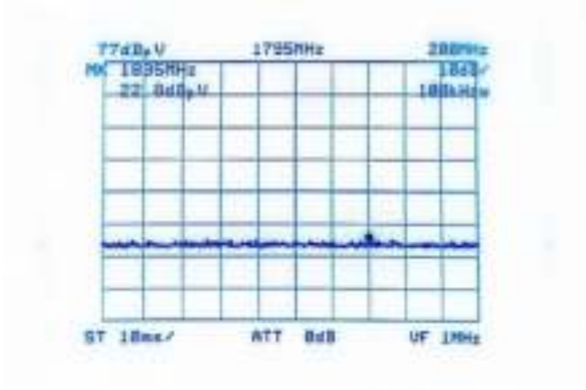
Plot 34



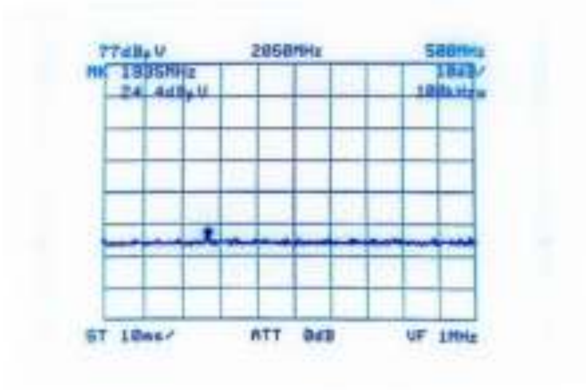
Plot 35



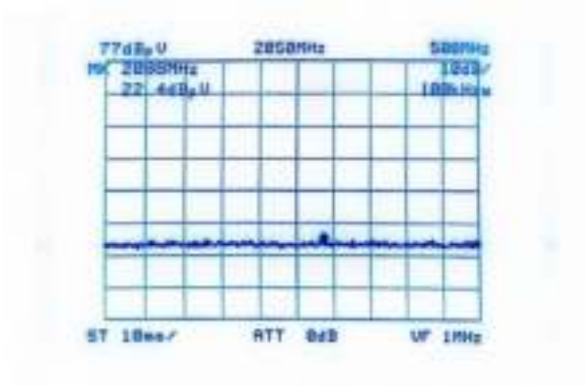
Plot 36



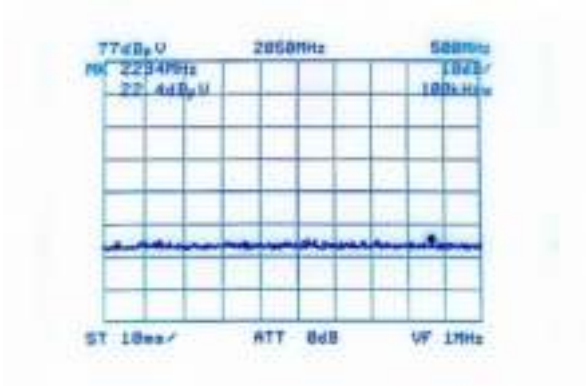
Plot 37



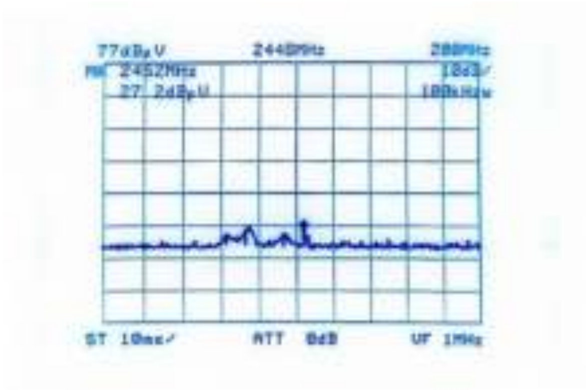
Plot 38



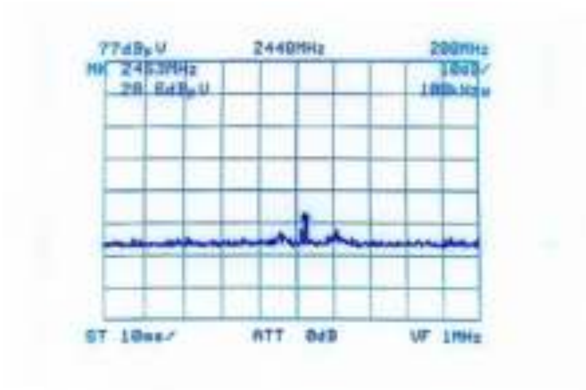
Plot 39



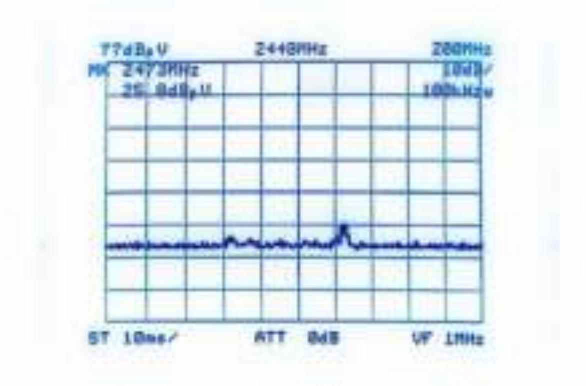
Plot 40



Plot 41



Plot 42

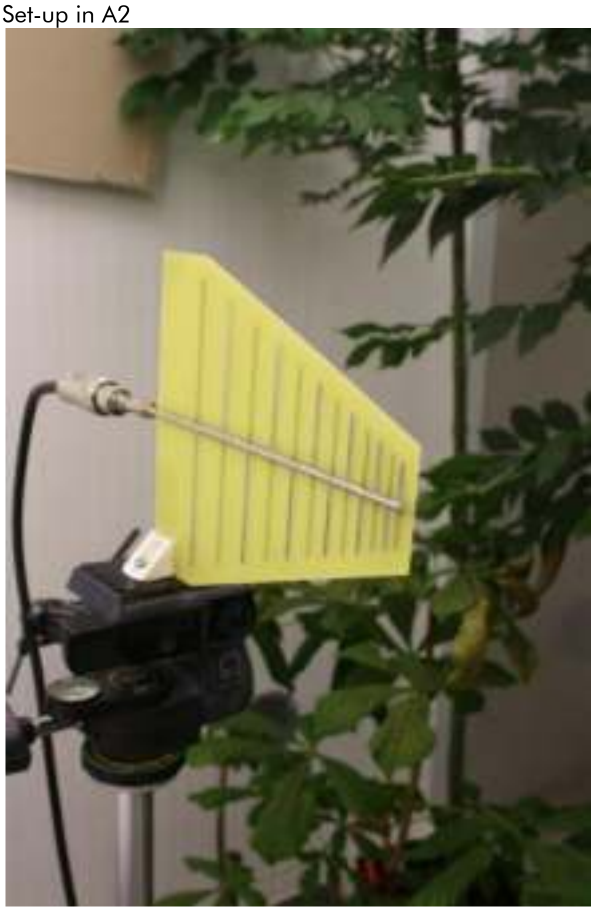


An overview of the measurement inside climate chamber A2 are displayed in the table below. The corresponded frequency plots are laid down after this table.

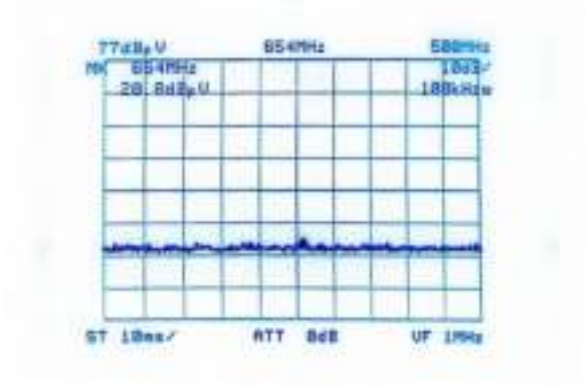
Plot	Location	DVB-T V/m	GSM 900 V/m	GSM 1800 V/m	UMTS V/m	WiFi V/m	Remarks
43	Door	0.0002	--	--	--	--	Noise
44	Centre	0.0002	--	--	--	--	Noise
45	Rear	0.0002	--	--	--	--	Noise
46	Door	--	0.0006	--	--	--	930 MHz
47	Centre	--	0.0013	--	--	--	926 MHz
48	Rear	--	0.0007	--	--	--	925 MHz
49	Door	--	--	0.0005	--	--	Noise
50	Centre	--	--	0.0005	--	--	Noise
51	Rear	--	--	0.0005	--	--	Noise
52	Door	--	--	--	0.0005	--	Noise
53	Centre	--	--	--	0.0008	--	1970 MHz
54	Rear	--	--	--	0.0006	--	Noise
55	Door	--	--	--	--	0.0012	2454 MHz
56	Centre	--	--	--	--	0.0013	2454MHz
57	Rear	--	--	--	--	0.0007	2472MHz

