# ETSI TS 102 903 V1.1.1 (2011-08)

Technical Specification

**Electromagnetic compatibility and Radio spectrum Matters (ERM); Compliance tests for cognitive interference mitigation for use by UHF RFID using Detect-And-Avoid (DAA) or other similar techniques**

Reference

DTS/ERM-TG34-012

Keywords

ER-GSM, radio, RFID

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# Foreword

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

# Introduction

In order to accommodate the spectrum needs for the increasing number of RFID devices and systems, an extension band for high power RFID systems in the range between 915 MHz and 921 MHz has been requested. This band is already used by RFID in several countries worldwide and its designation in Europe would increase its functionality and simplify the international movement of goods using RFID identification systems. In Europe, part of this new frequency band will be shared between the primary user ER-GSM and RFID. In order to guarantee an interference-free coexistence between the two systems, mechanisms have to be implemented by RFID systems to reduce the probability of interference to an acceptable minimum. These techniques can be either regulatory, or technical mechanisms or operational restrictions.

This Technical Specification (TS) includes a description of the practical evaluation and the certification test procedure for the mitigation mechanisms defined in TS 102 902 [3] (Methods, parameters and test procedures for cognitive interference mitigation towards ER-GSM for use by UHF RFID using Detect-And-Avoid (DAA) or other similar techniques). The focus in the present document will be on the sensing of the environment and estimation of the isolation between a RFID high power interrogator and a potential victim ER-GSM terminal. The location based mechanisms presented in [2] are not part of the present TS. The interference evaluations performed in [2] have shown that RFID devices will not cause any harmful interference towards the potential ER-GSM victim terminals if the power is below 0 dBm (1mW) and the protection distance is larger than 20 m. Since the maximum TX power of RFID tags in the band 915 MHz to 921 Mhz is below -10 dBm, they do not require any additional mitigation.

The present document follows on from the recommendations contained in TS 102 902 [2]. It begins by describing the results of a demonstration of principle which was performed by members of STF 397 (Specialist Task Force 397). The knowledge gained from this work was central to the development of the specifications for the tests. Finally the document outlines a set of practical tests which are considered necessary in order to finalise the values of certain critical parameters and to validate that the mitigation techniques function as predicted in an operational environment.

# 1 Scope

The present document reports on the practical evaluation, demonstrations and certification procedures for the mitigation mechanisms for RFID systems operating in the band between 915 MHz to 921 MHz as described in [2]. The active mechanisms covered in this Technical Specification are intended to mitigate against any harmful interference generated by RFID interrogators towards ER-GSM terminals operated in the band between 918 MHz to 921 MHz.

The report does not cover the location based methods presented in [2] nor does it include RFID tags operating in the band with a power levels up to -10 dBm.

# 2 References

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

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## 2.1 Normative references

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

[1] ETSI EN 302 208 (all parts) (V1.3.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W".

[2] ETSI TS 102 902 (V1.1.1): "Electromagnetic compatibility and radio spectrum matters (ERM); Methods, parameters and test procedures for cognitive interference mitigation towards ER-GSM for use by UHF RFID using Detect-And-Avoid (DAA) or other similar techniques".

## 2.2 Informative references

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

[i.1] ETSI ERM TG34: ERM-TG34#15-04r1: "ETSI tests at a Distribution Centre", September 2006.

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

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

**Cognitive Radio System (CRS):** radio system (optionally including multiple entities and network elements), which has the following capabilities:

- obtains knowledge of the radio operational environment and established policies and monitors usage patterns and users' needs;
- adjusts dynamically and autonomously its operational parameters and protocols according to this knowledge in order to achieve predefined objectives, e.g. minimize a loss in performance or increase spectrum efficiency; and
- learns from the results of its actions in order to further improve its performance.

**Detect And Avoid: (DAA):** technology used to protect radio communication services by avoiding co-channel operation.

NOTE: Before transmitting, a system senses the channel within its operational bandwidth in order to detect the possible presence of other systems. If the channel is occupied, the system avoids transmission until the channel becomes available.

**Downlink (DL):** direction of communication from master to slave, where in the case of a typical RFID system the direction flows from the interrogator to tag

**Dynamic Frequency Allocation (DFA):** protocol that allows for changing transmit frequency during operation

**Dynamic Power Control (DPC):** capability that enables the transmitter output power of a device to be adjusted during operation in accordance with its link budget requirements or other conditions

**fixed:** physically fixed, non- moving device; includes temporary installations as well

**link adaptation:** result of applying all of the control mechanisms used in Radio Resource Management to optimize the performance of the radio link

**Listen Before Talk (LBT):** spectrum access protocol requiring a cognitive radio to perform spectrum sensing before transmitting

**location awareness:** capability that allows a device to determine its location to a defined level of precision

**master:** controls the radio resource changing actions

**mobile:** physically moving device

**radio environment map:** integrated multi-domain database that characterises the radio environment in which a cognitive radio system finds itself.

NOTE: It may contain geographical information, available radio communication services, spectral regulations and policies, and the positions and activities of co-located radios

**Service Level Agreement (SLA):** defined level of service agreed between the contractor and the service provider

**slave:** performs the commands transmitted by the Master

**Uplink (UL):** direction of communication from Slave to Master

**white space:** term indicating a part of the spectrum, which is available for a radio communication application at a given time in a given geographical area on a non-interfering/non-protected basis with regard to other services with a higher priority on a national basis

## 3.2 Symbols

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

| | |
|---|---|
| $\alpha$ | pathloss exponent in the Friis Equation |
| dB | decibel |
| d | distance |
| f | frequency measured under normal test conditions |
| fc | centre frequency of carrier transmitted by interrogator |
| $\lambda$ | wavelength |
| $\Omega$ | omh |
| $\Delta f$ | frequency offset |

## 3.3 Abbreviations

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

| | |
|---|---|
| BCCH | Broadcast Control Channel |
| BTS | Base Transceive Station |
| DAA | Detect and Avoid |
| DL | Downlink |
| ER-GSM | Extended Railways GSM |
| GSM | Global System for Mobile Communication |
| IM3 | third order intermodulation |
| RBW | Resolution Band Width |
| RF | Radio Frequency |
| RFID | Radio Frequency Identification |
| R-GSM | Railways Global System for Mobile communications |
| RX | Receiver |
| TCH | Traffic Channel |
| TX | Transmitter |
| UHF | Ultra High Frequency |
| UL | Uplink |

# 4 Demonstration of principle

## 4.1 Introduction

The purpose of the initial demonstration of principle was to show the ability of an interrogator to detect the defined threshold levels for Uplink and Downlink detection. This demonstration of principle was also presented at the ECC workshop in Mainz in April 2011. The demonstration showed the feasibility of the active mitigation techniques proposed in [2]. Further information will follow as soon as a more detailed implementation is available.

For demonstrations of UL detection in the future, the effect of possible use of wireless smart metering applications in the band will have to be taken into account. This is covered in clause 5 of the present document, which describes the recognition of specific R-GSM and ER-GSM signal patterns.

The detection process of the ER-GSM Uplink and the Downlink is performed during the power up process of the interrogator. The method of measurement is similar to the test procedure defined in clause 5.3.6. All measurements are made as conducted.

## 4.2 Methods of measurement

The demonstration setup and procedure shows the detection process and the corresponding response of the interrogator. In the first step, downlink detection of a BCCH is demonstrated. The interrogator, operating in the band between 915 MHz to 921 MHz, monitors the complete R-GSM and ER-GSM bands between 918 MHz to 925 MHz in order to detect a BCCH. In the initial implementation, due to the non-availability of ER-GSM equipment, the core R-GSM band between 921 MHz to 925 MHz is monitored. For the initial demonstration of concept an unmodulated signal is used to show the ability of the interrogator to identify a specific detection threshold.

In the second step the interrogator is configured to detect an unmodulated signal at a specified threshold level in the ER-GSM uplink band.

### 4.2.1 Unmodulated Signal in the ER-GSM UL and DL band

This test shows that an interrogator is able to detect a signal in the ER-GSM Uplink and Downlink band down to the defined threshold levels. The demonstration only needs to be done for the lowest defined threshold level.

Step 1: The measurement receiver is connected to the input of a power splitter. One input of the power splitter is connected to a signal source A. The other input is connected to a 50 Ω resistor. Signal source A is adjusted to produce an un-modulated continuous carrier with its frequency tuned to 919,2 MHz. The signal is adjusted to give a level at the input to the measuring receiver that is 3 dB above the appropriate threshold limit taken from table 3 in clause 5.3.6.4. A diagram of the test configuration is shown at figure 1.

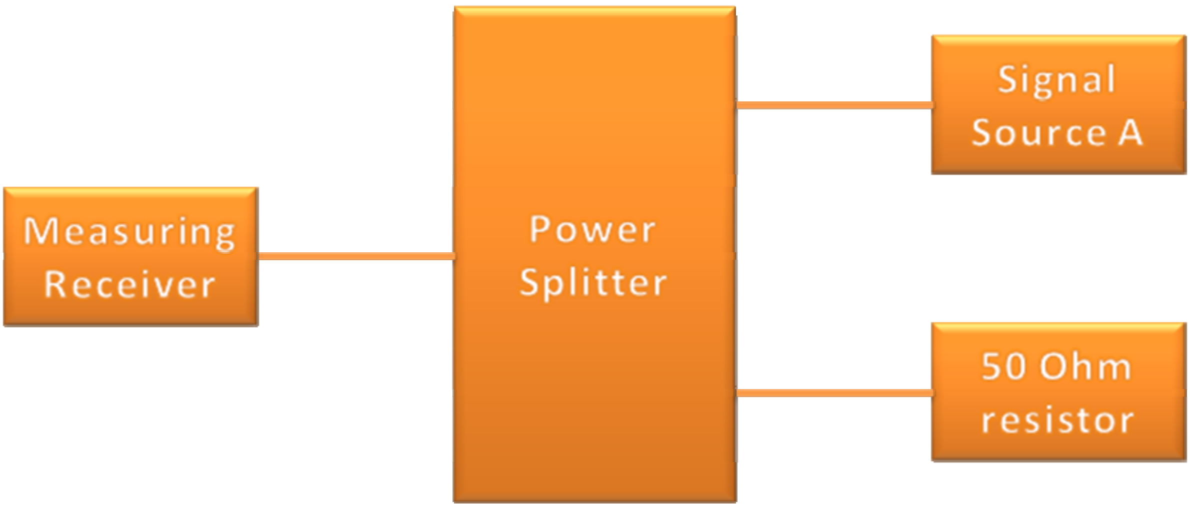



**Figure 1: Calibration for conducted measurement**

Step 2: The measuring receiver is replaced by the interrogator. The 50 Ω resistor is replaced by the measuring receiver. A diagram of the test configuration is shown at figure 2.

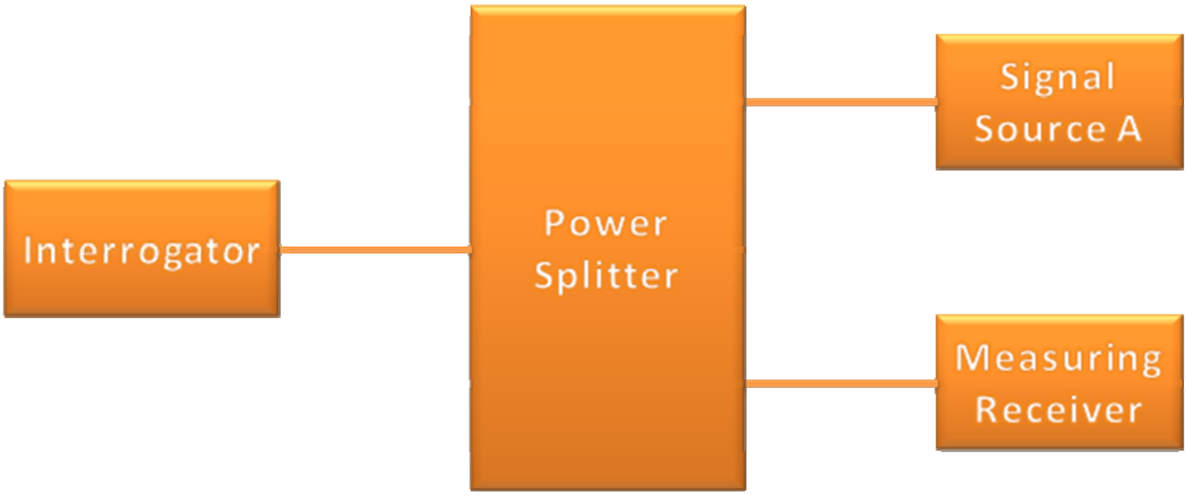



**Figure 2: Conducted measurement of signal detection**

Step 3: With signal source A switched off the interrogator is powered on.

Step 4: The interrogator should switch automatically to scan mode. The transmission from the interrogator shall be monitored. The interrogator shall start transmission at a frequency of 920,1 MHz.

Step 5: The power supply to the interrogator is turned off.

Step 6: With signal source A switched on the interrogator is powered up. The interrogator shall switch automatically to scan mode. The frequency of transmission from the interrogator shall be monitored.

Step 7: The frequency of transmission of the interrogator should be at 916,5 MHz, which shows that the interrogator has successfully detected the signal from source A.

In the second demonstration the signal source A is tuned to a frequency of 875 MHz and the threshold level in the interrogator is set to the value defined in table 5 of clause 5.3.7.4.2. This demonstration should show the capability of an RFID interrogator to detect signals in the uplink band of the ER-GSM system.

# 4.3 Results of the demonstration

## 4.3.1 Unmodulated Signal in the ER-GSM DL band

In the first part of the test the capability of the interrogator to detect a continuous unmodulated signal in ER-GSM downlink band was shown. Initially the interrogator was powered on while the signal source simulating the ER-GSM downlink signal was turned off. After power up the interrogator performed the downlink detection. No ER-GSM downlink signal was detected. In accordance with the specified test method, the interrogator started transmission at 920,1 MHz.

