European Radiocommunications Committee (ERC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

COMPATIBILITY BETWEEN RADIO FREQUENCY IDENTIFICATION DEVICES (RFID) AND THE RADIOASTRONOMY SERVICE AT 13 MHz

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1 INTRODUCTION

The band 13.553-13.567 MHz is designated by the ERC recommendation CEPT/ERC/REC 70-03 for non specific Short Range Device (Annex 1) and Inductive Applications (Annex 9). The fieldstrength level is 42 dBµA/m at 10 m, equivalent to approximately 10 mW ERP.

Industry has developed RFIDs for a number of new applications such as ticketing systems, access control, logistics applications, car entry, container identification, contactless credit cards, etc. RFID systems at 13.56 MHz use a modulated signal according to Annex 1 or 9 of CEPT/ERC/REC 70-03, with a fieldstrength level of 42 dBµA/m at 10 m. A modulated carrier must meet the transmitter mask of Annex 9 (Inductive Applications) at 13.41 MHz or lower frequencies and the modulation products must meet the spurious level of -3.5 dBµA/m (as per EN 300 330).

The band 13.36-13.41 MHz is allocated to the radio astronomy service on a primary basis. In Europe, the only radio astronomy site operating at 13 MHz is Nancay (France).Thus, the purpose of these measurements was to evaluate the interference potential of out of band and spurious emissions of 13.56 MHz RFID systems into the radio astronomy band.

2 DESCRIPTION OF NANCAY ACTIVITIES AT 13 MHz

The Decametric Array is an interferometer consisting of an array of 144 phased antennas. It is composed of two sub-arrays of 72 antennas, placed over an area of 10.000 square meters. The array is capable of measuring circular polarisation, which is very important since the radiation from Jupiter is highly polarised.

The frequency range that can be observed is 10-100 MHz (or 3-30 meter wavelengths): a typical observation for Jupiter activities ranges from 10 MHz to 40 MHz and from 20 MHz to 75 MHz for solar emissions. These frequencies are scanned every 350 msec.

The sensitivity of the receiver is equivalent to 10^{-24} W/m^2/Hz, the antenna gain is 25 dB at a frequency of 25 MHz. The principal beam, i.e. the spatial resolution, has a size of 7 by 14 degrees (large compared to the actual size of a few degrees for the solar corona or only a fraction of a degree for Jupiter's magnetosphere, as seen from the Earth). The resolution bandwidth is 3 kHz.

Around the site of Nancay, two protection zones are defined:

- Within a radius of 1 km, the installation of any radio transmitter is forbidden
- Within a 3 km radius, the radioastronomy site must be consulted when installing new radio transmitting equipment

3 DESCRIPTION OF THE RFID SYSTEMS

An RFID system consists of an interrogator or a reader and one or several tags as data carriers. The tags are attached to objects like warehouse goods or carried by human beings as smart cards or ticketing cards. RFID systems are used in logistics for manufacturing or in automotive applications, e.g. immobilisers or radio keys (car entry) systems, and in transportation for baggage tagging. Tags are only active when interrogated by the reader. They are normally batteryless, dormant and powered by the RF interrogation signal to respond with a data signal. The power level of tags is typically 60-80 dB below the carrier level of the interrogator.

Most RFID systems use bidirectional communications which means that the interrogation signal which is needed to power the tag, is modulated by ASK (Amplitude Modulation). To minimize the emitted spectrum with regard to amplitude and frequency, a low level ASK modulation (10%) in combination with optimized data transmission (encoding) methods are used.

RFID Systems under test in Nancay were supplied by Philips and Texas Instruments (TIRIS) (see **Figure 1**). The actual emission levels of the equipment were verified by a Rhode & Schwarz measurement receiver. The carrier power levels were adjusted to meet the emissions indicated below as defined by the ETSI Standard EN 300 330 (Final draft) and the CEPT/ERC/REC 70-03, Annexes 1 and 9.