Set-up in A2

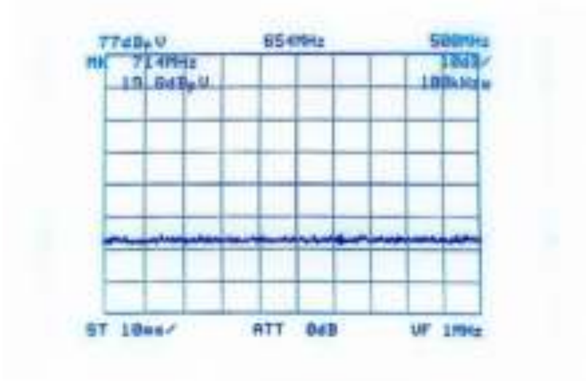
Set-up in A2



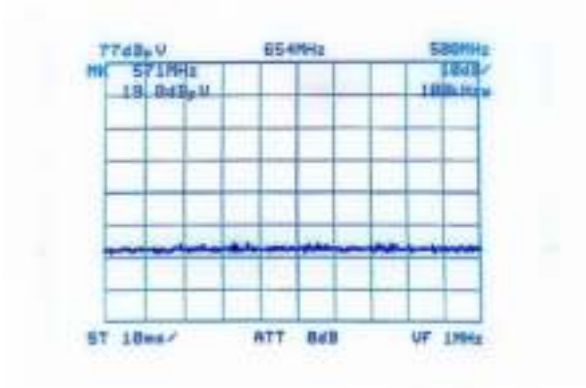
Plot 43



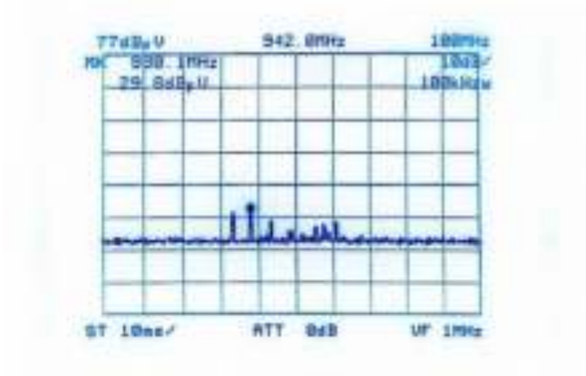
Plot 44



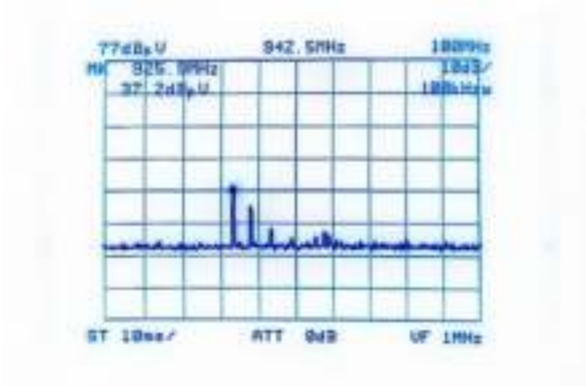
Plot 45



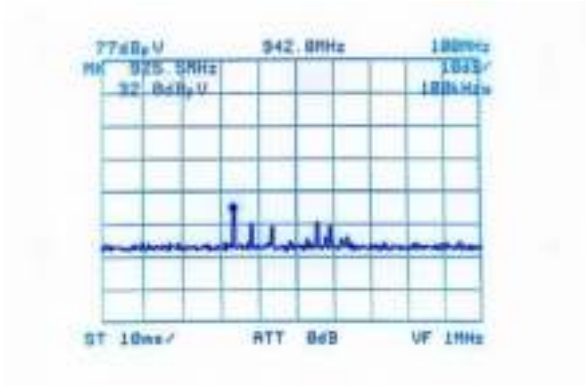
Plot 46



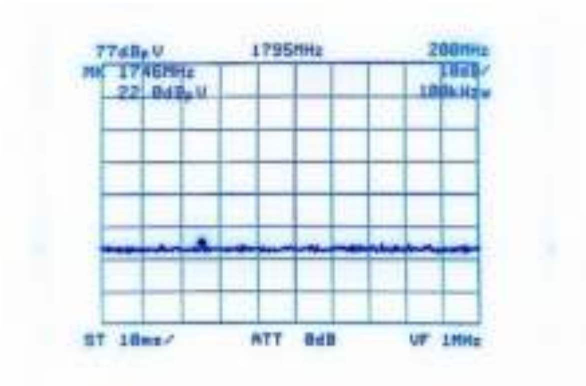
Plot 47



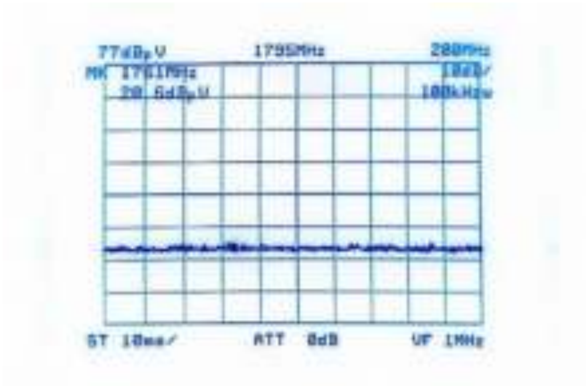
Plot 48



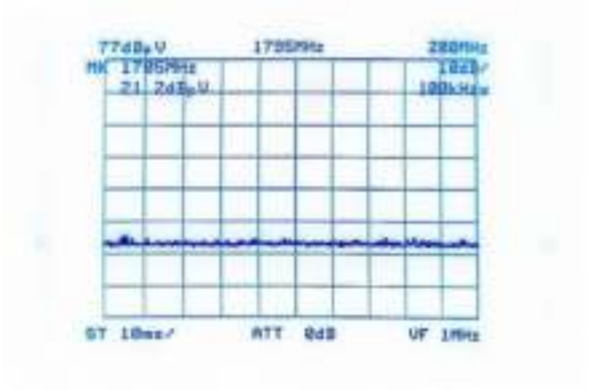
Plot 49



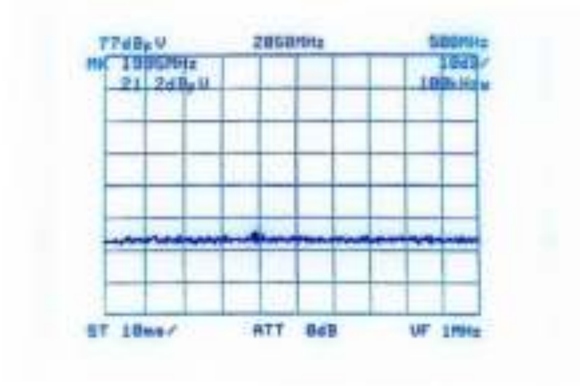
Plot 50



