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

# SHARING BETWEEN INDUCTIVE SRD SYSTEMS AND RADIO COMMUNICATION SYSTEMS OPERATING IN THE FREQUENCY BAND 10.2 - 11 MHz

**Vilnius, June 2000**

## Executive summary

This document summarises the work that has been conducted concerning inductive EAS (Electronic Article Surveillance) devices in the frequency range 10.2 – 11 MHz but is assumed to be applicable to general SRDs. This work supports the ongoing revision of the SRD recommendation CEPT/ERC/REC 70-03. Currently, these EAS devices operate within some CEPT countries under national type approvals, generally under the license exempt category.

Within these frequency ranges 10.2 – 11 MHz, the primary services are a subset of those examined in the reports on 8.2 MHz EAS systems and 6.78/13.56 MHz RF-ID systems. For this frequency range 10.2 – 11 MHz, the proposed limit is +9.0 dBμA/m measured at 10 m distance.

The maximum protection distances for EAS system to a primary fixed single side band receivers in the band 10.2 – 11 MHz is 1009 m.

Furthermore, most of the EAS systems are operated indoor. In this case an additional 5 dB building attenuation is used for victim receivers outside the building. This results in a protection distance of 757 m for the frequency band 10.2 – 11 MHz.

Based on studies, WG SE is endorsing the industry proposal as sharing with primary services is possible.

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# SHARING BETWEEN INDUCTIVE SRD SYSTEMS AND RADIO COMMUNICATION SYSTEMS OPERATING IN THE FREQUENCY BAND 10.2 - 11 MHz

## 1 INTRODUCTION

During the last several decades, industry has developed a number of EAS systems (EAS = Electronic Article Surveillance). This development has resulted in high volume products and the industry has expressed an urgent need for a standard. This is currently being addressed by ISO, IEC and ETSI.

Originally ETSI included the preliminary need of the industry in ETSI standard I-ETS 300 330 by a radiated limit in the frequency range 4.78 MHz - 30 MHz of +20 dBµA/m measured at 10 metres distance from the equipment.

Under these constraints, the industry has developed a minimum compromise solution reducing the limits to +9.0 dBµA/m for several frequency ranges from 7.4 MHz to the ISM band at 13.56 MHz. These limits are included in the published EN 300 330.

In the framework of the ERC/ETSI MoU, WG SE has been tasked to study the compatibility between EAS systems and primary radio services.

## 2 MARKET INFORMATION

It is estimated that some 150.000 inductive EAS systems and 5 billion security tags were sold worldwide in 1998 alone. Inductive EAS equipment and security tags are primarily sold to commercial retailers. The retailers place the security tags on the merchandise to protect it from being stolen. The systems in the retail shop alarm, via sound and/or lights, when an active tag is transported through the system. When merchandise is purchased, any security tags are deactivated at this time, to enable the patron to leave the store with out a system alarm.

The size of the worldwide market for EAS (Electronic Article Surveillance) is estimated to be worth 2.4 billion ECU for 1998. The market for EAS has been growing at over 20% per year for the last 10 years. This growth has been the result of retailers recognising that theft is a major drain on profits and that EAS provides a method to reduce theft. The awareness in theft has been a result of the retailers' investment to upgrade their logistics and inventory management systems. Another trend that is driving growth in EAS is the concept of source tagging. At present, retailer provide the labour (at a cost) to place security tags on their merchandise. Under source tagging, these tags are placed on merchandise at the point of manufacture. This eliminates the tagging cost to the retailer and increases the retailers' return on investment for the EAS equipment. The increasing commercial requirement for source tagging of goods is one of the driving forces for the harmonisation of inductive EAS systems.

EAS technology has also been found to have applications other than retail security. These applications include library security systems, video store security and commercial/industrial applications. The primary difference between these applications and retail security is that the security labels are not turn off. The various EAS companies use different names for these type systems. *Bypass* and *pass around* are the most common names. Tags used in these systems may circulate outside of the library, video store or commercial/industrial locations and thus may be brought into retail stores. If the same tag frequencies are used as retail security, then unwanted alarms will occur in the retail store. The generally accepted solution is to use different frequencies for these systems. For EAS systems using the principles of the 8.2 MHz technology, the frequencies used have centered 10.5 MHz.