System 1

The first RFID system used for the test was prepared by Philips and consisted mainly of the following parts:

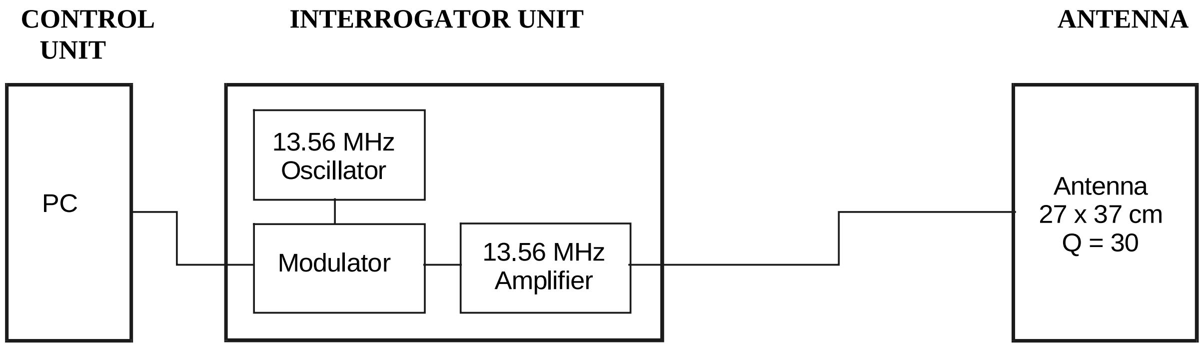


Figure 1

It was considered as reference system since it allowed all adjustments needed for the test variants.

The coding used was a "1 out of 256“ Pulse Position Code:

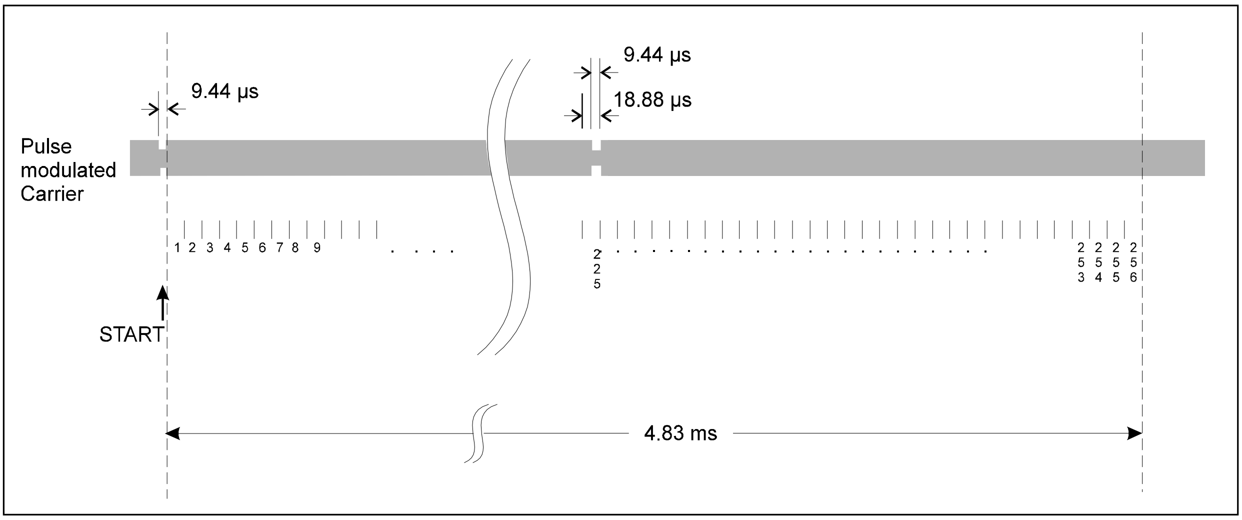


Figure 2

At the beginning of each transmission a start bit is sent. The position of a single pulse within a 256 position frame contains 1 byte of information. Therefore only one modulation is necessary to transmit one byte (see **Figure 2**).