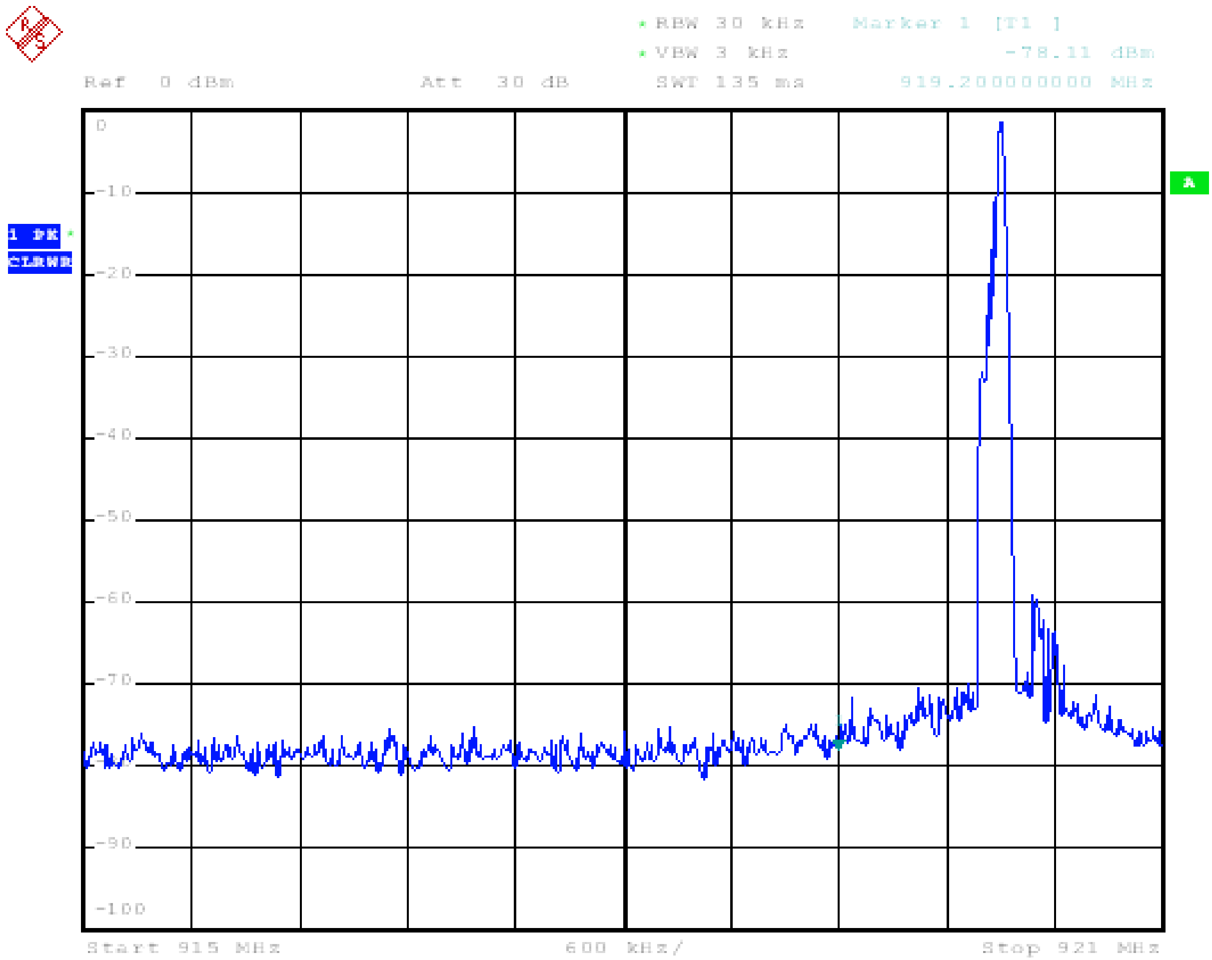



**Figure 3: Reader transmission at 920,1 MHz, no ER-GSM downlink signal**

The interrogator was then turned off. The signal source simulating the ER-GSM downlink signal was powered on. The signal source was adjusted to give a level at the input to the interrogator that is 3 dB above the appropriate threshold limit taken from table 3 in clause 5.3.6.4.

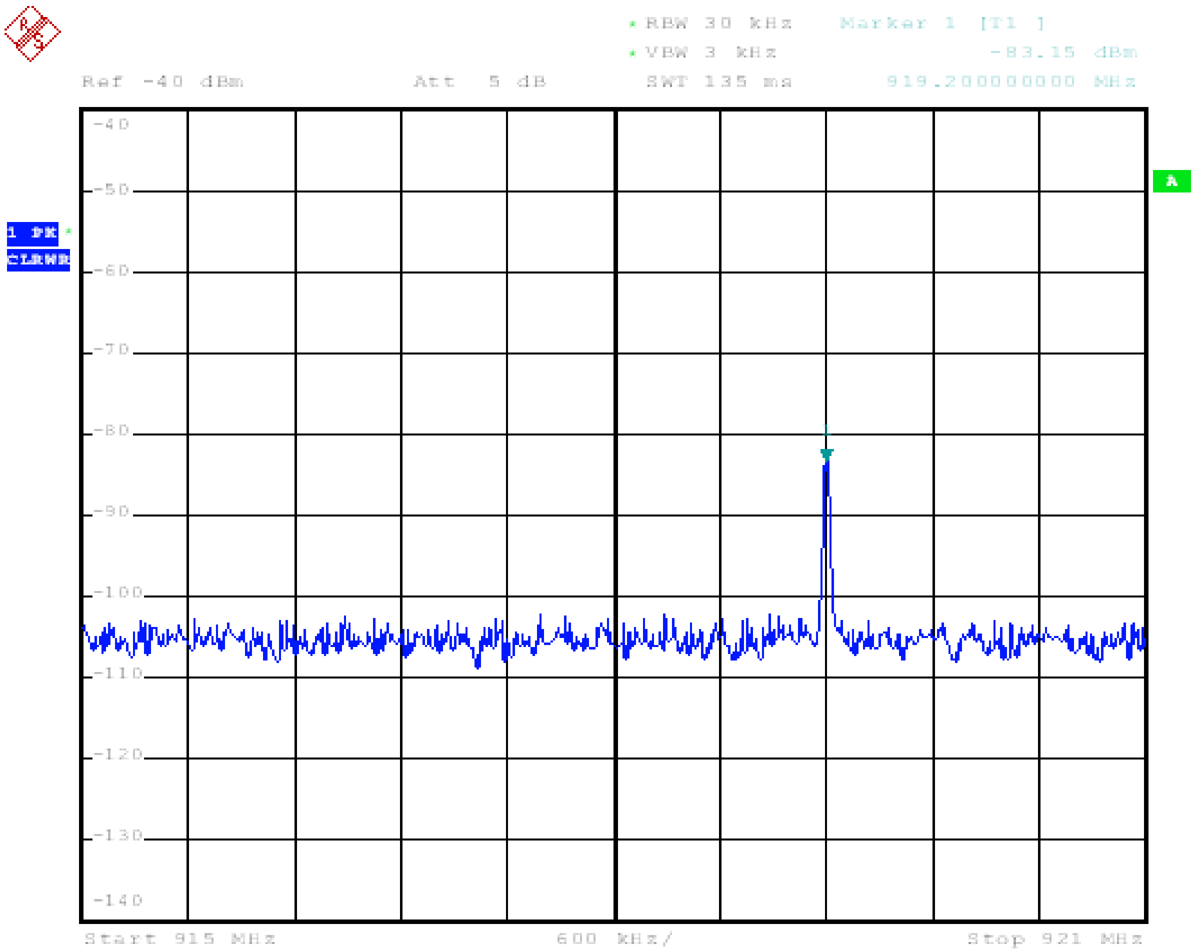



**Figure 4: Signal source at 919,2 MHz with a power level of -83 dBm**

The interrogator was powered on again. After power up the interrogator performed the downlink detection. The interrogator detected the downlink signal at a frequency of 919,2 MHz. In accordance with the specified test method, the interrogator started transmission at 916,5 MHz.

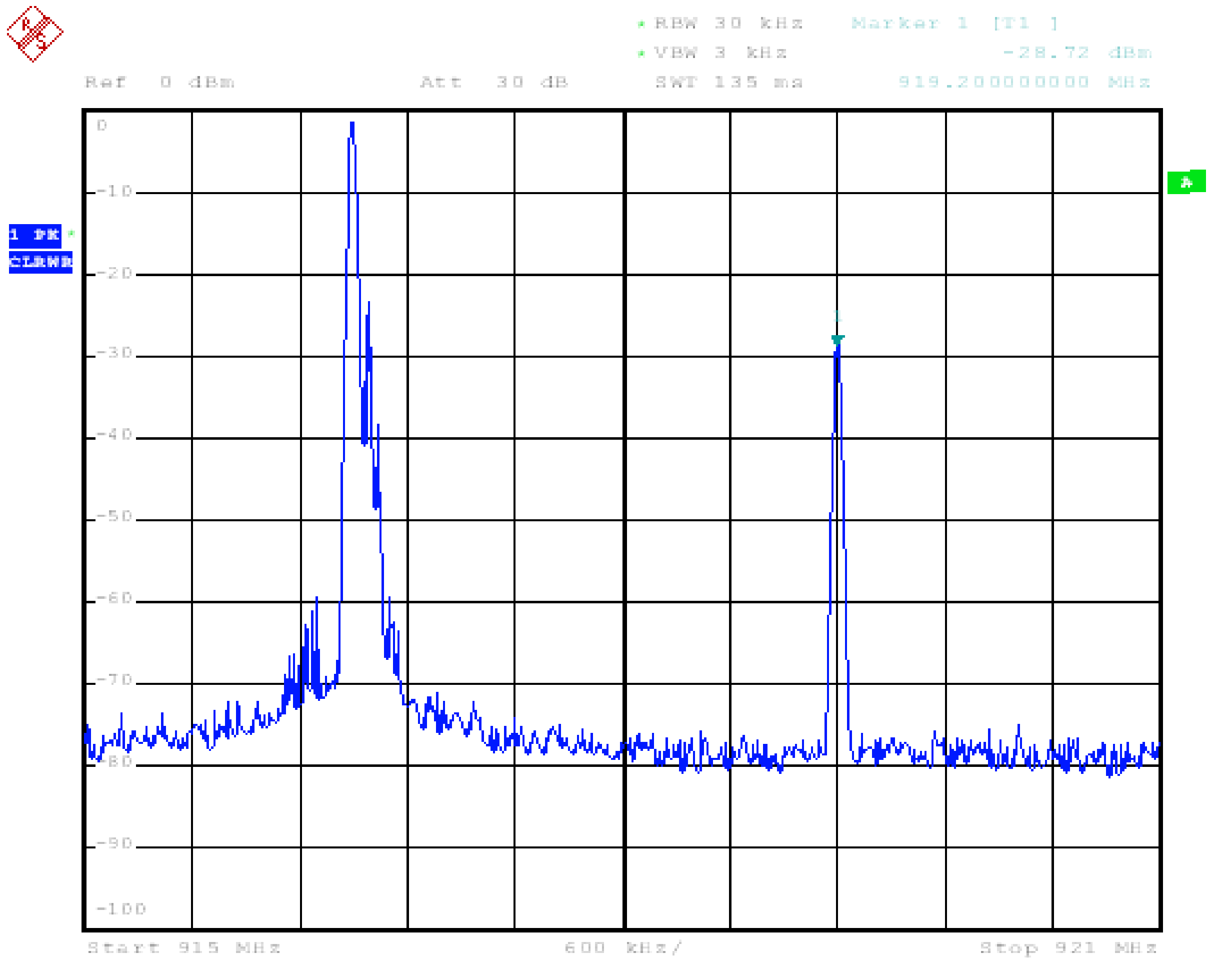



**Figure 5: Interrogator transmission at 916,5 MHz and ER-GSM downlink signal at 919,2 MHz**

This demonstration successfully showed that the interrogator is able to detect signals in the ER-GSM downlink band with power levels down to the defined threshold level.

## 5.3.2 Unmodulated Signal in the ER-GSM UL band

In the second part of the test the capability of the interrogator to detect a continuous unmodulated signal in the ER-GSM uplink band was shown. Initially the interrogator was powered on while the signal source simulating the ER-GSM uplink signal was turned off. After power up the interrogator performed the uplink detection. No ER-GSM uplink signal was detected. In accordance with the specified test method, the interrogator started transmission at 920.1 MHz.

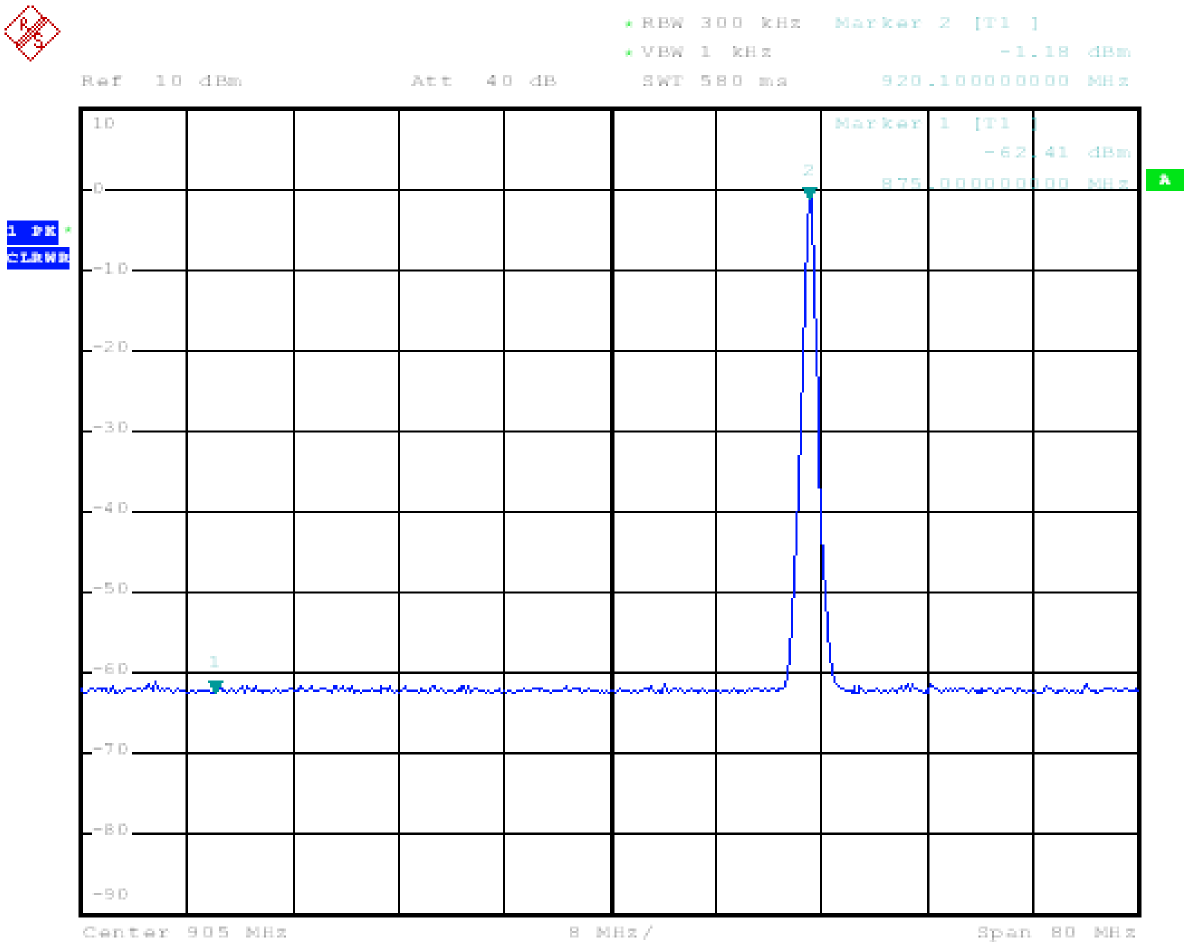



**Figure 6: Reader transmission at 920,1 MHz, no ER-GSM uplink signal**

The interrogator was then turned off. The signal source simulating the ER-GSM uplink signal was switched on. The signal source was adjusted to give a level at the input to the interrogator that is 3 dB above the appropriate threshold limit taken from table 5 in clause 5.3.7.4.2.