## 3 EAS SYSTEM OVERVIEW

### 3.1 Operating principle of an inductive EAS system

An EAS system is a loop coil based system with coverage of about 0.9 m. An identified item is equipped with a small transponder (a security tag). For the band 10.2 – 11 MHz, the transponder is usually a passive L/C circuit. Since the re-radiated field from a transponder can be very low due to a small physical size, the practical communications distance is around 0.9 m.

### 3.2 The reasons for operating in the frequency band 10.2 - 11 MHz

The size, cost and performance of the EAS transponder are dependent on its frequency of operation. The EAS industry has determined that for the best cost, size and performance, the frequency range from approximately 5 - 15 MHz is one of the optimal band. The security tag is a series LC circuit that resonants at around 10.5 MHz. The capacitor is created by laminating two layers of aluminium between a di-electric. For operation below 5 MHz, the size of the tag increases in size due to the requirement for a larger capacitor. Above 15 MHz, the capacitor is reduced in size, but susceptible to de-tuning for human touch or interaction with tagged merchandise. Based primarily on these effects, the inductive EAS industry has standardised on the frequency range 5 – 15 MHz. After examination of the 5 - 15 MHz band, industry has selected use of the several bands. The band 7.4 - 8.8 MHz has already been studied. Use the band 10.2 –11 MHz band is being suggested to stay out of bands used for the primary services of Amateur radio, Aeronautical, standard frequency & time signal and space research.

### 3.3 Present regulations

EAS systems operating in the band 7.4 – 8.8 MHz are covered by CEPT/ERC/REC 70-03. The limit is 9.0 dBµA/m. The regulations for the band 10.2 – 11 MHz are different in various CEPT countries. In some countries this equipment is not considered as radio equipment, and neither type approval nor limits for the magnetic field are set. In other countries inductive equipment is considered as radio equipment and there are various national type approval standards. The definition of the field strength, the limits, and the measurement methods, are not harmonised.

The inductive systems operate on a non-interference non-protected basis as defined in Radio Regulations (RR). Both existing and future primary services can claim protection from any interference caused by inductive systems.

Although CEPT REC T/R 01-04 did not cover the inductive loop systems, some administrations have adopted the spurious emissions limit of T/R 01-04 as a guideline when assessing the limits for these systems.

### 3.4 System details

A typical inductive loop EAS system is illustrated in figure 1 below:

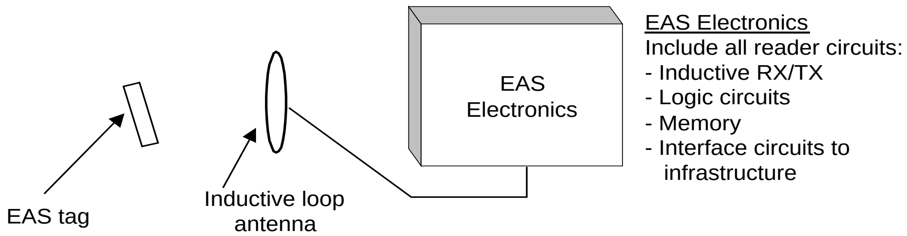


**Figure 1. EAS System configuration**

When the tag is within its detection range, it is powered by a magnetic field and the tag sends back a low energy signal, which is detected by EAS receiving antenna. The electronic components in the tag are only a coil (inductor) and a capacitor.

The maximum transmitted power by this EAS System is 9.0 dBµA/m at 10m distance.

### 3.5 Link budget

The following calculations identify the key parameters for operation of inductive EAS systems. EAS systems use distance cancellation antennas to accelerate the attenuation of the far field emissions. The typical distance cancellation antenna is a figure eight. The equations will first calculate the receiver sensitivity followed by the required antenna induced voltage, the required tag field and finally the required field strength measured at 10 m.