<u>Transmission Frame:</u>
One transmission frame consists of 1 start bit (1 modulation) and 8 bytes of data coded as shown above (total: 9 modulations). The data bytes are determined randomly for every transmission frame. This transmission frame is sent with a defined repetition rate.

All RFID emission levels were adjusted for each measurement to stay within the limits of the below given maximum carrier or spurious levels given below.

Three different modes were used

a) an unmodulated carrier with a field strength of 42 dBµA/m at 10 m.

b) a 10 % modulated carrier with a repetition rate of 80 msec, so that the maximum radiated field strength in the radio astronomy band is – 13.5 dBµA/m at 10 m, which is below the spurious emission level.

c) a 100% modulated carrier with a repetition rate of 250 msec, so that the maximum radiated field strength in the radio astronomy band is – 3.5 dBµA/m at 10 m, which corresponds to the spurious emission level.

System 2

The second system was prepared by Texas Instruments and used in the tests and for verification of a parasitic 13.038 MHz signal observed during one of the tests. The antenna size was 10x16 cm.

The second system transmitted only an unmodulated carrier with a measured field strength of 42 dBµA/m at 10 m (system D).

4 MEASUREMENT CONFIGURATIONS

For each measurement, the RFID emission was directed towards the antennas of the decametric array. The RFID system was turned "on" for 5 minutes, than "off" for a similar period in order to record the environmental noise for comparison. This procedure was necessary to allow the integration of the data over 5 minutes and allow direct comparison between the RFID system (on time) and the environmental noise (off time) recordings.

The measurements were performed at three different locations as described in the next paragraph, all times are in UTC:

Location 1 In the antenna field, at approximately 10 m of the decametric array: modulations schemes A, B and C were tested between 09h52 and 09h57, 10h12 and 10h17 and 10h55 and 11h00 (see **Annex 1** to **4**),

Location 2 In a car park at about 1.5 km from the decametric array: systems A, C and D were tested between 12h17 and 12h22, 12h29 and 12h34 and 12h44 and 12h49 respectively.

Location 3 In front of the church in Nancay, at about 3.5 km from the decametric array: systems A and C were tested between 13h02 and 13h07, and 13h14 and 13h19 respectively

*(For all measurements the spectrum was also recorded when the RFID systems were switched off, see **Annex 4** and **5**).*

The **Table 1** below summarises the different configurations identified by timing and location.

	(1) Philips System			**(2) TIRIS System**
Measurement site	A: unmodulated	B: 10% modulation	C: 100% modulation	D: unmodulated
(1) Astronomy Antenna	09h52 - 09h57	10h12 - 10h17	10h55 - 11h00	
(2) Parking (1.5 km)	12h17 - 12h22		12h29 - 12h34	12h44 - 12h49
(3) Church (3.5 km)	13h02 - 13h07		13h14 and 13h19	

Table 1

5 RESULTS

For the purpose of the tests, the astronomy receiver was configured as follows:

Fmin :	13 MHz
Fmax :	14 MHz
Resolution :	3 kHz
Scantime :	350 msec
Reference level	-40 dBm

(1) Interferer adjacent to the Antenna field

The position of the RFID system relative to the Astronomy antenna field was about 10-12 metres from the edge of the antenna field and the inductive antenna positioned such that the main lobe of the RFID antenna radiated towards the antenna field.

The results of the measurement for the systems 1(C) (100% modulated), the worst case, is given in **Annex 1** to **3**.

Annex 1 shows the measured power of **–** 55 dBm at the input of the radio astronomy receiver in the SRD band for the frequency 13.56 MHz. This frequency is outside the radio astronomy band. When the system 1 (C) is turned off at 11h00 (UTC), the signal disappears.

The received signal is 40 dB above the "sky" level (i.e. the level measured when the SRD system is off).

Annex 2 shows the same measurement at 13.038 MHz. The received signal is also outside the radio astronomy band, and is measured at –83 dBm.

The manufacturers declared that the signal at 13.038 MHz is a parasitic (spurious) signal of the particular system under test, caused by the modification for controlling the modulator by the PC. This signal will not be emitted by systems to be put on the market. In fact, a control measurement using the second RFID system did not exibit this signal so this frequency is not inherent to RFID systems nor is this frequency a result of intermodulation of the astronomy receiver.