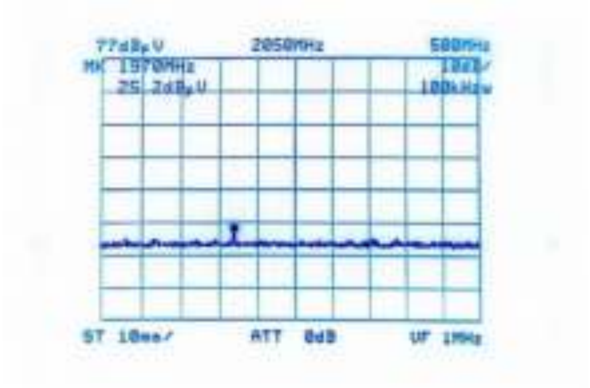
Plot 51



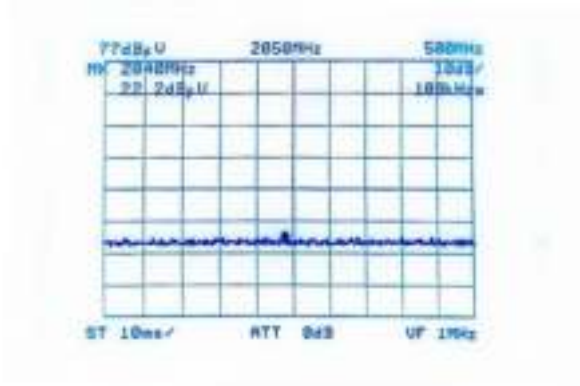
Plot 52



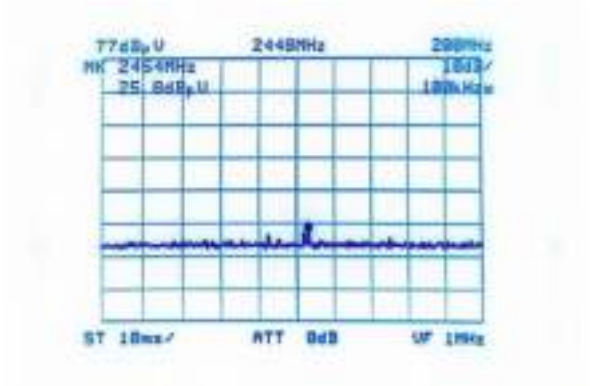
Plot 53



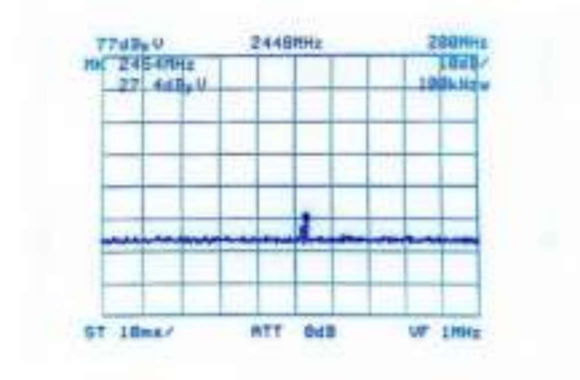
Plot 54



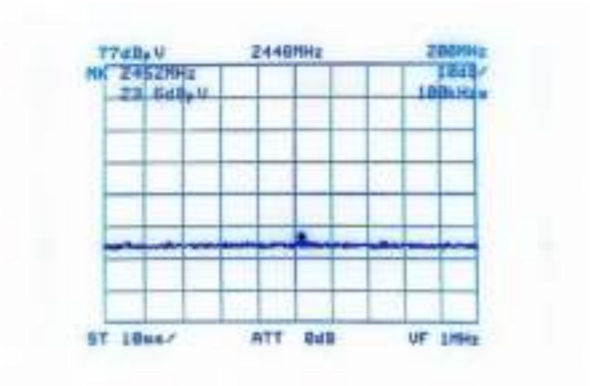
Plot 55



Plot 56



Plot 57



The light intensity is also measured in all three climate chambers. The measurement instrument is the one that was available at the WUR.
The light intensity is measured in μmol and the results are laid down in the next table.