Required receiver sensitivity – The required receiver sensitivity is based on the necessary S/N ratio above the ambient noise level. The necessary S/N ratio for EAS systems is 8 dB to obtain error free operation. There are two noise figures used in the calculations. One noise value is for the ambient noise in a commercial environment. The value used for the frequency range 10.2 - 11 MHz is –13 dBμA/m which is used in ERC Report 44. The second noise figure is the ambient noise for receivers outside the commercial environment. The ambient noise for the frequency range 10.2 - 11 MHz is –49.5 dBμA/m. This noise figure was obtained from the theoretical analyses reviewed in SE 24. From the field measurements (for the 8.2 MHz work) conducted in Germany, the measured value of ambient noise was –36.5 dBμA/m. To be conservative and determine the worst case protection distance, the value of –49.5 dBμA/m value was used for the value of ambient noise. Use of a lower noise value results in larger calculated interference distance.

In the typical case, inductive EAS systems use cancelling receive antennas to further reduce noise. The effect results in the received ambient noise being reduced an additional 6dB.

Receiver sensitivity calculation:

| | |
|---|---|
| Ambient noise level | =-13dBμA/m |
| Antenna noise cancellation effect | = -6dB |
| Required S/N | = +6dB |
| Receiver sensitivity, $H_{sens}$ | =-13dBμA/m = 0.22 μA/m |

Required Antenna induced voltage: At $H_{sens}$, the induced volt $E_{in}$, for a single loop of the figure 8 antenna is calculated according to Faraday's Law.

$$E_{in}= d\varphi/dt *Q=2\pi fQab\mu_o H_{sens} \quad (1)$$

Where Q is the Q of the receiver antenna and *a* and *b* are the dimensions of the typical receive antenna of an EAS system operating at in the frequency range of 10.2 – 11 MHz. A frequency value of 9.5 MHz is used for worst case calculations.

Inserting values used for the typical inductive EAS system:

$$E_{in}=2\pi*(10.5\ 10^6 MHz)*2.0*0.40m*0.7m*(4\pi\ 10^{-7} A*m^2)*(0.22\ 10^{-6}\mu A)=10.0\mu V$$

Knowing the required field strength at the receive antenna, the next steps are to compute the required field strength at the transponder (the security tag) and then the required transmit antenna field strength to induce the required transponder field.

Required transponder (tag) field

The required tag field, which is a re-radiated field, is a function of the effective volume of the tag, $V_{eff}$.

$$V_{eff}=m/H_{tag} \quad (2)$$

Where *m* is the magnetic moment of the tag
and $H_{tag}$ is the H field produced by the transmitting antenna at the location of the tag

The re-radiated field is:

$$H_{tag,re-rad} = m/(2\pi*r^3) \quad (3)$$

The required field from the transmitter at the location of the tag, $H_{tag}$, can be calculated from the induced voltage at the receive antenna

$$E_{in}= d\varphi/dt*Q*(C_d)^2 = 2\pi fab\mu_0 Q(C_d)^2*m/(2\pi d^3) \quad (4)$$

Where $C_d$ is a derating factor that is based on use of a cancelling antenna for the receive and transmit antenna and the orientation of the tag referenced to the antenna. The effect of the cancelling antenna results in an attenuation of 6 dB and the tag orientation in the worst case is a 4 dB attenuation. The result is a 10 dB attenuation, which is the 0.3 factor for $C_d$.

Reducing the equation:

$$E_{in}= f^*(ab/d^3)\mu_0 Q(C_d)^2{}^*V_{eff}{}^*H_{tag} \quad (5)$$

Solving for $H_{tag}$

$$H_{tag} = E_{in}d^3/(abf\mu_0(C_d)^2V_{eff}) \quad (6)$$

Substituting and reducing:

$$H_{tag} = (2\pi H_{sens}d^3)/((C_d)^2V_{eff}) \quad (7)$$

Calculate Htag with the following parameters:

| | |
|---|---|
| Distance between the tag and antenna, d | =0.9 m |
| Tag effective volume, $V_{eff}$=1 liter | =$10^{-3}$ $m^3$ |
| Tag correction factor, $C_d$ | =0.3 |

$$H_{tag} = (2\pi^*0.22\ 10^{-6}{}^*0.9^3)/(0.3^2{}^*10^{-3}) = 11.20\ 10^{-3} mA/m = 81.0\ dB\mu A/m \quad (8)$$

It should be noted that the distance d chosen is 0.9 m. 0.9 m results in an aisle width of 1.8 m. The 1.8 m is necessary given that many retail door openings have been standardised around 1.8 m. 1.8 m or greater is also required for safety reasons in some European countries.