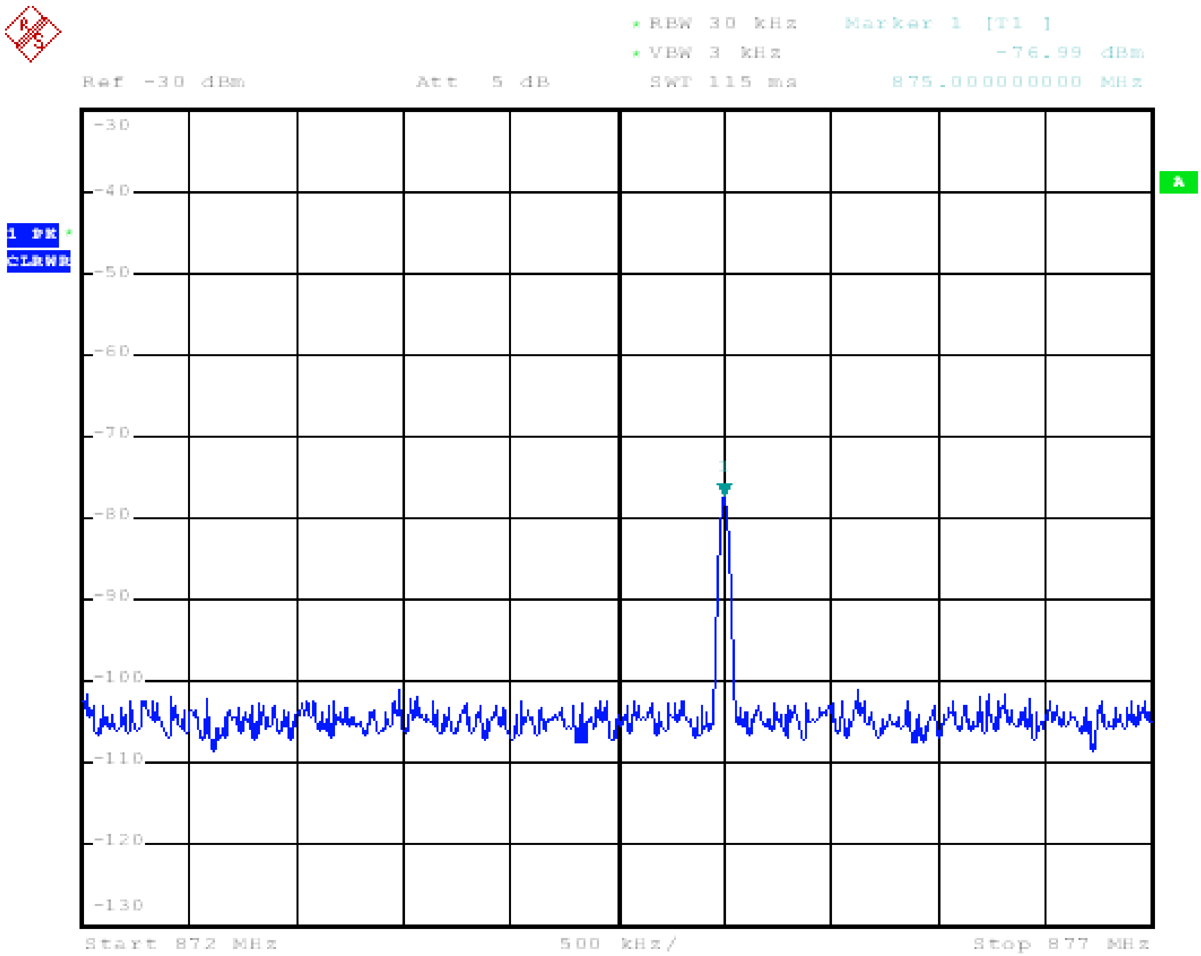



**Figure 7: Signal source at 875 MHz with a power level of -77 dBm**

The interrogator was powered up again. After power up the interrogator performed the uplink detection. The interrogator detected the uplink signal at a frequency of 875 MHz. In accordance with the specified test method, the interrogator started transmission at 916,5 MHz.

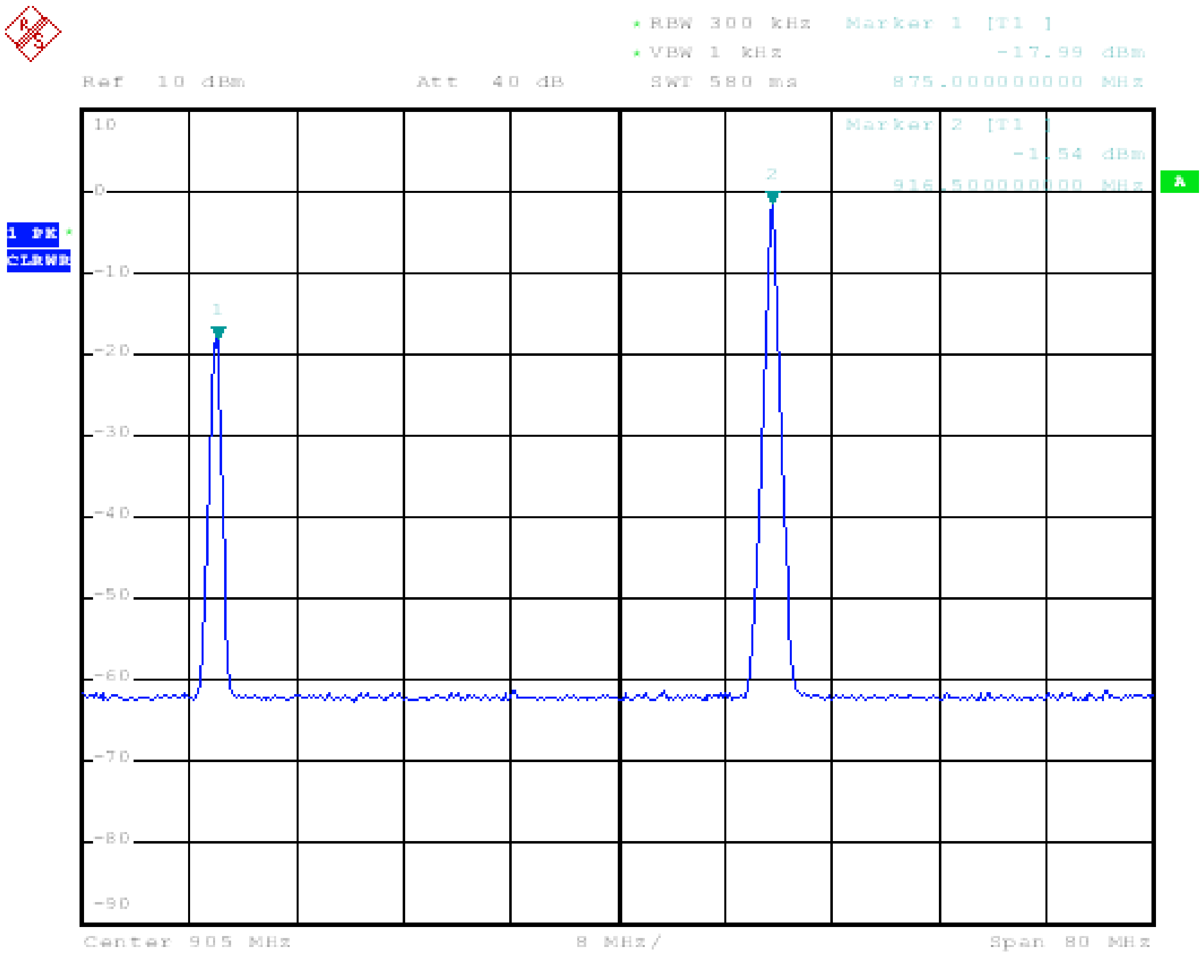



**Figure 8: Interrogator transmission at 916,5 MHz and ER-GSM uplink signal at 875 MHz**

This demonstration successfully showed that the interrogator is able to detect signals in the ER-GSM uplink band with power levels down to the defined threshold level.

# 5 Test procedures

## 5.1 Introduction

In this clause the conformance test procedures for the active mitigation techniques proposed in [2] will be presented.

## 5.2 Technical requirement specifications

### 5.2.1 General requirements

The present document describes test methods to ensure the co-existence of RFID and ER-GSM Systems in the frequency range between 915 MHz and 921 MHz. To achieve co-existence an interrogator should comply with the following requirements:

- The interrogator/interrogator antenna should be at least 20 m away from a railway track.

- Interrogators shall transmit on any of the high power channels specified in clause 5.2.2.2.1 at power levels up to the limit specified in clause 5.3.3.3. Interrogators shall transmit preferably on either of the high power channels with centre frequencies of 916,5 MHz and 917,7 MHz. The channels located at frequencies of, 918,9 MHz and 920,1 MHz shall be used either when the channels at 916,5 MHz and 917,7 MHz are unavailable or when the use of the channels 918,9 MHz or 920,1 MHz improves the performance of the RFID system. When interrogators use either of the channels 918,5 MHz or 920,1 MHz they shall use appropriate mitigation techniques as defined in the present document.

- Interrogators using only the high power channels with the centre frequencies 916,5 MHz and 917,7 MHz do not need to implement the additional mitigation techniques described below. Thus no tests related to the mitigation techniques are needed and only the spectrum requirements have to be met.

- In a preferred method of operation tags, which are activated by an interrogator transmitting in a high power channel, shall respond in the adjacent low power channels. This technique is called the dense interrogator mode. It has the benefit of separating the frequencies of transmission of the interrogators and tags, allowing multiple interrogators to share the same channel thereby improving system performance. It also minimizes the generation of inter-modulation products, which may disrupt the behaviour of tags.

Each interrogator shall be so configured as to ensure that its length of transmission is no greater than is necessary to perform the intended operation. According to their capabilities, interrogators can be categorized into three different classes:

- Class A: Interrogators without Detection Capabilities

- Class B: Interrogators with ER-GSM Downlink Detection Capability

- Class C: Interrogators with ER-GSM Uplink and Downlink Detection Capability

To demonstrate compliance with a specific class, the interrogator shall fulfil the requirements defined in table 1.

**Table 1: Interrogator classes**

<table>
<tr><th colspan="2">Class</th><th>Description</th><th>Compliance required in accordance with specified clauses</th></tr>
<tr><td colspan="2">A</td><td>Interrogators without Detection Capabilities</td><td>5.3.1, 5.3.2, 5.3.3, 5.3.4 and 5.3.5</td></tr>
<tr><td colspan="2">B</td><td>Interrogators with ER-GSM Downlink Detection Capability</td><td>5.3.1, 5.3.2, 5.3.3, 5.3.4, 6.3.5 and 5.3.6</td></tr>
<tr><td rowspan="2">C</td><td>C1</td><td>Interrogator with ER-GSM Downlink and Slow Uplink Detection Capability</td><td>5.3.1, 5.3.2, 5.3.3, 5.3.4, 5.3.5, 5.3.6 and 5.3.7</td></tr>
<tr><td>C2</td><td>Interrogator with ER-GSM Downlink and Fast Uplink Detection Capability</td><td>5.3.1, 5.3.2, 5.3.3, 5.3.4, 5.3.5, 5.3.6 and 5.3.7</td></tr>
</table>

### 5.2.1.1 Class A: Interrogators without detection capabilities

Interrogators according to class A shall only transmit at centre frequencies of 916,5 MHz and 917,7 MHz. Class A interrogators shall demonstrate this with the tests defined in clauses 5.3.1, 5.3.2, 5.3.3, 5.3.4 and 5.3.5.

### 5.2.1.2 Class B: Interrogators with ER-GSM Downlink detection capability

An interrogator complying with class B requirements shall perform a scan for the presence of a BCCH within the complete ER-GSM and R-GSM band across the frequency band 918,2 MHz to 924,8 MHz immediately on power up. There are 33 potential BCCH channels available located at centre frequencies between 918,2 MHz and 924,8 MHz with a spacing of 200 kHz. The detection threshold shall be in accordance with the limits defined in clause 5.3.6.4 measured at the centre frequency of each BCCH channel. To detect the presence of a BCCH, the interrogator shall recognize the pattern of its signal measured at the centre of a BCCH channel at a constant power level above the threshold for duration of at least 50 ms.

An interrogator shall not transmit on the RFID channels located at 918,9 MHz and 920,1 MHz while it continues to detect more than three BCCHs in the R-GSM band. If the number of detected BCCHs in the R-GSM band is three or less, the interrogator is allowed to transmit on all available RFID channels. If an interrogator detects the presence of a BCCH in the ER-GSM channel it shall not operate on the RFID channels 918,9 MHz and 920,1 MHz.

Scanning for BCCH by stationary interrogators shall be repeated at least once every 24 hours. A mobile interrogator shall repeat scanning at least every 15 minutes.

Class B interrogators shall demonstrate compliance with the tests defined in clauses 5.3.1, 5.3.2, 5.3.3, 5.3.4, 5.3.5, 5.3.6 and 5.3.7.

#### 5.2.1.3 Class C: Interrogators with ER-GSM Uplink and Downlink detection capability

##### 5.2.1.3.1 Class C1: Slow Uplink detection

A class C1 interrogator may transmit a continuous signal on any of the high power channels for a period not exceeding the limit defined in clause 5.3.7.4.3. At the end of the transmission the interrogator may transmit again for the same period on the same channel provided that it is still available.