Annex 3 shows also a time domain recording but inside the astronomy band (13.398 MHz). The level of the received interference signal was –95 dBm at the receiver input level. This corresponds to the highest side lobe of the modulated RFID signal.

Annex 4 shows the result of the integrated data over the 5 minutes “on” and “off” respectively. The two lines at 13.56 MHz and 13.038 MHz are visible. The graph also shows the third line, which falls within the radioastronomy band at 13.398 MHz. The power is about –95 dBm at the astronomy receiver input and is 20 dB above the environmental noise and clearly visible by the radiotelescope.

(2) Interferer positioned in the car park (1.5 km)

The position of the RFID system was about 1.5 km from the center of the antenna field but still inside the Nancay observatory site. The main lobe of the H-field emission was also directed towards the antenna field.

Annex 4 gives the measured signal integrated over the 5 minutes “on” and “off” respectively, for the system A. Both graphs show that no signal could be detected during the “on” period.

Even the 13.56 MHz carrier of the RFID system was not detectable.

At a distance of 1.5 km, the radiotelescope is not disturbed by the SRD.
The attenuation of the RFID signal is due to the distance, the shielding of the environment (e.g. wood), the fact that the main lobe of the decametric antenna points towards the sky, implying attenuation for sources on the surface. These factors add up and provide protection to the radiotelescope against potential interference of the SRD RFID.

(3) Interferer positioned in front of the church (3.5 km)

The location of the RFID systems was in the center of Nancay and in front of the church, the distance was about 3.5 km to the antenna field. This position is still within a controlled zone where radio systems must be co-ordinated with the radio astronomy site on a consultation basis.

The results are similar to those obtained in (2): no signals from the RFID systems could be recorded.

6 Conclusions

The only case of interference which was recorded in the radioastronomy band occurs when the SRD is very close to the edge of the decametric array (a few metres), which is a very unrealistic case.
In this case the interference signal is approx. 20 dB above the observed environmental noise at the radioastronomy receiver input.

As soon as the distance increases to 1.5 km, just outside the protection area, no signal is detected in the radioastronomy band nor from the 13.56 MHz powering carrier frequency at a level of 42 dBµA/m at a distance of 10 metres.

The spurious level of –3.5 dBµA/m at 10 m in the astronomy band 13.36-13.41 MHz is sufficient for inductive 13.56 MHz RFID systems to protect the radioastronomy site of Nancay; so a margin of 45.5 dB is realised (See Note 1 below).

The results and conclusions are representative for decametric astronomy receiving sites.

Note 1: Refering to the interference range calculation in the Inductive System Propagation Model Report;

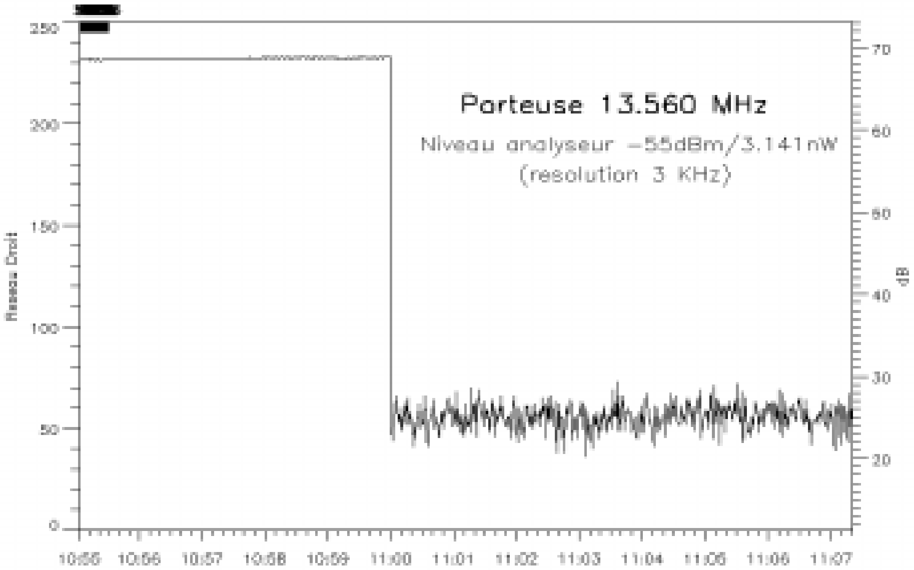
- using a carrier limit of 42dBµA/m at a distance = 10 m at a frequency of 13.56 MHz , at which limit an interference range of 1.5 km was measured;
- assuming a ground type of „medium dry ground“, defined by a conductivity of 1mS/m and a relative permittivity of 15;