Climate chamber C8
68,27 μmol

Climate chamber A1
53.64 μmol

Climate chamber A2
55.01 μmol

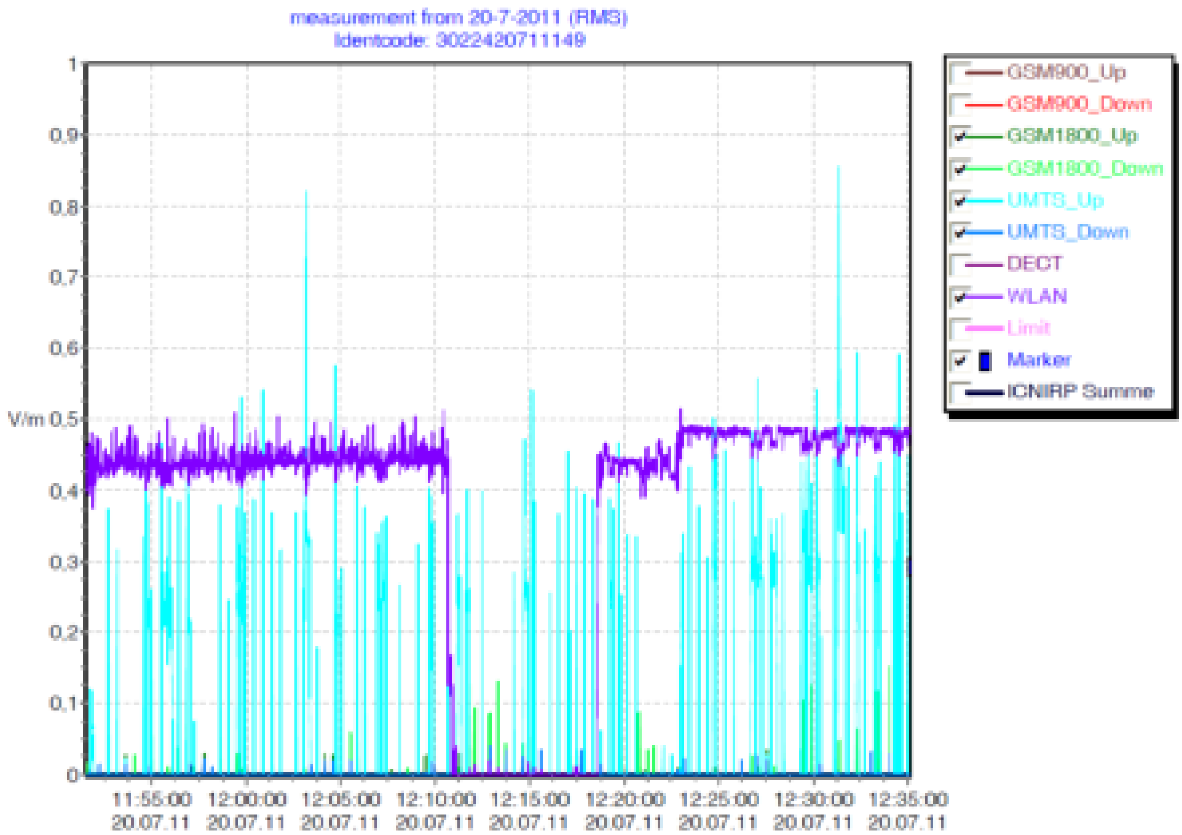
The difference between the light intensity is clearly visible between C8 and both other climate chambers A1 and A2.

An additional EM logger is used to measure the field strength in the climate chambers. This EM logger is normally carried by a person. After consultation with the manufacturer a bottle of water is used to simulate a person to have an accurately measurement result. According the manufacturer this EM logger is also calibrated with a bottle of water.

During the measurements with the EM logger metal objects (antennas, e.g.) and people were moving around inside the climate cambers. Due to this the measurements are influenced and not stable by the reflections of this metal and moving objects (people) inside the climate chambers.

The measurements are laid down in the table below.

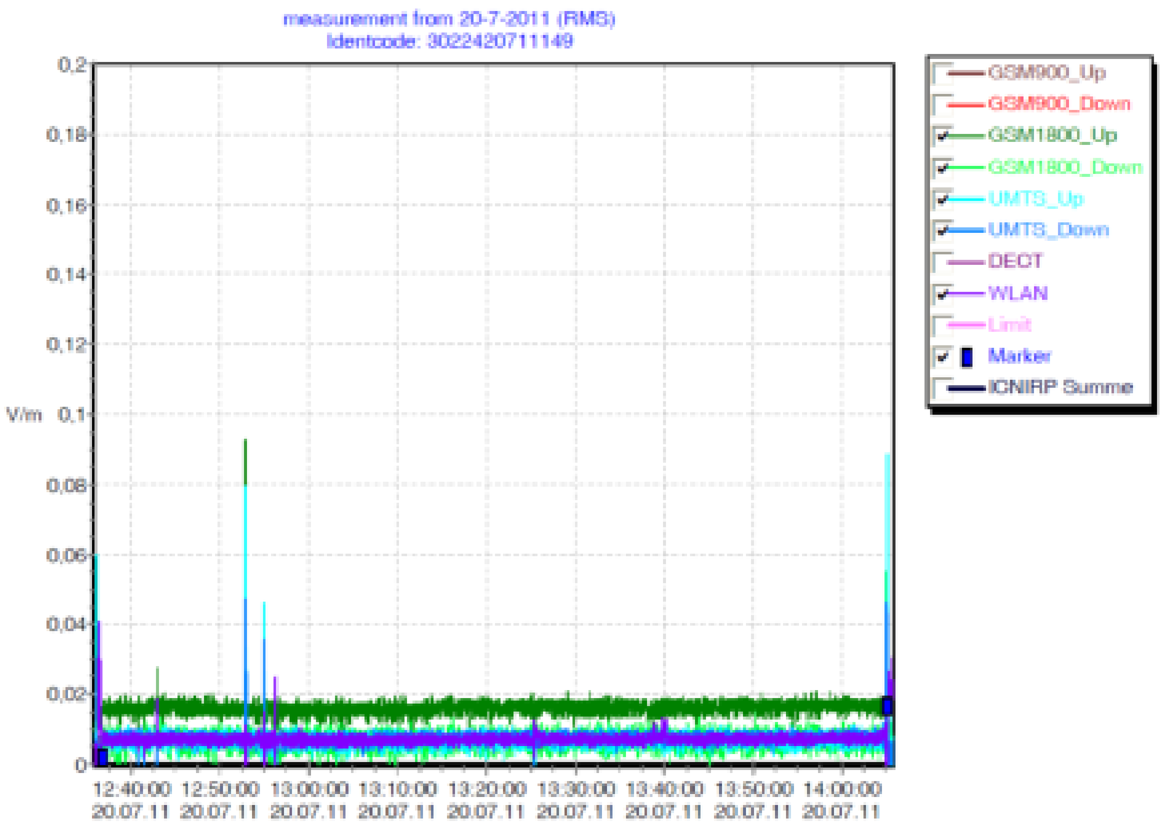
Climate chamber C8



The EMF signals of the UMTS and WiFi are clearly recognizable. The measurement of the GSM 900 signal were switched off. There was a overload due to the DVB-T signal. Because there are no GSM 900 Signals available during this measurement they were switch off.