Interrogators complying with class C1 shall be capable of detecting the downlink transmission from a BCCH in accordance with the specification in clause 5.2.1.2. If a class C1 interrogator detects a downlink transmission from a BCCH Channel in the ER-GSM or R-GSM band, detection of an ER-GSM uplink is mandatory. The detection of the uplink shall be performed within ±300 kHz of the uplink frequency corresponding to the RFID transmit channels located at either 918,9 MHz or 920,1 MHz. The detection threshold shall be in accordance with the limits defined in clause 6.3.7.4 at the centre frequency of the corresponding ER-GSM uplink channels. For uplink detection the interrogator shall detect the protocol sequence as defined in clause 5.3.7.4. If no uplink signal is detected within ±300 kHz of the corresponding ER-GSM uplink channels, the interrogator can transmit on the RFID channel in the corresponding ER-GSM downlink band. This is 45 MHz above the ER-GSM uplink channel as a consequence of the duplex spacing between UL and DL. (e.g. if the BCCH of a base station operates at a frequency of 920 MHz, the Mobile will transmit at a frequency of 875 MHz. The nearest high power RFID channel is located just 100 kHz below the BCCH of the base station.) Channels within ±300 kHz of the centre frequency of transmission of an interrogator on which no uplink signal is detected shall be monitored continuously by the interrogator. Any signal above the threshold level on an uplink channel within ±300 kHz shall be detected by the interrogator within 4 s of its transmission. If an uplink signal is detected within the specified frequency range, the interrogator shall register as blocked the channel on which the transmission occurred and shall not use the channel again until it is no longer occupied. A channel can be considered unoccupied once it is no longer possible to detect the BCCH transmission.

Class C1 interrogators shall demonstrate compliance with the tests defined in clauses 5.3.1, 5.3.2, 5.3.3, 5.3.4, 5.3.5, 6.3.6 and 5.3.7.

##### 5.2.1.3.2 Class C2: Fast Uplink detection

Interrogators complying with class C1 shall be capable of detecting the downlink transmission from a BCCH in accordance with the specification in clause 5.2.1.2. If a class C1 interrogator detects a downlink transmission from a BCCH Channel in the ER-GSM or R-GSM band, detection of an ER-GSM uplink is mandatory. The detection of the uplink shall be performed within ±300 kHz of the uplink frequency corresponding to the RFID transmit channels located at either 918,9 MHz or 920,1 MHz. The detection threshold shall be in accordance with the limits defined in clause 5.3.7.4 at the centre frequencies of the corresponding ER-GSM uplink channels. For uplink detection the interrogator shall detect the protocol sequence as defined in clause 5.3.7.4. If no uplink signal is detected within ±300 kHz of the corresponding ER-GSM uplink channel, the interrogator can use the RFID channel. (This is 45 MHz above the ER-GSM uplink channel as a consequence of the duplex spacing between UL and DL. e.g. If the BCCH of a base station is located at a frequency of 920 MHz, the Mobile communicates at a frequency of 875 MHz.) Channels within ±300 kHz of the centre frequency of transmission of an interrogator on which no uplink signal is detected shall be monitored continuously by the interrogator. Any signal above the threshold level on an uplink channel within ±300 kHz shall be detected by the interrogator within 50 ms of its initialisation. If an uplink signal is detected within the specified frequency range, the interrogator shall register the channel in which the transmission occurred as blocked and shall not use the channel again until it is no longer occupied. A channel can be considered unoccupied if it is not possible to detect the transmission specified in clause 5.3.8.4.2 in the channel for a continuous period of 1 second.

Class C2 interrogators shall demonstrate compliance with the tests defined in clauses 5.3.1, 5.3.2, 5.3.3, 5.3.4, 5.3.5, 5.3.6 and 5.3.7.

### 5.2.2.2 Operational frequency ranges

#### 5.2.2.2.1 Choice of frequencies

Interrogators shall operate within the band 915 MHz to 921 MHz in any one of the four specified high power channels as illustrated in figure 9. The band width of each high power channel shall be 400 kHz and the centre frequency of the lowest channel shall be 916,5 MHz. The remaining three high power channels shall be spaced at equal intervals of 1 200 kHz. Tags should preferably respond in the dense interrogator mode within the adjacent low power channels.

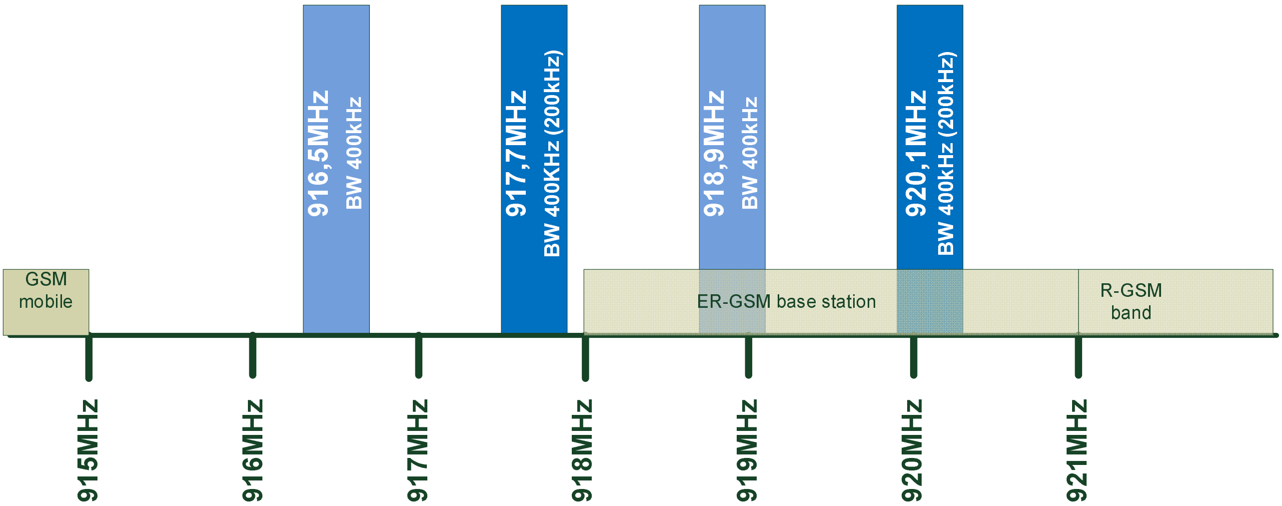



**Figure 9: Diagram of channel plan**

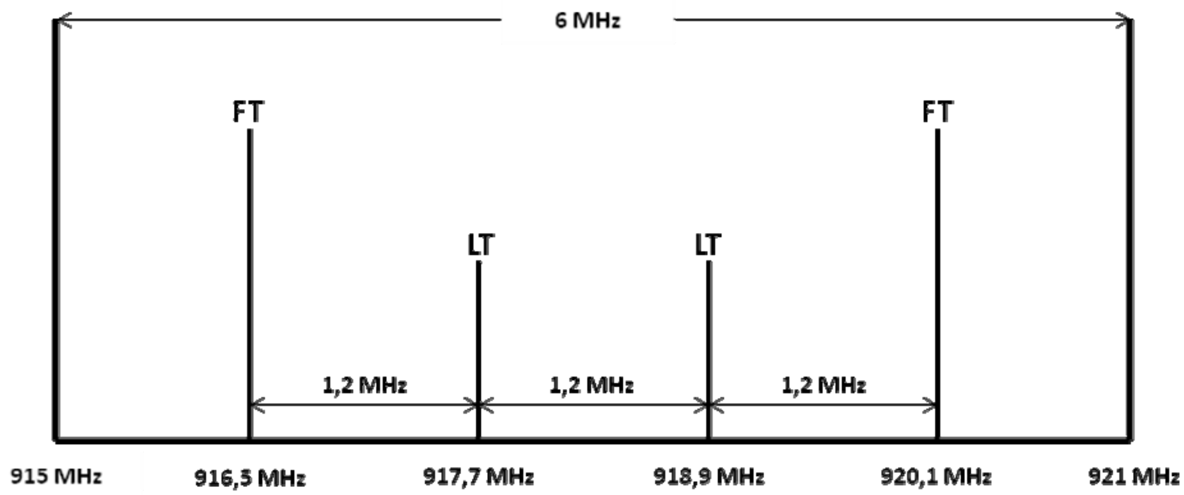
#### 5.2.2.2.2 Channel range

When submitting equipment for testing, the provider shall state the frequencies of the channels on which the interrogator will operate. The provider shall also confirm that the interrogator shall operate on each of the declared channels without any change to the circuit or trimming of discrete components.

Trimming is an act by which the value (in this case relating to frequency) of a component is changed within the circuit. This act may include the physical alteration, substitution (by components of similar size and type) or activation/de-activation (via the setting of soldered bridges) of components.

#### 5.2.2.2.3 Testing of operational frequencies

Figure 9 shows the centre frequencies of the four high power channels permitted for use by interrogators at levels up to 4 W e.r.p. within the band designated for RFID. Full (FT) and Limited (LT) Tests, as defined in clause 3.1 in [1], shall be carried out in the applicable channels at the frequencies shown in figure 10.




Legend: LT: Limited tests, see clause 3.1 in [1].
FT: Full tests, see clause 3.1 in [1].

**Figure 10: Tests on a single sample for equipment within the band 915,0 MHz to 921,0 MHz**

# 5.3 Methods of measurement and limits for transmitter parameters

Where the interrogator is designed with an adjustable carrier, then all transmitter parameters specified in clause 6.3 shall be measured at the highest power level. The equipment shall then be set to the lowest carrier power setting and the measurements for spurious emissions shall be repeated (see clause 6.3.5).

During all tests care should be taken to ensure that no IM3 products above the corresponding threshold level are generated by the measurement equipment.

## 5.3.1 Frequency error for mains operated equipment

### 5.3.1.1 Definition

The frequency error, known as frequency drift, is the difference between the frequency of the device under test measured under normal test conditions (see clause 5.3 in [1]) and the frequency measured under extreme test conditions (see clause 5.4 in [1]).

### 5.3.1.2 Method of measurement of frequency error

The measurements shall be made with the interrogator set to transmit a continuous un-modulated carrier and performed at each of the applicable frequencies specified in clause 5.2.3.

a) Under normal test conditions:

- The signal transmitted by the interrogator shall be connected by suitable means to the input of a frequency counter. The frequency displayed on the frequency counter shall be recorded.

b) Under extreme test conditions:

- For each combination of extreme voltage and temperature (see clause 5.4 in [1]) the frequency displayed on the frequency counter shall be recorded. Four values shall be measured.

#### 5.3.1.3 Limits

The maximum permitted frequency drift, defined as the absolute value of fe-f, shall not exceed ±10 ppm relative to the nominal centre frequency of each of the applicable channels, where:

- f = the frequency measured under normal test conditions (see clause 5.3.1.2, a)).
- fe = the maximum frequency drift as measured in clause 5.3.1.2, b).

NOTE: Where multiple interrogators are co-located, tighter limits may be necessary to avoid unacceptable beat tones.

### 5.3.2 Frequency stability under low voltage conditions

This test is for battery operated equipment. The measurement shall be made under normal temperature and humidity conditions (see clause 5.3.1 in [1]).

#### 5.3.2.1 Definition

The frequency stability under low voltage conditions is the ability of the equipment to remain within its permitted frequency limits when the battery voltage falls below the lower extreme voltage level.

#### 5.3.2.2 Method of measurement

Step 1: An interrogator shall be set up to transmit a continuous un-modulated carrier. The signal transmitted by the interrogator shall be connected by suitable means to the input of a frequency counter.

Step 2: The frequency displayed on the frequency counter shall be recorded.

Step 3: The voltage from the test power source shall be reduced below the lower extreme test voltage limit towards zero. Whilst the voltage is reduced the carrier frequency shall be monitored.

#### 5.3.2.3 Limits

The equipment shall either:

- transmit with a carrier frequency within the limits of ±10 ppm whilst the radiated or conducted power is below the spurious emission limits; or
- automatically cease to function below the provider's declared operating voltage.

NOTE: Where multiple interrogators are co-located, tighter limits may be necessary to avoid unacceptable beat tones.

### 5.3.3 Radiated power (e.r.p.)

This measurement applies to equipment with an integral antenna and to equipment supplied with an external antenna. Both radiated and conducted methods of measurement are permitted. Where the conducted method is used, the conducted power shall be adjusted to take into account the gain of the antenna and be stated as e.r.p.

If the equipment is designed to operate with different carrier powers, the provider shall declare the rated power for each level or range of levels.

#### 5.3.3.1 Definition

The effective radiated power is the product of the power supplied to the antenna and its gain relative to a half wave dipole in the direction of maximum gain in the absence of modulation.

### 5.3.3.2 Method of measurement

These measurements shall be performed with an un-modulated carrier at the highest power level at which the transmitter is intended to operate.

For both methods of measurement the measuring receiver shall be set up in accordance with the requirements of clause 6.6 in [1].

#### 5.3.3.2.1 Radiated measurement

This measurement shall be carried out under normal test conditions only (see clause 5.3 in [1]).

Step 1: On a test site, selected from annex A in [1] the interrogator shall be placed at the specified height on a support, as specified in annex A in [1], and in the position closest to normal use as declared by the provider.

Step 2: A test antenna shall be oriented initially for vertical polarization and shall be chosen to correspond to the carrier frequency of the interrogator. The output of the test antenna shall be connected to a measuring receiver.

Step 3: The interrogator shall be set to transmit continuously, without modulation, on one of the high power channels shown in figure 10. The measuring receiver shall be positioned in the far field as defined in annex A in [1] and tuned to the frequency of the transmission under test.

Step 4: The test antenna shall be raised and lowered through the specified heights until the maximum signal level is detected by the measuring receiver.

Step 5: The interrogator shall then be rotated through 360º in the horizontal plane, until the maximum signal level is detected by the measuring receiver.

Step 6: The test antenna shall be raised and lowered again through the specified heights until the maximum signal level is detected by the measuring receiver. The maximum signal level detected by the measuring receiver shall be noted.

Step 7: The antenna of the interrogator shall be rotated in the horizontal plane in both directions to positions where the signal at the measuring receiver is reduced by 3 dB. The total angle of rotation (which is the horizontal beamwidth of the antenna) shall be recorded.

Step 8: The interrogator shall be replaced by a substitution antenna as defined in clause A.1.5 in [1]. The substitution antenna shall be connected to a calibrated signal generator. The substitution antenna shall be orientated for vertical polarization and the length of the substitution antenna shall be adjusted to correspond to the frequency of transmission of the interrogator. If necessary, the setting of the input attenuator of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver.

Step 9: The test antenna shall be raised and lowered through the specified heights to ensure that the maximum signal is received.

Step 10: The input signal to the substitution antenna shall be adjusted to give a level at the measuring receiver that is equal to the radiated power previously measured from the interrogator, corrected for any change to the setting of the input attenuator to the measuring receiver.

Step 11: The input level to the substitution antenna shall be recorded as power level, corrected for any change of input attenuator setting of the measuring receiver.

Step 12: The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarization.

Step 13: The measure of the effective radiated power is the larger of the two levels recorded at the input to the substitution antenna, corrected if necessary for the gain of the substitution antenna.

Step 14: With the interrogator fitted into a suitable test fixture, the relative change of the effective radiated power between normal and extreme test conditions (see clauses 5.4.1 and 5.4.2 in [1] applied simultaneously) shall be compared. Any increase in the radiated power under extreme test conditions shall not cause the level to exceed the limit specified in clause 5.3.3.3.