a permissible interference level of 27 dBµV/m is found for interfering sources on the surface.

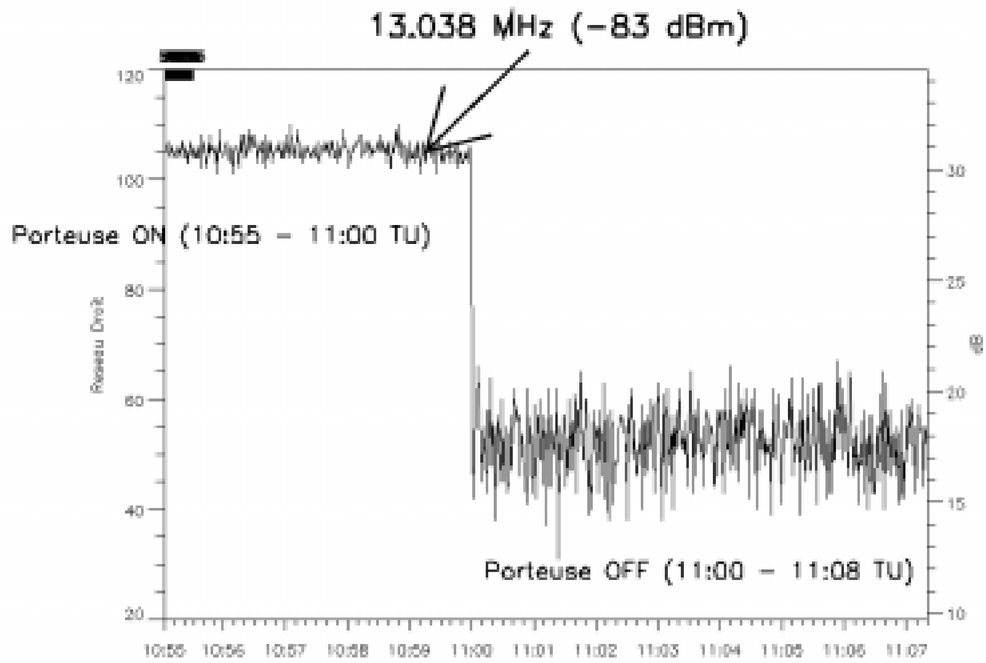
Attachments:

Annex 1:	Measurement in the Antenna field: 13.56MHz signal RFID Carrier
Annex 2:	Measurement in the Antenna Field: 13.038 MHz signal Spurious signal
Annex 3:	Measurement in the Antenna Field: 13.398 MHz signal A modulation product
Annex 4:	Measurement in the Antenna Field: Frequency spectrum RFID transmitter "on“ Measurement in the Antenna Field: Frequency spectrum RFID transmitter "off“
Annex 5:	Measurement in Car Park, 1.5 km from the Antenna RFID transmitter "on“ Measurement in Car Park, 1.5 km from the Antenna RFID transmitter "on“
Annex 6:	Photograph of the antenna array site