The effective volume of the tag, $V_{eff}$, is a function of the size of the tag. The smaller the tag, the larger required transmit field strength. The value of $10^{-3}$ $m^3$ was chosen as it represents the typical security tag.

### 3.6 Calculation of the required transmitter field measured at 10 m

The far-field/near-field boundary is at $\lambda/2\pi$ which is 4.55 m at 10.5 MHz.

The propagation model described in the ERC Report 069 is used to calculate the field strength at a specified distance from a distance cancelling antenna. The distance cancelling antenna used is a figure eight. The following results are acquired by applying the propagation model for a transmitting EAS figure eight antenna with dimensions, a=0.4 m by b= 0.7 m.

For the typical antenna produced by a quality EAS manufacturer, there is a factor that represents the degree to which the antenna is balanced (cancelling). The factor, $\Delta$, is noted as the imbalance of the current in the cancelling loops. The typical value of $\Delta$, is 0.1. The factor is required to account for the effects of manufacturing tolerances for the antenna, the effect of metal near the antennas in door frames and Point of Sale checkout stands and the effect of metal in floor structures.

From equation 8, the required field strength required for proper EAS operation at 1.8 m is 82.1 dBµA/m. To generate this field strength, the loop current is I=283 *m*A. This current corresponds to a magnetic dipole moment of 8.93 mA/$m^2$ for each loop. Linking to the far field model gives according to equation A7 from Annex 1, a field strength at 10 m (horizontal component) H@ 10m = 2.82 µA/m = 9.0 dBµA/m.

The value of 9.0 dBµA/m applies to the frequency band 10.2 - 11 MHz is used for all further calculations.

# 4 INTERFERENCE CALCULATIONS

## 4.1 Interference between EAS systems

Inductive EAS systems have been designed to operate in close proximity to one another. At least two methods can be used to decrease the interference potential: One method is to sweep at different rates. Another method is to detect other systems and remove their effect from the received signal.

There could be a risk of interference between co-channel EAS systems if the distance between separate systems is less than 15m (with 9.0 dBµA/m at 10 m). In the case of interference, the manufacturers/installers of the EAS equipment will resolve the problem.

## 4.2 Interference from the EAS System to primary services

a) The propagation model defined in ERC Report 069 is used to calculate the protection distances.
b) For the frequency range 10.2 – 11 MHz, there are two primary services: Fixed and Mobile (except aeronautical mobile)
c) For protection distance calculation, the environment noise level is used unless the victim receiver's parameters are known.
d) The protection distances are calculated for worst case situations for a 9 m EAS system range with a distance cancellation antenna.

## 4.3 10.2 - 11 MHz potential interference to primary services

| Frequency kHz | Type of Service | Signal to be protected dBµV/m | Signal to Interference Ratio (dB) | Environmental Noise level (dBµV/m) | Protection distance to victim receiver |
|---|---|---|---|---|---|
| 10200 | FIXED | 14 | 14 | | 1009 m |
| 11000 | Mobile (except Aeronautical) | | | 1 (80%) | 708 m |

# 5 CONCLUSIONS

The results of this study follow from the previous work completed for 8.2 MHz EAS and 6.78/13.56 MHz RF-ID systems. The band 10.2 – 11 MHz was examined. The primary services involved are a subset of those studied for 8.2 MHz EAS and 6.78/13.56 MHz RF-ID systems. For a field strength of 9.0 dBµA/m, the worst case interference distance was calculated to be 1009 m for the frequency band 10.2 – 11 MHz. When a conservative 5 dB attenuation factor for a commercial building is applied (e.g. in case of indoor EAS applications), the worst case interference distance is reduced to 757 m for the frequency band 10.2 – 11 MHz.

The field strength of 9.0 dBµA/m is an acceptable level to SRD industry and results in a potential interference distance that is acceptable for other radiocommunication systems.