#### 5.3.3.2.2 Conducted measurement

Where an interrogator is fitted with an external antenna connector it is permissible to measure the conducted power. In this case the provider shall declare the maximum gain and beamwidth(s) of the external antenna(s) at the time that the equipment is presented for test.

Step 1: The transmitter shall be configured to operate on one of the high power channels shown in figure 10 and shall be connected to an artificial antenna (see clause 6.2 in [1]). The carrier or mean power delivered to this artificial antenna shall be measured under normal test conditions (see clause 5.3 in [1]).

Step 2: The measurement shall be repeated under extreme test conditions (see clauses 5.4.1 and 5.4.2 in [1] applied simultaneously).

Step 3: The recorded value shall be corrected for each of the antenna gains and be stated in e.r.p. To calculate the allowed conducted power with a circularly polarized antenna, the following formula shall be used:

$$P_C = P_{erp} - G_{IC} + 5{,}15 + C_L \text{ dBm}$$

Where:

$P_C$ = interrogator conducted transmit power in dBm;

$G_{IC}$ = antenna gain of a circular antenna in dBic;

$C_L$ = total cable loss in dB.

Step 4: Where the interrogator switches between multiple transmitter outputs, the power level shall be measured at each output.

### 5.3.3.3 Limits

The effective radiated power on each of the four high power channels specified in figure 10 shall not exceed 36 dBm e.r.p.

## 5.3.4 Transmitter spectrum mask

### 5.3.4.1 Definition

The transmitter spectrum mask defines the limits within the range fc ± 1 000 kHz for the average power of all modulated signals including all side bands associated with the carrier.

### 5.3.4.2 Method of measurement

The RF output of the equipment shall be connected to a spectrum analyser via a 50 Ω connector. In the case of equipment with an integral antenna, the equipment shall be placed in the test fixture (see clause 6.3 in [1]) and the test fixture shall be connected to the spectrum analyser. Measurements shall be made on the declared channels of operation of the interrogator on those channels requiring full tests as defined in figure 10.

Step 1: The interrogator shall be operated at the carrier power measured under normal test conditions in clause 5.3.3. The attenuator shall be adjusted to give an appropriate display on the spectrum analyser screen.

Step 2: The interrogator shall be configured to generate a succession of modulated transmit pulses. Each transmit pulse shall be modulated by the normal test signal (see clause 6.1 in [1]). The length of each transmit pulse shall be not less than 10 ms and not greater than 50 ms. The interval between successive transmit pulses shall be not less than 1 ms and shall not exceed 10 ms.

Step 3: The output power of the interrogator, with or without a test fixture, shall be measured using a spectrum analyser, which shall be set to the following values:

- Resolution bandwidth: 1 kHz
- Video bandwidth: Equal to the RBW
- Sweep Time: AUTO
- Span: 2 MHz
- Trace mode Max hold sufficient to capture all emissions
- Detection mode Average

Step 4: For frequencies inside fc ± 1 000 kHz the measured values are the absolute values. The absolute levels of RF power shall be compared to the spectrum mask at figure 11 (see note).

Step 5: Where the interrogator includes multiple transmitter outputs, all of the outputs shall be connected via a suitable combiner network to the spectrum analyser. With the interrogator set up as in step 1 and configured to transmit the test signal described in step 2 while in its operational mode, the spectrum mask shall be measured at the spectrum analyser. The measured values shall be adjusted to compensate for the attenuation of the combiners and compared to the spectrum mask at figure 11.

NOTE: If for any reason the spectrum is measured with a resolution bandwidth other than 1 kHz, the measured values may be converted to the absolute values using the formula:

$$B = A + 10 \log \frac{1kHz}{BW_{MEASURED}}$$

Where:

- A is the value at the measured resolution bandwidth;
- B is the absolute value referred to a 1 kHz reference bandwidth; or

use the measured value, A, directly if the measured spectrum is a discrete spectral line (a discrete spectrum line is defined as a narrow peak with a level of at least 6 dB above the average level inside the measurement bandwidth).

### 5.3.4.3 Limits

The absolute levels of RF power at any frequency shall not exceed the limits defined in the spectrum mask envelope at figure 11 in which the X axis shall be in linear frequency and the Y axis shall be scaled in dBm e.r.p.

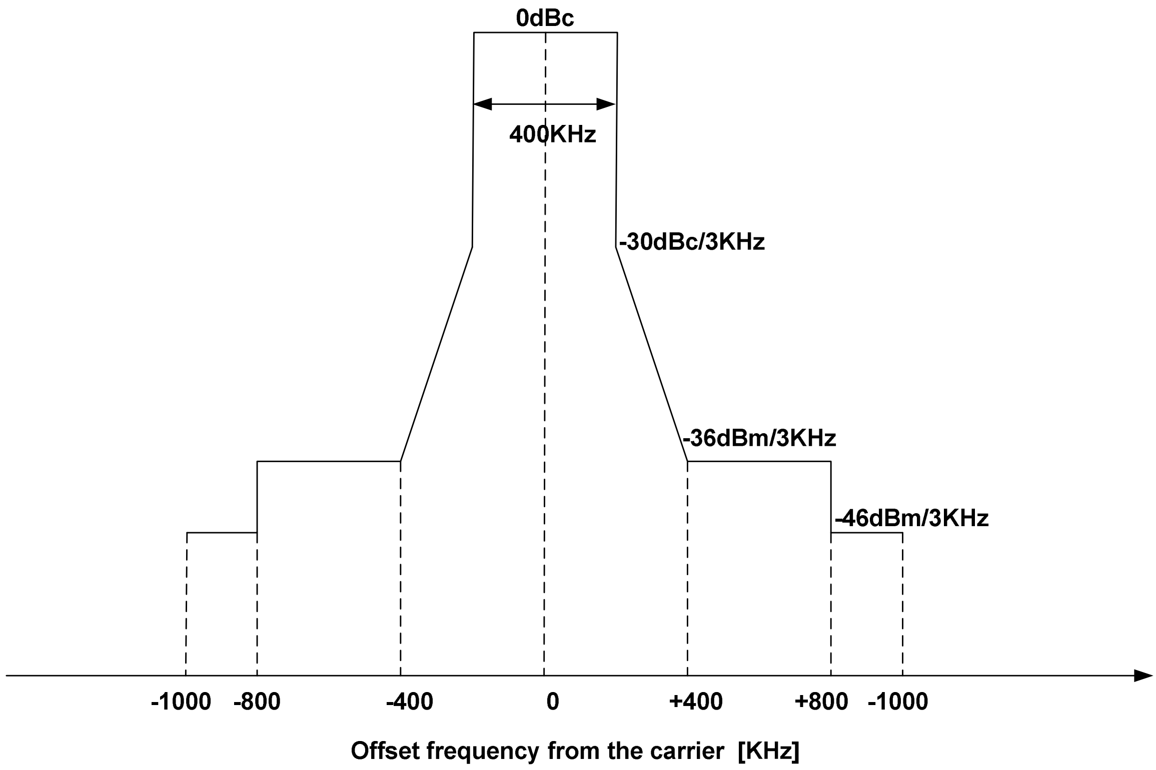



**Figure 11: Spectrum mask for modulated signals**

## 5.3.5 Unwanted emissions in the spurious domain

### 5.3.5.1 Definition

Spurious emissions are emissions at frequencies other than those of the wanted carrier frequency and its sidebands associated with normal test modulation.

### 5.3.5.2 Method of measurement

Spurious emissions shall be measured at frequencies outside the band fc ± 1 000 kHz where fc is the carrier frequency of the interrogator. The level of spurious emissions shall be measured as:

either:

a) i) their power level in a specified load (conducted spurious emission); and

ii) their effective radiated power when radiated by the cabinet and structure of the equipment (cabinet radiation); or

b) their effective radiated power when radiated by the cabinet and the integral antenna, in the case of equipment fitted with such an antenna and no external RF connector.

#### 5.3.5.2.1 Method of measuring the power level in a specified load, clause 5.3.5.2, a) i)

This method applies only to equipment with an external antenna connector.

Step 1: The interrogator shall be connected to a 50 Ω power attenuator. The output of the power attenuator shall be connected to a measuring receiver. The interrogator shall be set up to generate a succession of modulated transmit pulses (see clause 8.4.2 of [1]).

In the event that the carrier signal from the interrogator is too high for the dynamic range of the measurement receiver, a notch filter may optionally be connected between the measurement antenna and the measurement receiver to attenuate the carrier signal. This may be used for measurements at greater than 4 MHz from the carrier. The filter shall have a loss of less than 3 dB at ±2 MHz from fc.

Step 2: The measuring receiver, (see clause 6.6 of [1]) shall be tuned over the frequency range of 30 MHz to 5 GHz. For each of the frequency ranges specified in figure 12, the measuring receiver shall be set to the following values:

a) Resolution bandwidth: In accordance with the figure 12

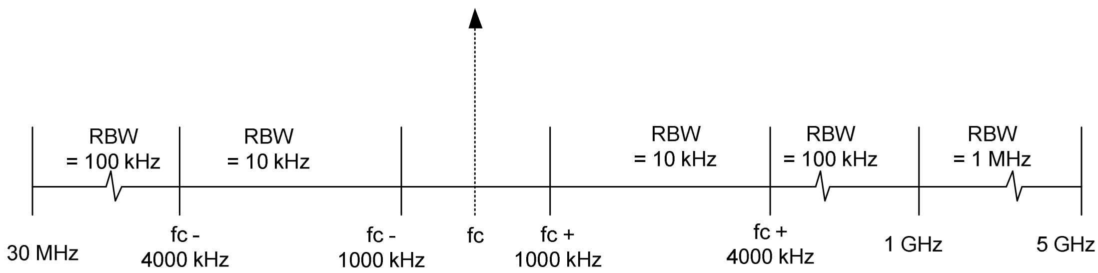
b) Video bandwidth: Equal to the RBW

c) Sweep time: Auto

d) Span: As defined by the relevant frequency ranges in figure 12

e) Trace mode: Max hold sufficient to capture emissions

f) Detection mode: Average




NOTE: See clause 5.3.4 for the frequency range fc - 1 000 kHz to fc + 1 000 kHz.

**Figure 12 Resolution bandwidths for spurious emissions**

Step 3: At each frequency outside the band defined by fc ± 1 000 kHz at which a spurious component is detected, the power level shall be recorded as the conducted spurious emission level delivered into the specified load.

Step 4: The measurements shall be repeated with the interrogator on stand-by.

Step 5: The measurements shall be adjusted to give the output power of the interrogator with its declared antenna in e.r.p.

#### 5.3.5.2.2 Method of measuring the effective radiated power, clause 5.3.5.2, a) ii)

This method applies only to equipment with an external antenna connector.

Step 1: On a test site, selected from annex A, the interrogator shall be placed at the specified height on a non-conducting support and in the position closest to normal use as declared by the provider.

Step 2: The antenna connector of the interrogator shall be connected to an artificial antenna (see clause 6.2 of [1]).

Step 3: A test antenna shall be orientated for vertical polarization and the length of the test antenna shall be chosen to correspond to the instantaneous frequency of the measuring receiver. The output of the test antenna shall be connected to a measuring receiver.

In the event that the carrier signal from the interrogator is too high for the dynamic range of the measurement receiver, a notch filter may optionally be connected between the measurement antenna and the measurement receiver to attenuate the carrier signal. This may be used for measurements at greater than 4 MHz from the carrier. The filter shall have a loss of less than 3 dB at ±2 MHz from fc.

Step 4: The interrogator shall be set up to generate a succession of modulated transmit pulses as described in step 2 of (see clause clause 8.4.2 of [1]).

Step 5: The measuring receiver (see clause 6.6 of [1]) shall be tuned over the frequency range 30 MHz to 5 GHz, but excluding the band defined by fc ±500 kHz. The measurements shall be performed with the measuring receiver set to the following values:

a) Resolution bandwidth: In accordance with the figure 12

b) Video bandwidth: Equal to the RBW

c) Sweep time: Auto

d) Span: As defined by the relevant frequency ranges in figure 12

e) Trace mode: Max hold sufficient to capture emissions

f) Detection mode: Average

Step 6: At each frequency at which a spurious component is detected, the test antenna shall be raised and lowered through the specified heights until a maximum signal level is detected by the measuring receiver.

Step 7: The interrogator shall then be rotated through 360º in the horizontal plane, until the maximum signal level is detected by the measuring receiver and the test antenna height shall be adjusted again for maximum signal level.

Step 8: The maximum signal level detected by the measuring receiver shall be noted.

Step 9: The interrogator shall be replaced by a substitution antenna (see clauses A.1.4 and A.1.5 in [1]).

Step 10: The substitution antenna shall be orientated for vertical polarization and calibrated for the frequency of the spurious component detected.

Step 11: The substitution antenna shall be connected to a calibrated signal generator.

Step 12: The frequency of the calibrated signal generator shall be set in turn to the frequency of each of the spurious components detected. If necessary the input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver.

Step 13: The test antenna shall be raised and lowered through the specified range of heights to ensure that the maximum signal is received. (When a test site according to clause A.1.1 is used, the height of the antenna need not be varied.)

Step 14: The input signal to the substitution antenna shall be adjusted to give a level at the measuring receiver, that is equal to the level noted while the spurious component was measured, corrected for any change to the setting of the input attenuator of the measuring receiver.

Step 15: The input level to the substitution antenna shall be recorded as a power level, corrected for any change of input attenuator setting of the measuring receiver.

Step 16: The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarization.

Step 17: The measure of the effective radiated power of the spurious components is the larger of the two power levels recorded for each spurious component at the input to the substitution antenna, corrected if necessary for the gain of the substitution antenna.

Step 18: If applicable, the measurements shall be repeated with the interrogator on standby.

#### 5.3.5.2.3 Method of measuring effective radiated power, clause 5.3.5.2, b)

This method applies only to equipment without an external antenna connector. The method of measurement shall be performed according to clause 5.3.5.2.2, except that the interrogator output shall be connected to the integral antenna and not to an artificial antenna.

### 5.3.5.3 Limits

The level of any spurious emission, conducted or radiated, outside the frequency range fc ± 1 000 kHz shall not exceed the values given in table 2.

**Table 2: Spurious emission limits in e.r.p.**

| State | 47 MHz to 74 MHz<br>87,5 MHz to 118 MHz<br>174 MHz to 230 MHz<br>470 MHz to 862 MHz | Other frequencies below 1 000 MHz | Frequencies above 1 000 MHz |
|---|---|---|---|
| Operating | 4 nW (-54 dBm) | 250 nW (-36 dBm) | 1 µW (-30 dBm) |
| Standby | 2 nW (-57 dBm) | 2 nW (-57 dBm) | 20 nW (-47 dBm) |

## 5.3.6 Downlink detection

### 5.3.6.1 Definition

Downlink detection is necessary to demonstrate that an interrogator is able to detect the presence of a ER-GSM Base Station. To avoid interference between an active interrogator and the TCH of an ER-GSM Base Station, the interrogator shall detect the presence of a BCCH within the complete frequency band between 918 MHz and 924,8 MHz. This is the band used by R-GSM and ER-GSM systems for their down link.