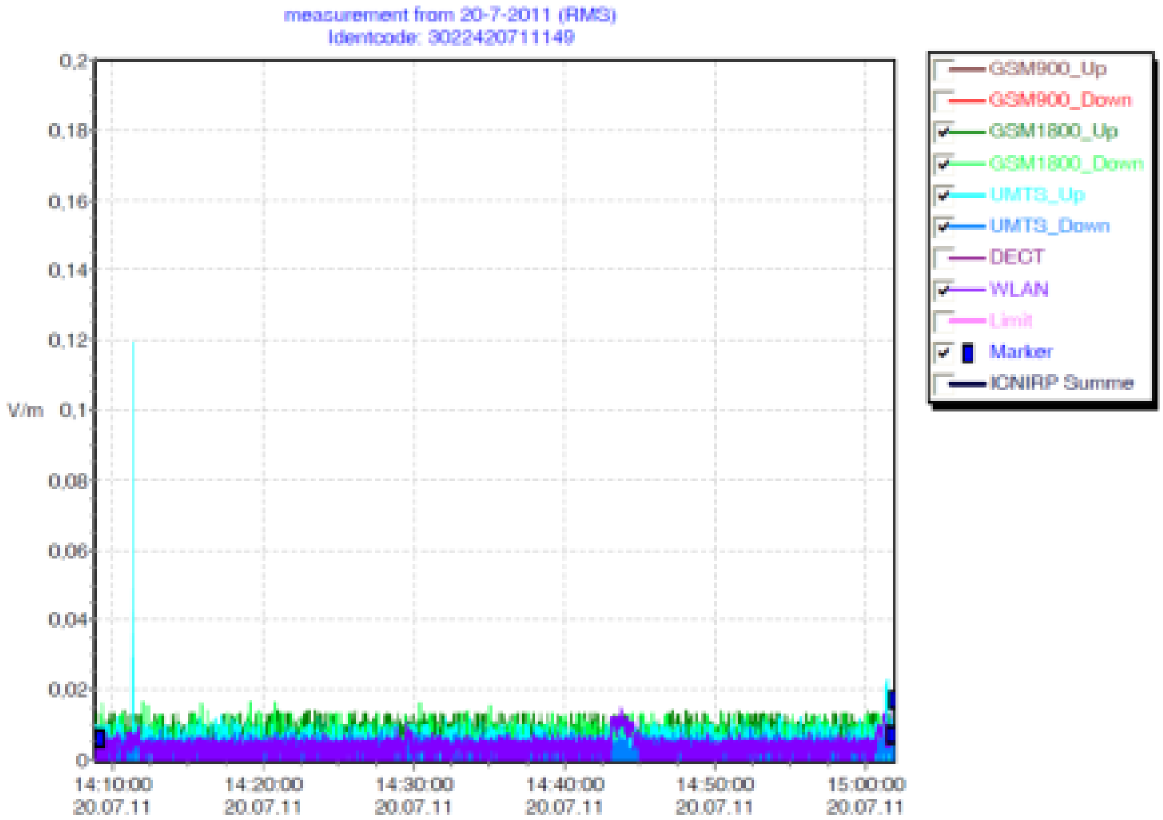
Clearly is visible that at 12:10 the Wifi signals were switched off. At 12:18 the Wifi signals were switched on in two stages.

Climate chamber A1



Mainly noise signals and a view signals with peaks to 0.09 V / m Probably caused by the opening of the door of the climate chamber and "outside" mobile phone signals could be measured.

Climate chamber A2



Mainly noise signals and a view signals with peaks to 0.12 V / m Probably caused by the opening of the door of the climate chamber and “outside” mobile phone signals could be measured.

EM logger in climate chamber C8

EM logger in climate chamber A1

EM logger in climate chamber A2

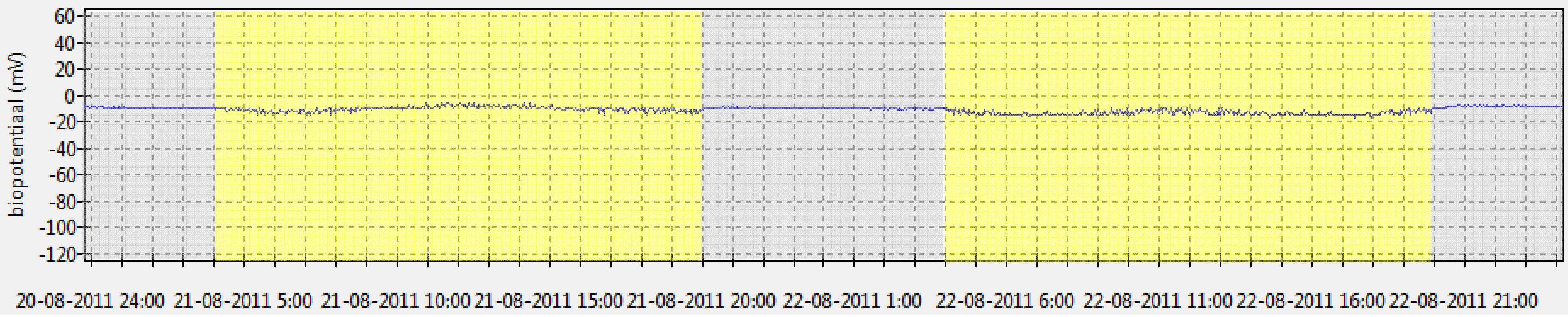
Sectional Appendix 5

Biopotential measurements, Wageningen, 2011 – 2012

(3 pages)