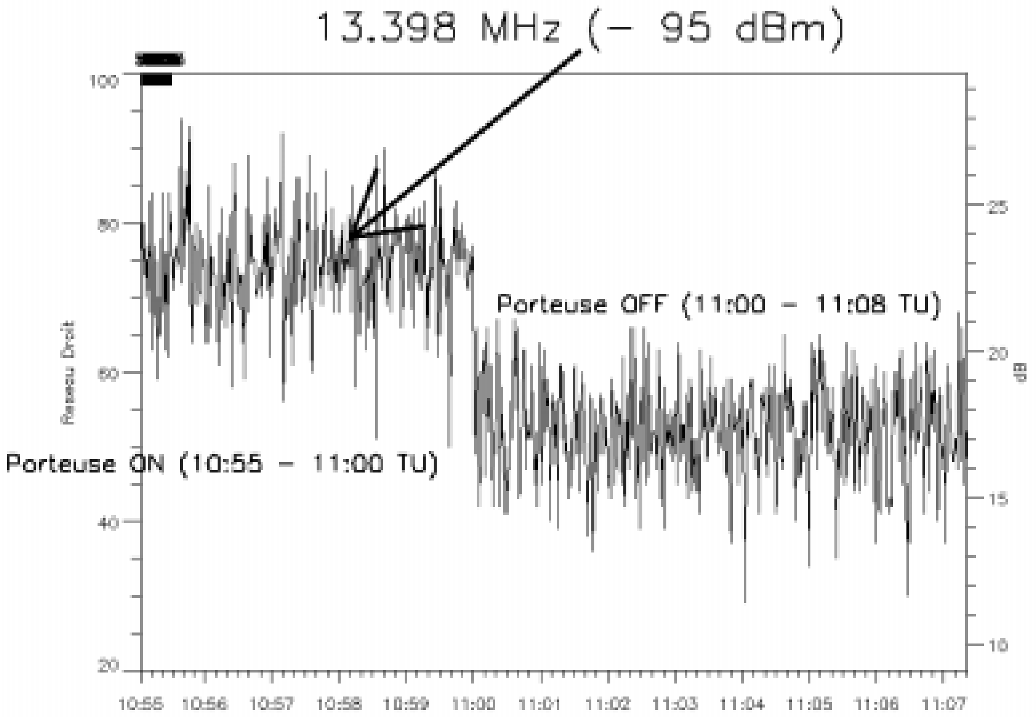
ANNEX 1: Measurement in the Antenna field, 13.56MHz signal: RFID Carrier



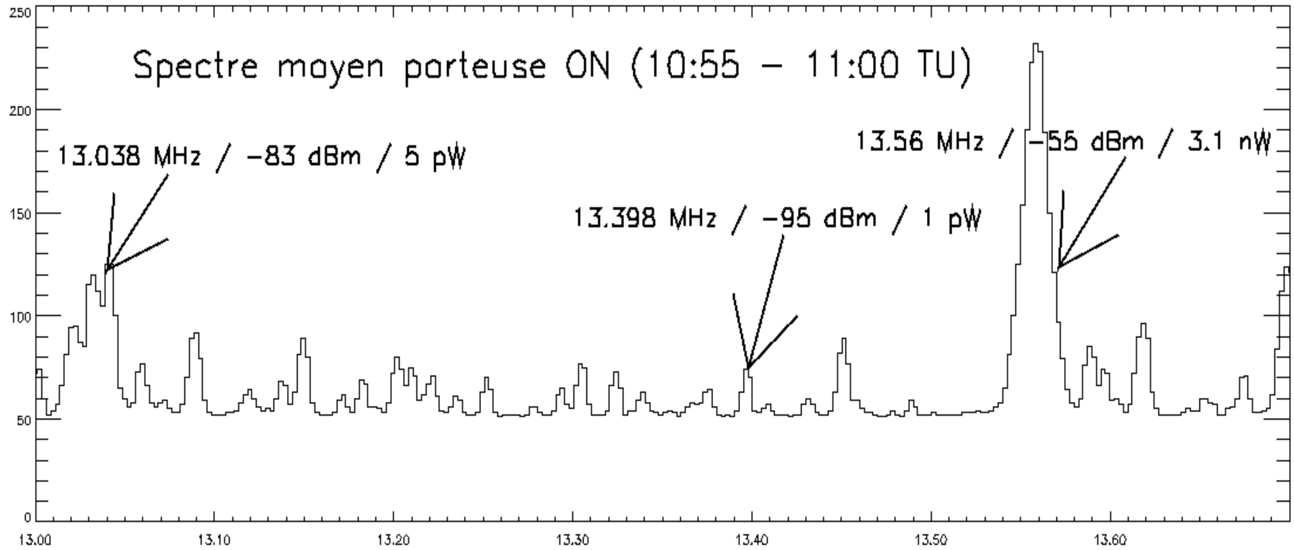
ANNEX 2: Measurement in the Antenna Field, 13.038 MHz signal: Spurious signal