### 5.3.6.2 Downlink detection mode

The manufacturer shall demonstrate that immediately after power-up, the receiver associated with an interrogator shall first monitor for the presence of BCCHs within the frequency band 918 MHz to 925 MHz (ER-GSM and R-GSM bands). The detection capability of the interrogator shall be tested according to clause 5.3.6.3.

The interrogator shall not operate on RFID channels 918,9 MHz and 920,1 MHz when it detects the presence of a single BCCH in the ER-GSM band. An interrogator shall not operate using the RFID channel 918,9 MHz and 920,1 MHz when more than three BCCH channels have been detected in the R-GSM band between 921 MHz to 925 MHz. A detected BCCH is defined as a BCCH received with a power level above the given threshold defined in clause 5.3.6.4.

Detecting the presence of a BCCH shall be performed each time an interrogator is switched on. If a fixed interrogator is dedicated for permanent operation, detection shall be repeated at least once every 24 hours. A mobile interrogator shall perform a detection at least once every 15 minutes. This timing constraint shall be declared by the manufacturer in accordance with the type of interrogator.

### 5.3.6.3 Method of measurement

This test is designed to verify that the interrogator is able to detect the presence of a R-GSM Base Station . The measurement shall be carried out under normal conditions.

#### 5.3.6.3.1 Method of measuring radiated signals in the R-GSM band

Step 1: A measurement antenna shall be positioned at a known point on a test site selected from annex A in [1] and connected either to a measurement receiver or spectrum analyser.

Step 2: A second antenna shall be positioned at a distance of 3 m from the measurement antenna in its direction of maximum gain. The antenna shall be connected to a combiner which adds the signals coming from 4 connected signal sources A, B, C and D.

Step 3: Signal source A shall be set to transmit a continuous carrier and its frequency tuned to 921,2 MHz. The signal from signal source A shall be adjusted to give a level at the measurement receiver that is 3 dB above the appropriate threshold limit taken from table 3. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test.

Step 4: Signal source B shall be set to transmit a continuous carrier and its frequency tuned to 922,2 MHz. The signal from signal source B shall be adjusted to give a level at the measurement receiver that is 3 dB above the appropriate threshold limit taken from table 3. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test.

Step 5: Signal source C shall be set to transmit a continuous carrier and its frequency tuned to 923,2 MHz. The signal from signal source C shall be adjusted to give a level at the measurement receiver that is 3 dB above the appropriate threshold limit taken from table 3. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test.

Step 6: Signal source D shall be set to transmit a continuous carrier and its frequency tuned to 924,2 MHz. The signal from signal source D shall be adjusted to give a level at the measurement receiver that is 3 dB above the appropriate threshold limit taken from table 3. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test.

During calibration only one signal source shall be active at any time.

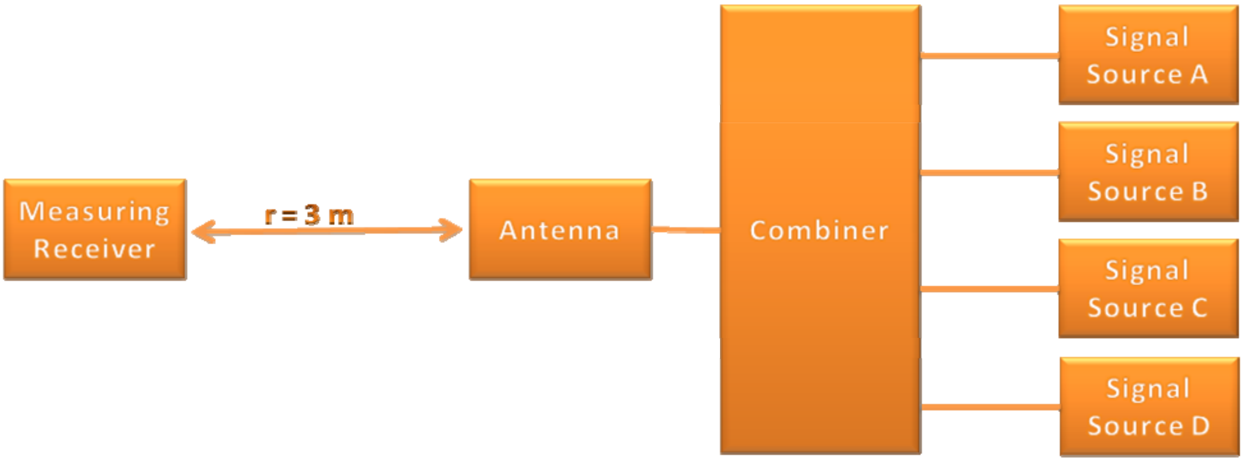



**Figure 13: Calibration of field levels for R-GSM Downlink detection**

Step 7: The measurement antenna and receiver shall be replaced by the interrogator under test. The antenna of the interrogator shall be orientated so that its direction of maximum gain is aligned with the antenna of the four signal sources.

Step 8: The measurement antenna and receiver shall be positioned at a convenient distance from the interrogator in accordance with the layout in figure 14. The sensitivity of the measurement receiver shall be adjusted to measure transmissions from the interrogator while not detecting transmissions from the signal sources A, B, C and D.

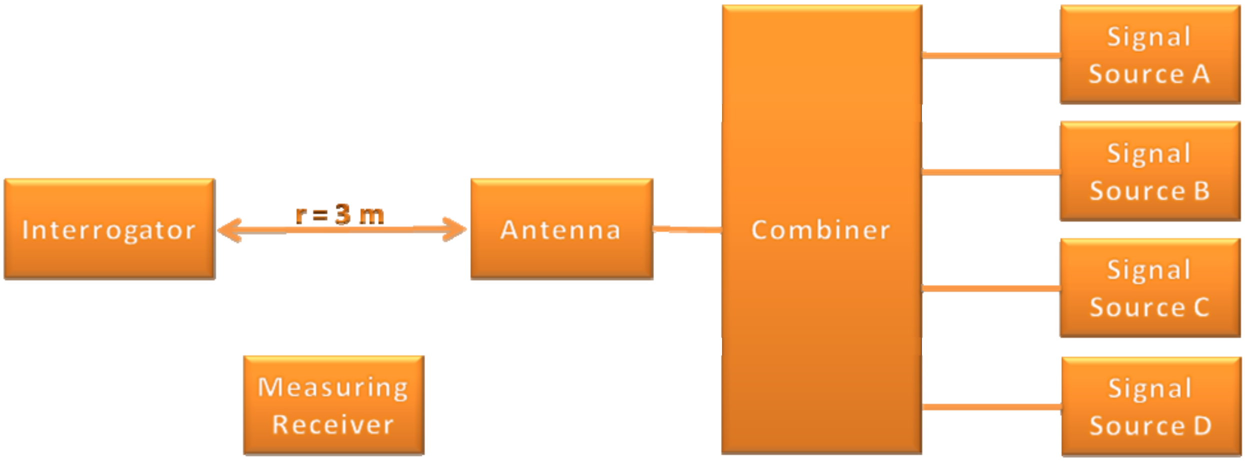



**Figure 14: Radiated measurement of R-GSM Downlink detection**

Step 9: With signal sources A, B, C and D switched off, the power supply to the interrogator shall be switched on. After power up the interrogator shall automatically switch to scan mode.

Step 10: The transmission from the interrogator shall be monitored. The interrogator transmission shall hop through all the available high power channels in the frequency range between 915 MHz and 921 MHz.

Step 11: The supply voltage of the interrogator shall be switched off.

Step 12: With signal sources A, B, C and D switched on the power supply to the interrogator shall be switched on and the interrogator should automatically switch to scan mode. The frequency of transmission from the interrogator shall be monitored.

Step 13: If the frequency of transmission from the interrogator lies always below 918 MHz, the interrogator has successfully detected the signals from sources A, B, C and D. If transmission by the interrogator is also detected within the band from 918 MHz to 921 MHz, the interrogator has failed to detect the signals from sources A, B, C and D.

#### 5.3.6.3.2 Method of measuring radiated signals in the ER-GSM band

Step 1: A measurement antenna shall be positioned at a known point on a test site selected from annex A in [1] and connected either to a measurement receiver or spectrum analyser.

Step 2: A second antenna shall be positioned at a distance of 3 m from the measurement antenna in its direction of maximum gain. The antenna shall be connected to a signal source A.

Step 3: Signal source A shall be set to transmit a continuous carrier and its frequency tuned to 918,2 MHz. The signal from signal source A shall be adjusted to give a level at the measurement receiver that is 3 dB above the appropriate threshold limit taken from table 3. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test.


**Figure 15: Calibration of field levels for ER-GSM Downlink detection**

Step 4: The measurement antenna and receiver shall be replaced by the interrogator under test. The antenna of the interrogator shall be orientated so that its direction of maximum gain is aligned with the antenna of the signal source.

Step 5: The measurement antenna and receiver shall be positioned at a convenient distance from the interrogator in accordance with the layout in figure 16. The sensitivity of the measurement receiver shall be adjusted to measure transmissions from the interrogator while not detecting transmissions from the signal source A.

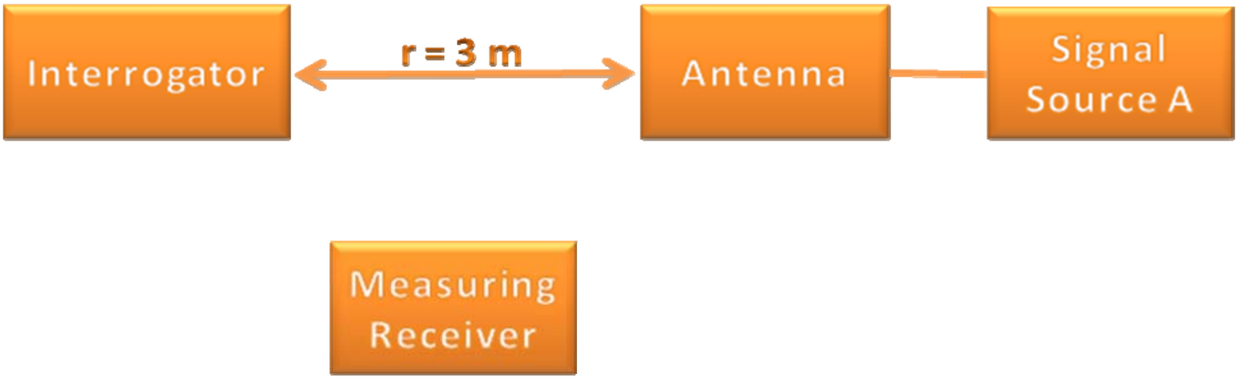



**Figure 16: Radiated measurement of ER-GSM Downlink detection**

Step 6: With signal source A switched off, the power supply to the interrogator shall be switched on. After power up the interrogator shall automatically switch to scan mode.

Step 7: The transmission from the interrogator shall be monitored. The interrogator transmission shall hop through all the available high power channels in the frequency range between 915 MHz and 921 MHz.

Step 8: The supply voltage of the interrogator shall be switched off.

Step 9: With signal source A switched on the power supply to the interrogator shall be switched on and the interrogator should automatically switch to scan mode. The frequency of transmission from the interrogator shall be monitored.

Step 10: If the frequency of transmission from the interrogator lies always below 918 MHz, the interrogator has successfully detected the signal from source A. If transmission by the interrogator is also detected within the band from 918 MHz to 921 MHz, the interrogator has failed to detect the signal from source A.

### 5.3.6.3.3 Conducted method of measurement for signals in the R-GSM band

Where the interrogator is fitted with an external antenna connector, the measurement may be made using power splitters.

Step 1: The measurement receiver is connected to the input of a power splitter. Four inputs of the power splitter are connected to a signal sources A, B C and D. The other input is connected to a 50 Ω resistor. A diagram of the test configuration is shown at figure 17.

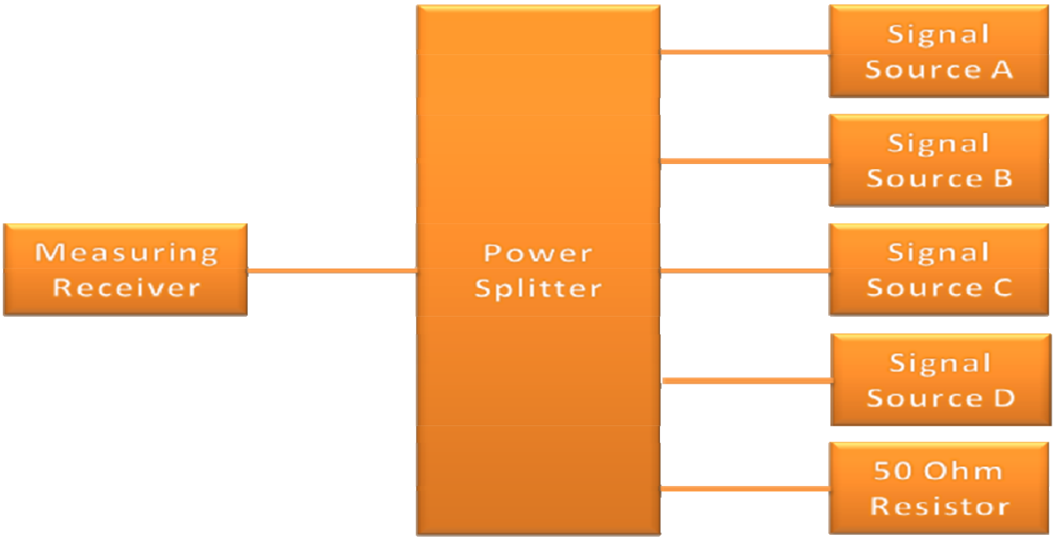



**Figure 17: Calibration of field levels for Conducted R-GSM Downlink detection**

Step 2: Signal source A shall be adjusted to produce an un-modulated continuous carrier with its frequency tuned to 921,2 MHz. The signal shall be adjusted to give a level at the input to the receiver of the interrogator that is 3 dB above the appropriate threshold limit taken from table 3. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test. The level of the signal from the signal source A shall be adjusted for any loss in the power splitters to give the corrected signal received by the interrogator.

Step 3: Signal source B shall be adjusted to produce an un-modulated continuous carrier with its frequency tuned to 922,2 MHz. The signal shall be adjusted to give a level at the input to the receiver of the interrogator that is 3 dB above the appropriate threshold limit taken from table 3. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test. The level of the signal from the signal source B shall be adjusted for any loss in the power splitters to give the corrected signal received by the interrogator.