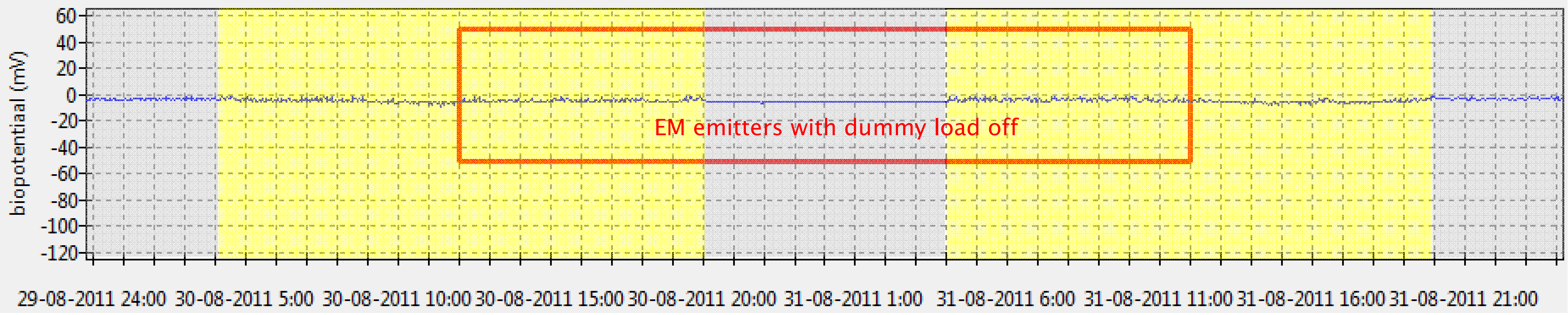
2011 Climate Chamber A1 (no EM)

Climate chamber A1, 21 – 22 August 2011, EM emitters (WiFi routers) with dummy load. Day/night rhythm



30 – 31 August 2011

Climate chamber A1, 30 – 31 August 2011, EM emitters (WiFi routers) with dummy load Switched-off EM emitters have no effect.

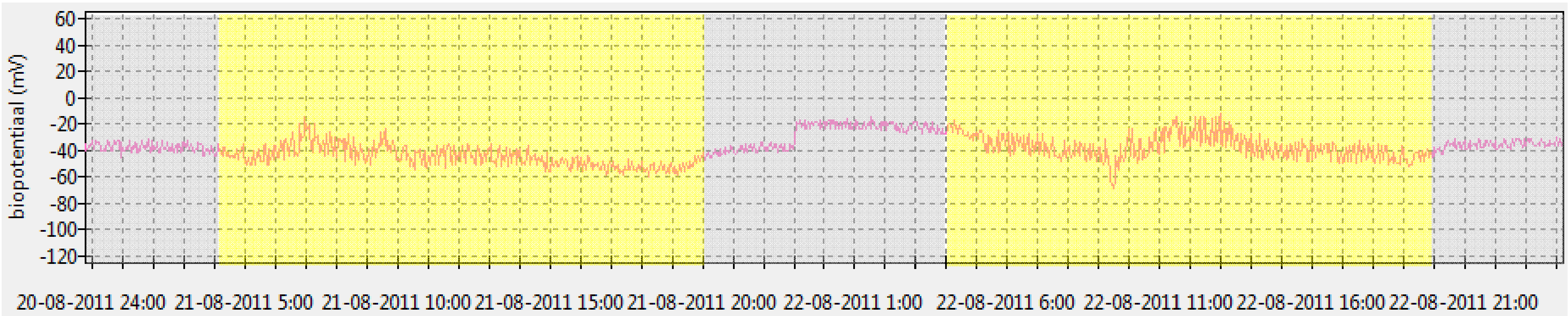


Grey: light OFF from 20:00 – 4:00 hours

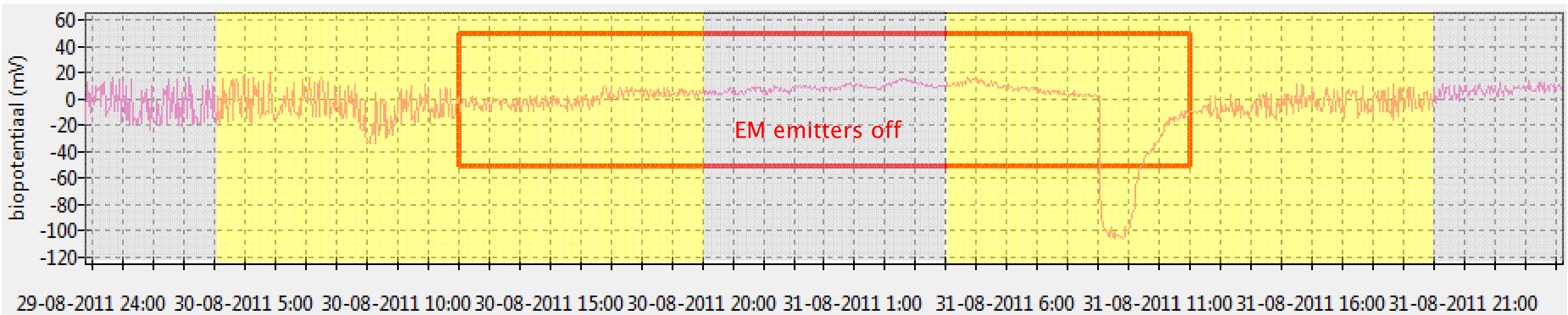
Yellow: light ON from 4:00 – 20:00 hours (switched on between 4:00 and 5:00 hours switched off between 19:00 and 20:00 hours)