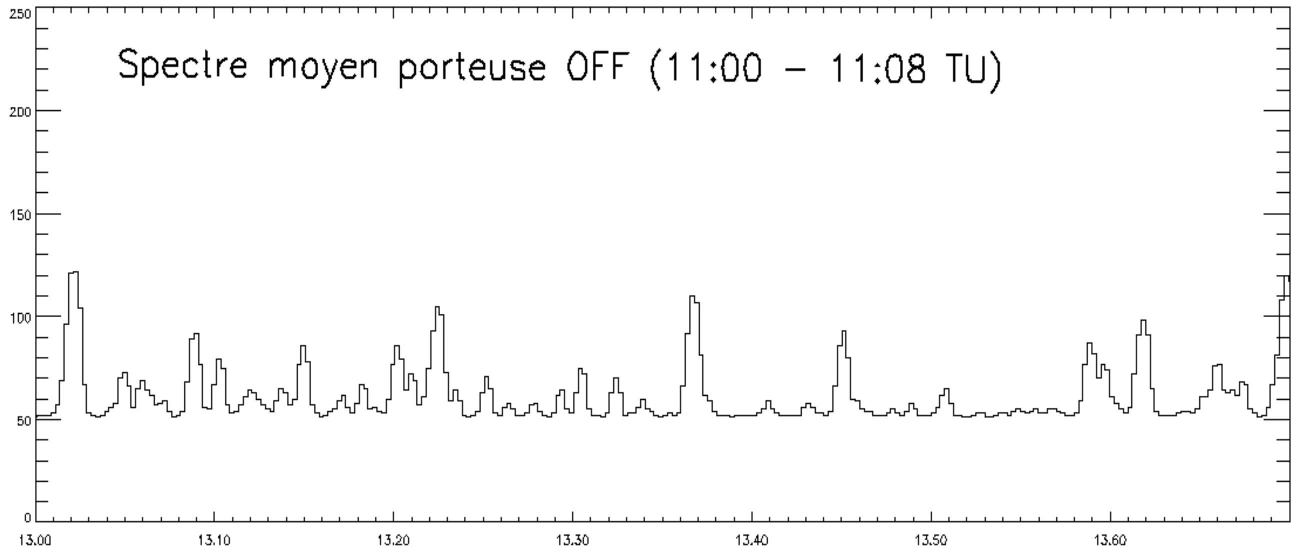


ANNEX 3: Measurement in the Antenna Field, 13.398 MHz signal: A modulation product