Step 4: Signal source C shall be adjusted to produce an un-modulated continuous carrier with its frequency tuned to 923,2 MHz. The signal shall be adjusted to give a level at the input to the receiver of the interrogator that is 3 dB above the appropriate threshold limit taken from table 3. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test. The level of the signal from the signal source C shall be adjusted for any loss in the power splitters to give the corrected signal received by the interrogator.

Step 5: Signal source D shall be adjusted to produce an un-modulated continuous carrier with its frequency tuned to 924,2 MHz. The signal shall be adjusted to give a level at the input to the receiver of the interrogator that is 3 dB above the appropriate threshold limit taken from table 3. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test. The level of the signal from the signal source C shall be adjusted for any loss in the power splitters to give the corrected signal received by the interrogator.

Step 6: The measuring receiver is replaced by the interrogator. The 50 Ω resistor is replaced by the measuring receiver. A diagram of the test configuration is shown at figure 18.

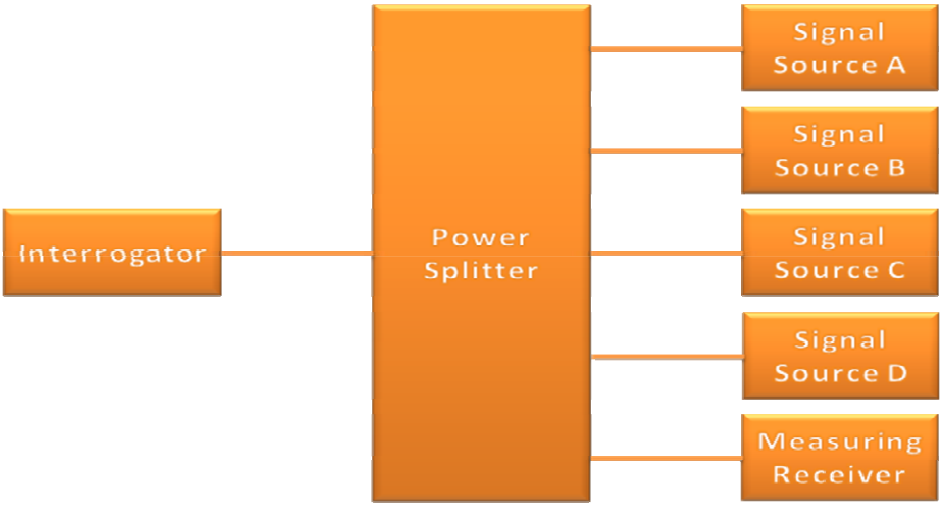



**Figure 18: Conducted measurement of R-GSM Downlink detection**

Step 7: With signal sources A, B, C and D switched off the power supply to the interrogator shall be switched on. After power up the interrogator shall automatically switch to scan mode.

Step 8: The transmission from the interrogator shall be monitored. The interrogator transmission shall hop through all the available high power channels in the frequency range between 915 MHz and 921 MHz.

Step 9: The power supply to the interrogator shall be switched off.

Step 10: With signal sources A, B, C and D switched on the power supply to the interrogator shall be switched on and the interrogator should automatically switch to scan mode. The frequency of transmission from the interrogator shall be monitored.

Step 11: If the frequency of transmission from the interrogator lies always below 918 MHz, the interrogator has successfully detected the signals from sources A, B, C and D. If transmission by the interrogator is also detected within the band from 918 MHz to 921 MHz, the interrogator has failed to detect the signals from sources A, B, C and D.

#### 5.3.6.3.4 Conducted method of measurement for signals in the ER-GSM band

Step 1: The measurement receiver is connected to the input of a power splitter. One input of the power splitter is connected to a signal sources A. The other input is connected to a 50 Ω resistor. A diagram of the test configuration is shown at figure 19.


**Figure 19: Calibration of field levels for Conducted ER-GSM Downlink detection**

Step 2: Signal source A shall be adjusted to produce an un-modulated continuous carrier with its frequency tuned to 918,2 MHz. The signal shall be adjusted to give a level at the input to the receiver of the interrogator that is 3 dB above the appropriate threshold limit taken from table 3. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test. The level of the signal from the signal source A shall be adjusted for any loss in the power splitters to give the corrected signal received by the interrogator.

Step 3: The measuring receiver is replaced by the interrogator. The 50 Ω resistor is replaced by the measuring receiver. A diagram of the test configuration is shown at figure 20.


**Figure 20: Conducted measurement of ER-GSM Downlink detection**

Step 4: With signal source A switched off the power supply to the interrogator shall be switched on. After power up the interrogator shall automatically switch to scan mode.

Step 5: The transmission from the interrogator shall be monitored. The interrogator transmission shall hop through all the available high power channels in the frequency range between 915 MHz and 921 MHz.

Step 6: The power supply to the interrogator shall be switched off.

Step 7: With signal source A switched on the power supply to the interrogator shall be switched on and the interrogator should automatically switch to scan mode. The frequency of transmission from the interrogator shall be monitored.

Step 8: If the frequency of transmission from the interrogator lies always below 918 MHz, the interrogator has successfully detected the signal from source A. If transmission by the interrogator is also detected within the band from 918 MHz to 921 MHz, the interrogator has failed to detect the signal from source A.

#### 5.3.6.4 Limits

The minimum permitted levels for the threshold of the receiver in the interrogator while in the "detect" mode is specified in table 3.

**Table 3: Levels of receiver threshold**

| | |
|---|---|
| **Threshold (e.r.p.)** | **≤ -86 dBm** |

### 5.3.7 Uplink detection

#### 5.3.7.1 Definition

This test is necessary to demonstrate that a Class C interrogator is able to detect the presence of an ER-GSM Mobile in the ER-GSM uplink band and to estimate the isolation between the RFID interrogator and the terminal to be protected. To avoid interferences between an active interrogator and the ER-GSM mobile, the interrogator shall detect the presence of a transmission by an ER-GSM mobile in the relevant ER-GSM UL channels. In table 4 the relevant ER-GSM UL channels are given for the two high power RFID channels where an active mitigation mechanism is needed. The given separation frequency Δf shall be used to determine the required detection threshold given in table 5.

**Table 4: RFID high power channels and the corresponding ER-GSM DL channels to be protected and UL channels to be measured**

| RFID high power channel frequency | ER-GSM DL channels to be protected | ER-GSM UL channel to be checked |
|---|---|---|
| 918,9 MHz | 918,6 MHz (Δf = 300 kHz) | 873,6 MHz |
| | 918,8 MHz (Δf = 100 kHz) | 873,8 MHz |
| | 919,0 MHz (Δf = 100 kHz) | 874,0 MHz |
| | 919,2 MHz (Δf = 300 kHz) | 874,2 MHz |
| 920,1 MHz | 919,8 MHz (Δf = 300 kHz) | 874,8 MHz |
| | 920,0 MHz (Δf = 100 kHz) | 875,0 MHz |
| | 920,2 MHz (Δf = 100 kHz) | 875,2 MHz |
| | 920,4 MHz (Δf = 300 kHz) | 875,4 MHz |

### 5.3.7.2 Uplink detection mode

The manufacturer shall demonstrate that when the interrogator has detected at least one BCCH channel in the frequency band 918 MHz to 921 MHz (ER-GSM) or more than 3 BCCH channels in the frequency band 921 MHz to 925 MHz (R-GSM) and is in the RF off state, its receiver shall monitor for the presence of an active ER-GSM terminal at the frequencies given in table 4. For the purpose of the tests the ER-GSM UL pattern given in figure 24 shall be used.

If for a given RFID high power channel the corresponding ER-GSM UL channels given in table 4 are free, the interrogator is allowed to operate on that specific channel. A check for the presence of an ER-GSM UL signal shall be performed immediately prior to each transmission of an interrogator.

Two methods for uplink detection should be considered:

- Slow Uplink Detection (interrogator class C1)
- Fast Uplink Detection (interrogator class C2)

For slow uplink detection the interrogator shall detect the presence of an ER-GSM uplink signal within 4 s of its initialisation. If the ER-GSM UL frequency bands corresponding to the specific RFID high power channel are occupied, the interrogator shall avoid transmission on the corresponding Downlink channel until it no longer detects the presence of a BCCH signal.

For fast uplink detection the interrogator shall detect the presence of an uplink signal within 50 ms of its initialisation. If the corresponding ER-GSM UL frequency bands given in table 4 are occupied by an ER-GSM Mobile, the interrogator shall not transmit on the corresponding Downlink channels until the uplink signal is no longer detected.

### 5.3.7.3 Method of measurement

This test is designed to verify that the interrogator is able to detect the presence of an ER-GSM Mobile. The measurement shall be conducted under normal test conditions.

#### 5.3.7.3.1 Method of measuring radiated signals

Step 1: A measurement antenna shall be positioned at a known point on a test site selected from annex A in [1] and connected either to a measurement receiver or spectrum analyser.

Step 2: A signal source A shall be positioned at a distance of 3 m from the measurement antenna in its direction of maximum gain.

Step 3: Signal source A shall be set to transmit a modulated sequence as defined in figure 24 and its frequency selected at random from the list of uplink frequencies in table 4. Signal source A shall be adjusted to give a level at the measurement receiver that is 3 dB above the appropriate threshold limit taken from table 5. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test.

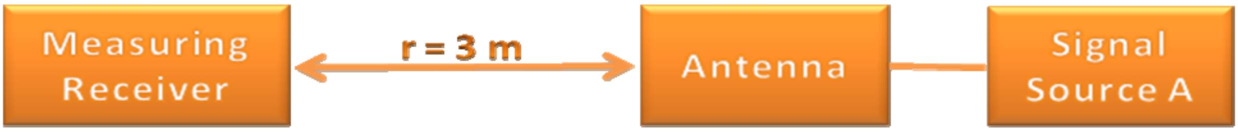



**Figure 21: Calibration of field levels for Uplink detection**

Step 4: The measurement receiver shall be replaced by the interrogator under test. The antenna of the interrogator shall be orientated so that its direction of maximum gain is aligned with the signal source A.

Step 5: The measurement receiver shall be positioned at a convenient distance from the interrogator in accordance with the layout in figure 22. The sensitivity of the measurement receiver shall be adjusted to measure transmissions from the interrogator while not detecting transmissions from the signal source A.

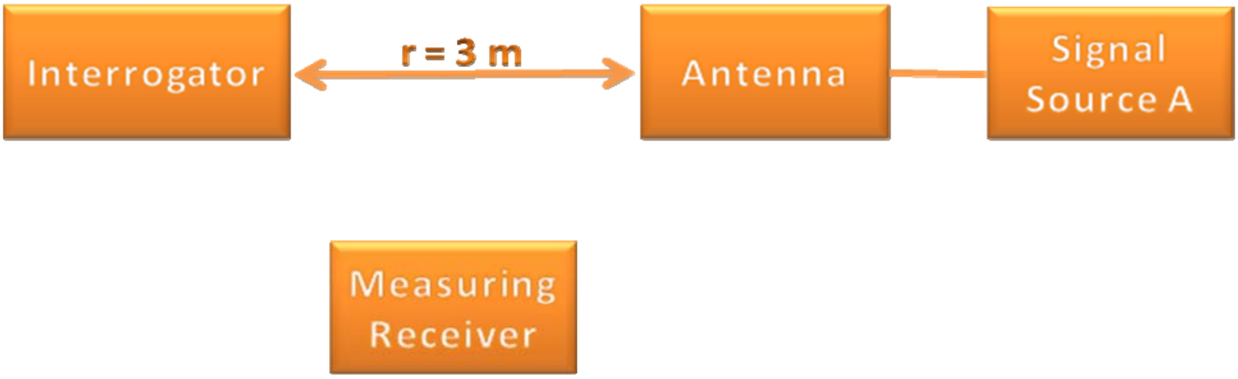



**Figure 22: Radiated measurement of Uplink detection**

Step 6: With signal source A switched off the supply voltage of the interrogator shall be switched on. After power up the interrogator shall automatically switch to scan mode.

Step 7: The interrogator shall be configured to operate on the interrogator channel corresponding to the chosen ER-GSM UL frequency given in table 4. The transmission from the interrogator shall be monitored.

Step 8: Signal source A shall be switched on.

For a Class C1 Interrogator:

The signal source shall transmit the defined sequence described in clause 5.3.7.4.1 for a duration of 5 s. The frequency of transmission from the interrogator shall be monitored. After the period specified in table 6 has passed, the interrogator shall have detected the presence of the mobile.

For a Class C2 Interrogator:

The signal source shall continuously transmit the defined sequence described in clause 5.3.7.4.1. The frequency of transmission from the interrogator shall be monitored. After the period specified in table 6 has passed the interrogator shall have detected the presence of the mobile.

Step 9: If the interrogator switches to another channel, it has successfully detected the signal from source A. If the interrogator continues to transmit at the frequency chosen in step 7, it has failed to detect the signal from source A.

Step 10: Signal source A should be switched off. The transmission of the interrogator shall be monitored. The Class C2 interrogator shall return to the originally chosen transmit channel.

#### 5.3.7.3.2 Conducted method of measurement

Where the interrogator is fitted with an external antenna connector, the measurement may be made using power splitters.

Step 1: The external antenna connector of the interrogator shall be connected to a power splitter. One input of the power splitter shall be connected via an attenuator to a measurement receiver. The other input shall be connected to signal source A. A diagram of the test configuration is shown at figure 23.

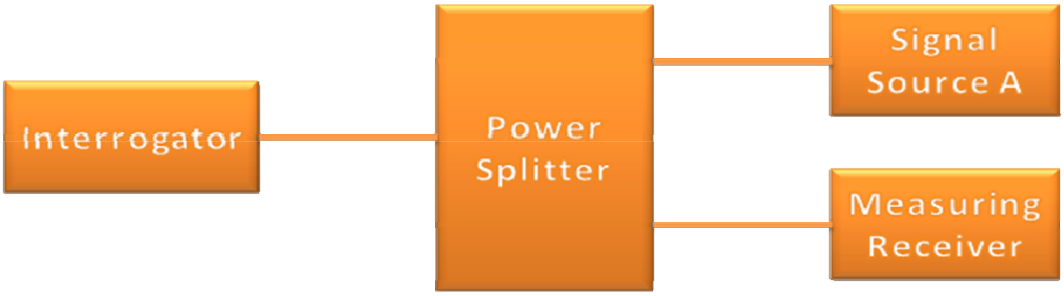



**Figure 23: Conducted measurement of Uplink detection**

Step 2: Signal source A shall be set to transmit a modulated sequence as defined in figure 24 and its frequency selected at random from the list of uplink channels in table 4. Signal source A shall be adjusted to give a level at the measurement receiver that is 3 dB above the appropriate threshold limit taken from table 5. The limit selected shall correspond to the tabulated threshold level associated with the maximum transmitted power of the interrogator under test. The level of signal from the signal source shall be adjusted for any loss in the power splitters and for the antenna gain of the interrogator to give the corrected signal received by the interrogator.