2011 Climate Chamber C8 (with EM)

Climate chamber C8, 21 – 22 August 2011, EM emitters (WiFi routers) ON Day/night rhythm



Climate chamber C8, 30 – 31 August 2011, EM emitters (WiFi routers) ON The switching-off of the EM emitters did affect bio-potential.



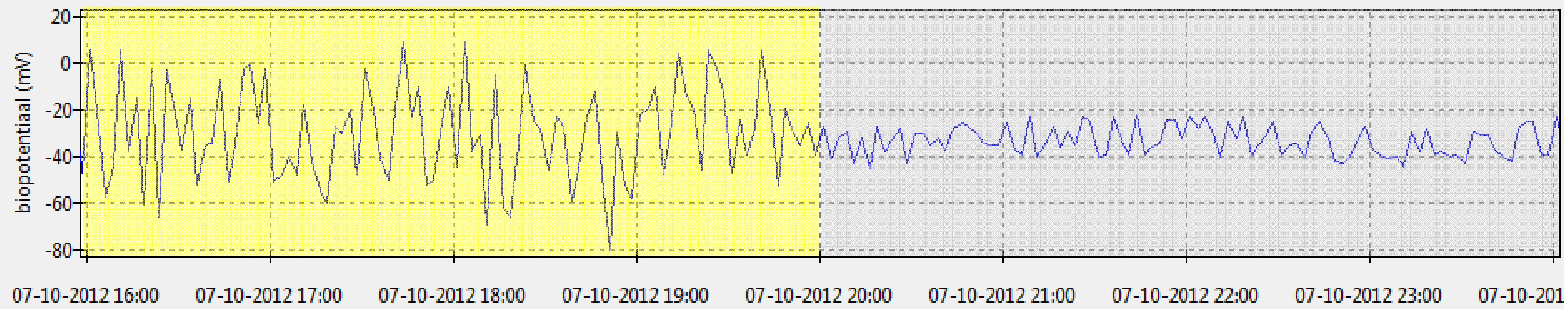
Grey: light OFF from 20:00 – 4:00 hours

Yellow: light ON from 4:00 – 20:00 hours (switched on between 4:00 and 5:00 hours; switched off between 19:00 and 20:00 hours)

2012 Climate Chamber A4 (with EM)

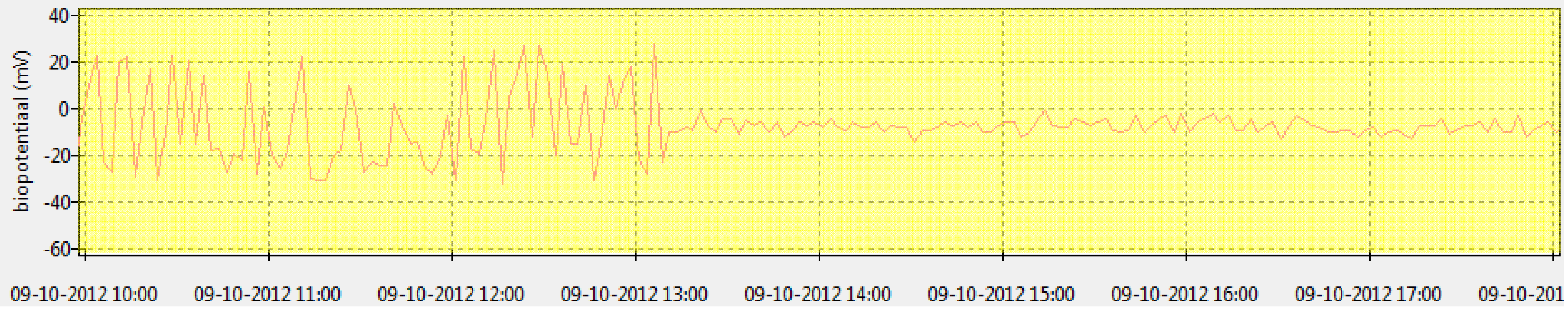
Change in bio-potential on 7 October 2012

Forced transition from diurnal to nocturnal state (between 19:00 and 20:00 hours) in climate chamber A4; horse chestnut tree, EM emitters switched ON



Change in bio-potential on 9 October 2012

Forced transition by means of switching off the EM emitters at 13:00 hours in climate chamber A4, ash tree



Grey: light OFF from 20:00 – 4:00 hours

Yellow: light ON from 4:00 – 20:00 hours (switched on between 4:00 and 5:00 hours; switched off between 19:00 and 20:00 hours)