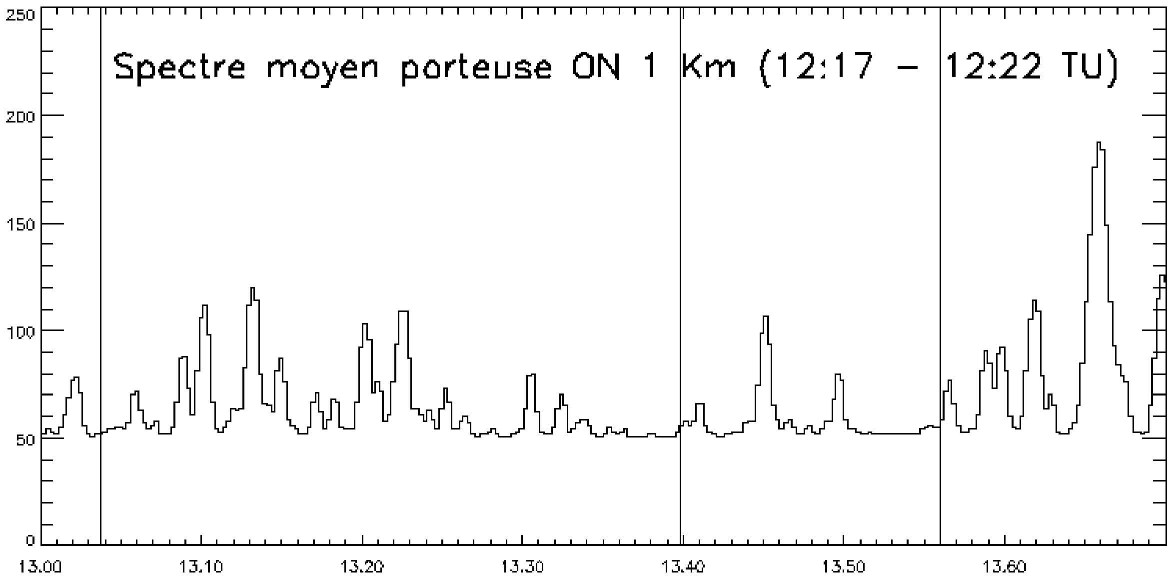


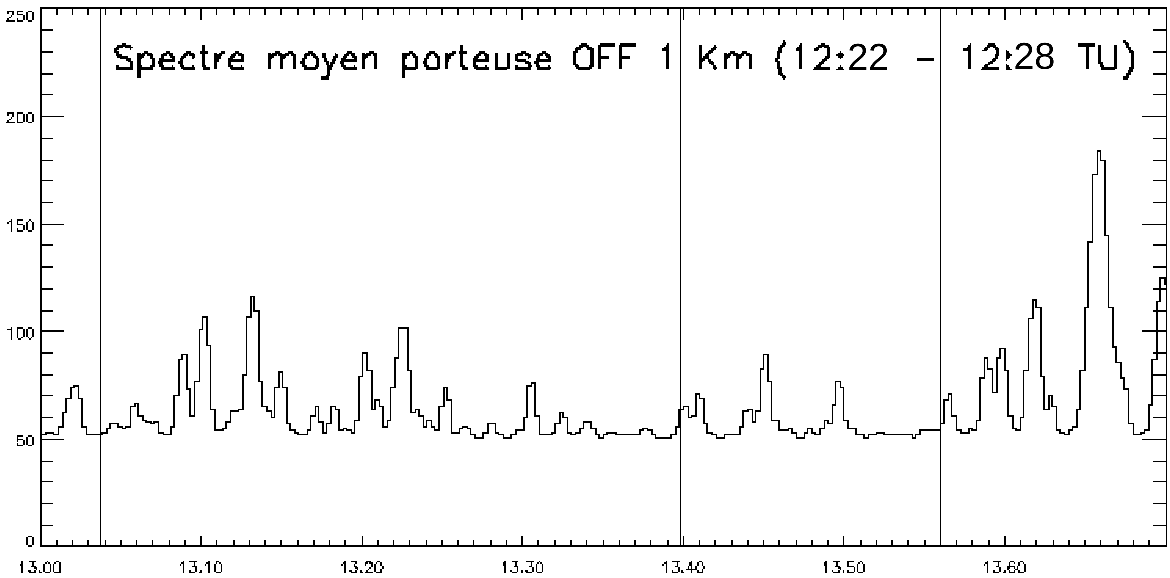
ANNEX 4: Measurement in the Antenna Field, Frequency spectrum
RFID transmitter "on“
Measurement in the Antenna Field, Frequency spectrum,
RFID transmitter "off“





ANNEX 5: Measurement in Car Park, 1.5 km from the Antenna
RFID transmitter "on“
Measurement in Car Park, 1.5 km from the Antenna.,
RFID transmitter "on“





ANNEX 6: Photograph of the antenna array site