Step 3: With signal source A switched off, the interrogator shall be switched on. After power up the interrogator shall automatically switch to scan mode.

Step 4: A check shall be made to verify that the interrogator is transmitting on the channel corresponding to the chosen ER-GSM UL frequency.

Step 5: Signal source A shall be switched on.

For a Class C1 Interrogator:

The signal source shall transmit the defined sequence described in clause 5.3.7.4.1 for a duration of 5 s. The frequency of transmission from the interrogator shall be monitored. After the period specified in table 6 has passed, the interrogator shall have detected the presence of the mobile.

For a Class C2 Interrogator:

The signal source shall continuously transmit the defined sequence described in clause 5.3.7.4.1. The frequency of transmission from the interrogator shall be monitored. After the period specified in table 6 has passed, the interrogator shall have detected the presence of the mobile.

Step 6: If the interrogator switches to another channel it has successfully detected the signal from source A. If the interrogator continues to transmit on the originally chosen channel, it has failed to detect the signal from source A.

Step 7: Signal source A should be switched off. The transmission of the interrogator shall be monitored.

For a Class C1 Interrogator:

The interrogator shall not return to the originally chosen RFID channel.

For a Class C2 Interrogator:

The interrogator shall return to the originally chosen RFID channel.

### 5.3.7.4 Limits

#### 5.3.7.4.1 Test sequence

The interrogator shall detect the test sequence from the signal source as defined in figure 24.

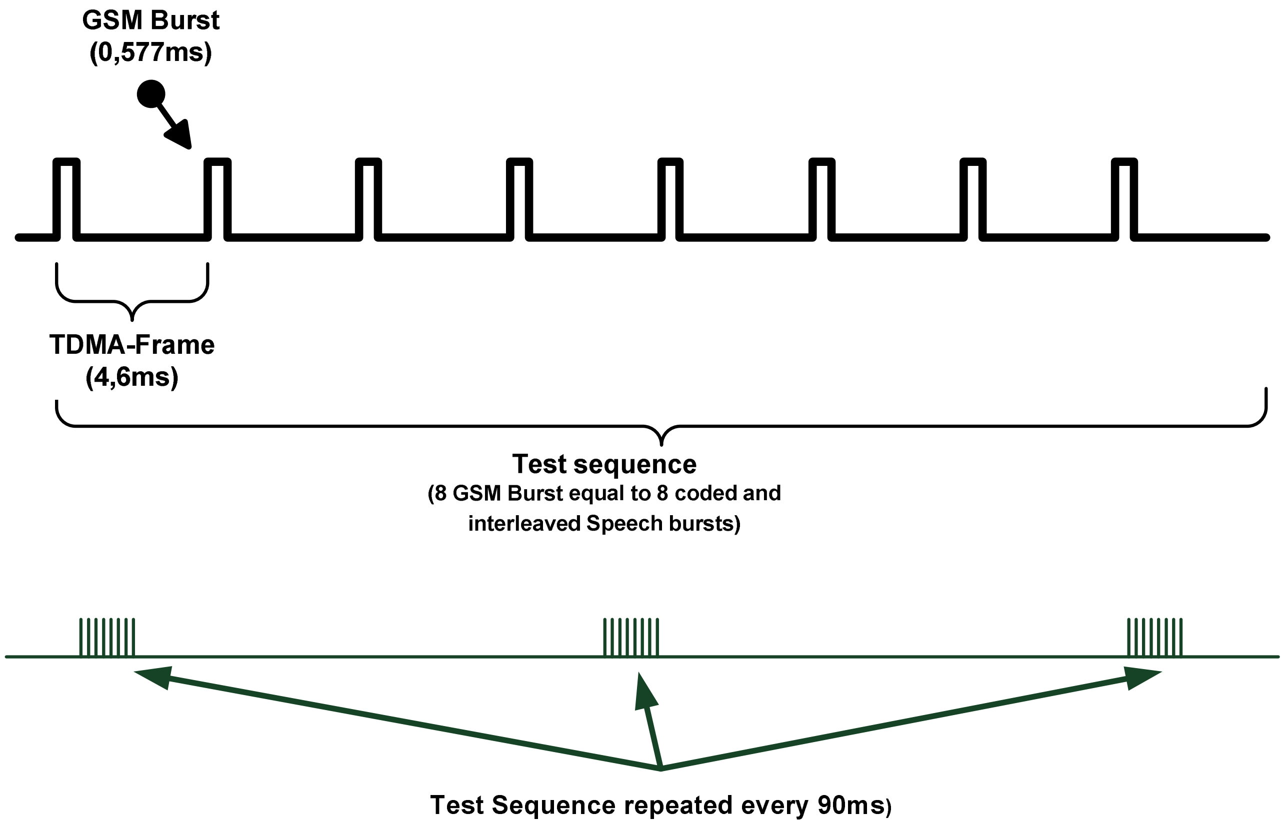



**Figure 24: UL ER-GSM test pattern**

#### 5.3.7.4.2 Threshold levels

The minimum permitted levels for the threshold of the receiver in the interrogator when set to the "detect" mode are defined in table 5.

**Table 5: Levels of receiver threshold (e.r.p.)**

| | ER-GSM Offset | Threshold |
|---|---|---|
| High Power Transmission (0,5 W to 4 W) | 100 kHz | -80 dBm |
| | 300 kHz | -34 dBm |
| Low Power Transmission (0 W to 0,5 W) | 100 kHz | -71 dBm |
| | 300 kHz | -25 dBm |

#### 5.3.7.4.3 Transmission times for class C1 interrogators

This transmission timing applies to the two upper high power channels for Class C1 interrogators only. For Class C2 no transmission time limits apply in the upper two channels.

The manufacturer shall declare that the measured length of transmission is no greater than is required to read the tags present in the field and to verify that there are no additional tags present. The maximum time for transmission is defined in figure 25. After each transmission time the interrogator shall listen for an uplink signal.

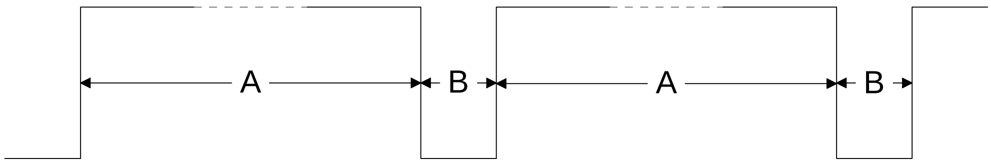



**Figure 25: Repeated transmissions**

where:

- the duration of A shall not exceed 4 s;
- the duration of B shall be not less than 100 ms.

#### 5.3.7.4.4 Uplink detection time

**Table 6: Uplink detection time**

| Interrogator Class | Uplink detection time |
|---|---|
| Slow Uplink Detection (Class C1) | 4 s |
| Fast Uplink Detection (Class C2) | 50 ms |

# 6 Field evaluation test

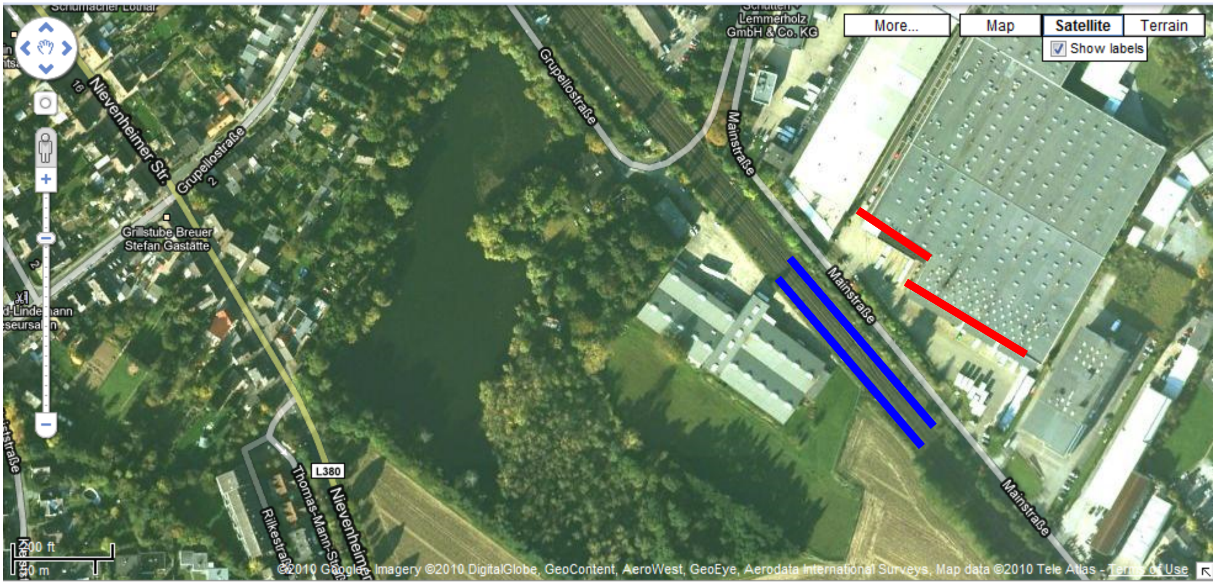
## 6.1 Introduction

During the initial investigation on interference at the start of the project, some missing data and simulation models were identified. The main issue was the modelling of the interference potential from a RFID interrogator towards an ER-GSM terminal and the potential signal levels received by an RFID interrogator from an ER-GSM system (BTS DL signal and ER-GSM terminal UL signal). No channel and pathloss models currently exist to simulate this scenario. In particular the positioning of an ER-GSM terminal at a very low height above the ground and the installation of RFID interrogators at dock doors have not been considered in any previous investigations on compatibility.

The results from an initial investigation on interference [i.1] between RFID and ER-GSM showed a significantly higher attenuation than the worst case conditions (Line-of-sight) assumed in [2]. In order to predict realistic probabilities of interference between a RFID interrogator and an ER-GSM terminal, suitable interference and path loss models are needed. These models can then be used to determine the detection thresholds required by the proposed mitigation mechanisms for both UL and DL detection.

In order to obtain accurate information, measurements should be made under realistic field conditions based on typical operational scenarios. The tests proposed in this clause should permit realistic estimates to be made of the interference potential between RFID interrogators and ER-GSM terminals.

This clause proposes a two step approach for the field tests, which has the benefit of reducing the workload. With assistance from DB, initial testing will be performed close to a RFID manufacturer. For this step no additional railway equipment will be required and no measurements on trains will be necessary. Thus this step will consume only limited resources and its timing is more flexible. The results from step 1 will subsequently be verified in step 2 which will comprise tests at a Deutsche Bahn shunting area or at a distribution centre such as illustrated in figure 26.




red: Loading gate for trucks.
blue: Railway (Neuss - Köln via Dormagen).

**Figure 26: Loading gate position in relation to R-GSM equipped rail way track Metro EECC Neuss, Germany**

## 6.2 Initial field test

Step 1 will be performed at a location close to an RFID manufacturer. This will use a portal system equipped with a RFID interrogator, which will form a reference. The portal will be positioned in a realistic industrial environment and thus the results for path loss and interference should also be valid for ER-GSM. A typical RFID portal system is depicted in figure 27.

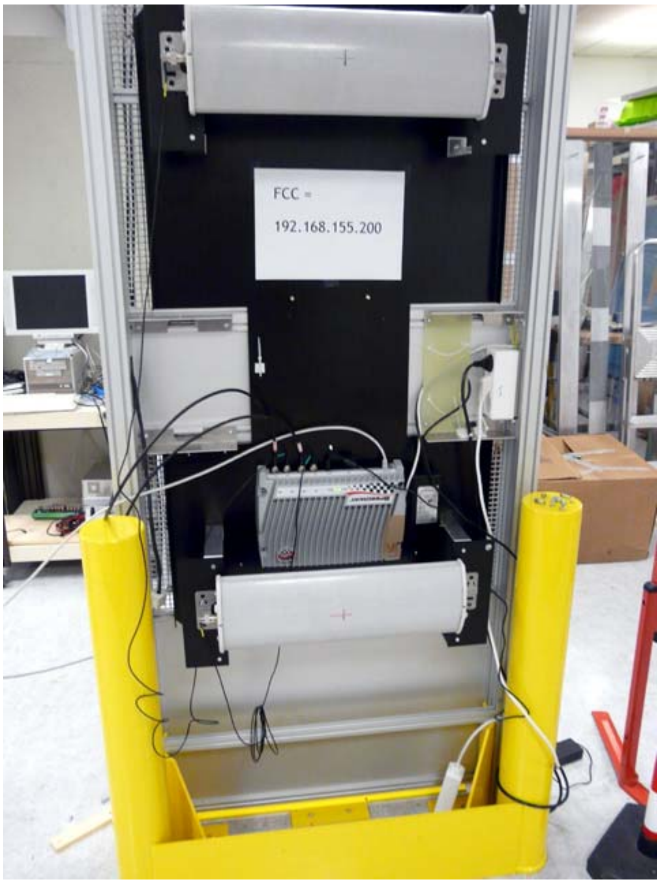



**Figure 27: Typical RFID portal system**

The portal system will be positioned in a way that is representative of its use in a real distribution centre and thus will generate realistic interfering signals. The investigation will be carried out using the worst case interference scenario identified in [2]. All other scenarios will lead to lower probabilities of interference.

Investigation of the propagation characteristics will be carried out across the frequency range 850 MHz to 960 MHz. These results will be used in later investigations. Measurements will be made using different transmitter parameters and will be carried out at different distances. The following list specifies the parameters to be measured:

- Polarization: circular, horizontal and vertical
- Distance from portal antenna: 10 m, 20 m, 50 m, 100 m, 200 m, 500 m and 1 000 m Additional distances will be included if considered appropriate during the tests
- Ground conditions: concrete dry and wet, grassland, rail tracks
- ER-GSM antenna height over ground: 1 m and 2 m

During these tests the propagation in both the X and Y planes should be measured. The results of the path loss measurements should lead to a better understanding of the interference potential of an RFD interrogator towards an ER-GSM system. Furthermore, the measurements should assist in the definition of realistic threshold levels for the mitigation mechanisms proposed in [2]. Following these tests a more detailed test plan will be prepared for the second step.

## 6.3 Field test at a shunting area/distribution centre

Based on the results of field measurements carried out at a RFID manufacturer, further tests will be performed at a railway distribution centre or a DB shunting area These measurements will use the set up values derived from the tests in the first step as an initial reference point. This approach should significantly reduce the resources required to undertake the second step.

During these tests a similar set of parameters will be evaluated as presented in clause 5.2. The principal focus will be directed at the most critical scenario identified during the first step.

# Annex A (informative): Bibliography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# History

| Document history | | |
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| V1.1.1 | August 2011 | Publication |
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