

**Evaluating the Effect of EMI in
Transceivers (Readers) Used to
Identify Animals Electronically
Contract FF/05/19
Final Report
for
Scottish Executive Environment
and Rural Affairs Department
Report (copy 1 of 3)**

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Author:
G. Whyte, HND
Senior EMC Engineer

Checked:
D. T. Hambley, CEng, MSc., MIET
Principal EMC Engineer

Approved:
D. Bozec, DUT, BSc (Hons), PhD, MIET, MIEE, MIHEEM
Laboratory Manager

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The results contained in this report are only applicable to the apparatus tested.

Executive Summary

A study was carried out to investigate the effects of electromagnetic interference (EMI) in transceivers used to identify animals electronically, commonly known as RF identification (RFID) or electronic identification (EID). This study was commissioned by Scottish Executive Environment and Rural Affairs Department, SEERAD, as part of the ongoing project aimed at providing an advanced and highly efficient electronic cattle traceability system using EID and supported by EDT (e-Delivery Team) that was later extended to include sheep.

Various UK manufacturers were contacted with the intention of obtaining samples of RFID tag readers for the laboratory EMC testing. It was clearly anticipated that manufacturers would be eager to have the EMC performance of their equipment assessed or re-assessed, especially since the testing was offered at no cost to the various manufacturers. Unfortunately, there was a lack of response from most, which was extremely disappointing and somewhat limited the laboratory study to the manufacturers who kindly offered their equipment for testing. Large amount of time and effort was concentrated in generating the interest in this study, but most manufacturers were simply not willing to participate in the investigation.

Research into the current knowledge of RFID systems found much about the theory and implementation of such systems but very little on any studies into the effects of EMI on the ability of these systems to operate under adverse electromagnetic conditions.

To determine what levels of EMI were likely to be present at locations where these EID systems would be used, radio frequency measurements were performed and recorded at a selection of sites during normal working conditions in order to compare actual EMI levels on site with the immunity levels normally required for compliance of equipment to the EU EMC Directive.

The sites chosen for these measurements were auction marts and abattoirs in Scotland since they are the places where major movements of livestock occur. At present, these sites use standard visual ear tags as identification, matching the tags with the animal 'passports' and manually recording the data prior to transfer to central recording.

A brief visual survey of the auction marts did not reveal any major sources of EMI, and this was borne out by analysis of the recorded data. Typically the main sources of radio frequency emissions noted were local broadcast transmissions, e.g. radio, television and mobile telephone base stations.

The abattoir environment was found to more electromagnetically noisy. At the stunning areas, cattle and sheep, there were various sources of EMI such as conveyors, stunning equipment, hoists and processing equipment. These produced significant amounts of RF interference as both conducted (onto power cables) and radiated.

Samples of RFID tag readers, panel antenna type and hand held stick type, were also obtained for laboratory testing, where they could be subjected to EMI under controlled conditions. These tag readers were compliant to the ISO 11784/11785 standards, operating at 132.4kHz and reading both full and half duplex (FDX and HDX) tags. In addition to testing to the requirements of applicable EMC standards for immunity, the levels and frequency ranges of the EMI could be varied to examine the effects on the reader systems.

The results of the laboratory studies showed that the panel tag readers tested were susceptible to both radiated and conducted RF interference to the extent that they would require some mitigating modifications to make them fully compliant to the EMC requirements. They were particularly susceptible to conducted RF interference in the range 150kHz to 230kHz. Varying the frequency range showed the susceptibility extended down to at least 10kHz. Increasing the applied disturbance to the next higher level increased the frequency range of the immunity effects to 288kHz.

The laboratory studies indicate that the manufacturers should ensure that their equipment is, at a minimum, compliant to the requirements of EN 301 389-1 this is an RTTE standard. All equipment of this type should be, since compliance to the EU EMC Directive is a legal requirement. If the equipment is to be installed in an electromagnetically severe environment or close to equipment that is a known source of EMI, then manufacturers should introduce measures in either or both manufacture of the equipment and installation of the equipment to mitigate the effects of any local EMI.

To this end a Guideline for Build and Installation manual has been compiled outlining steps that can be taken to reduce the effects of EMI on both manufactured and installed equipment, through good design and careful installation.

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Report Change History

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List of Terms and Abbreviations

| | |
|--------|---|
| AC | Alternating Current |
| ARA | Active Receive Antenna |
| CISPR | Comité International Spécial des Perturbations Radioélectriques |
| CTS | Cattle Tracing System |
| DC | Direct Current |
| EDT | e-Delivery Team |
| EID | Electronic Identification |
| EMC | ElectroMagnetic Compatibility |
| EMI | ElectroMagnetic Interference |
| EN | European Norm |
| ETSI | European Telecommunications Standards Institute |
| EU | European Union |
| FDX | Full Duplex |
| HDX | Half Duplex |
| ISO | International Standards Organisation |
| IT | Information Technology |
| LAN | Local Area Network |
| OFCOM | Office of Communication |
| OJEU | Official Journal of the European Union |
| PC | Personal Computer |
| PSU | Power Supply Unit |
| RF | Radio Frequency |
| RFID | Radio Frequency Identification |
| RTTE | Radio and Telecommunications Terminal Equipment |
| SAOS | Scottish Agricultural Organisation Society |
| SEERAD | Scottish Executive Environment and Rural Affairs Department |
| SRD | Short range Radio Device |
| WAN | Wide Area Network |
| YES | York EMC Services Ltd |

1 Introduction

1.1 Brief History of RFID

The concept of Radio Frequency Identification (RFID) has been around since the development of Radiocommunications and RADAR in the 1930s and 1940s, and early applications of the idea are to be found in the Identification Friend or Foe (IFF) transponder systems developed in the UK and used in the Second World for aircraft identification. The transponder fitted to the aircraft was interrogated by a radio signal and transmitted a reply identifying the aircraft as friendly.

A patent for a rewriteable, passive RFID transponder was submitted by Mario Cardullo in 1973 and throughout the 1970's and 1980's, the theory and development of RFID systems was refined through research by companies and institutions, for example, the Los Alamos Scientific Laboratory and the Microwave Institute Foundation in Sweden amongst others.

Electronic technology also advanced significantly during this period, particularly in cost, which made the widespread application RFID a commercial reality.

Early applications of RFID systems were as simple security devices, e.g. in libraries, to prevent theft of books. This is known as Electronic Article Surveillance (EAS) where the presence of a tag is detected without necessarily any transfer of data. Governments and large organisations were quick to realise the huge potential of RFID and it entered widespread use in toll collecting systems and in product (including animal) tracking.

Today, RFID systems are ubiquitous wherever large numbers of items are required to be tracked, inventoried or controlled, from supermarkets and stores, worldwide distribution networks to governmental departments.

1.2 What is RFID?

In general terms, RFID refers to a system whereby a transponder (e.g. tag or label) can be interrogated using a radio frequency signal by a reader and respond with data which identifies the tag.

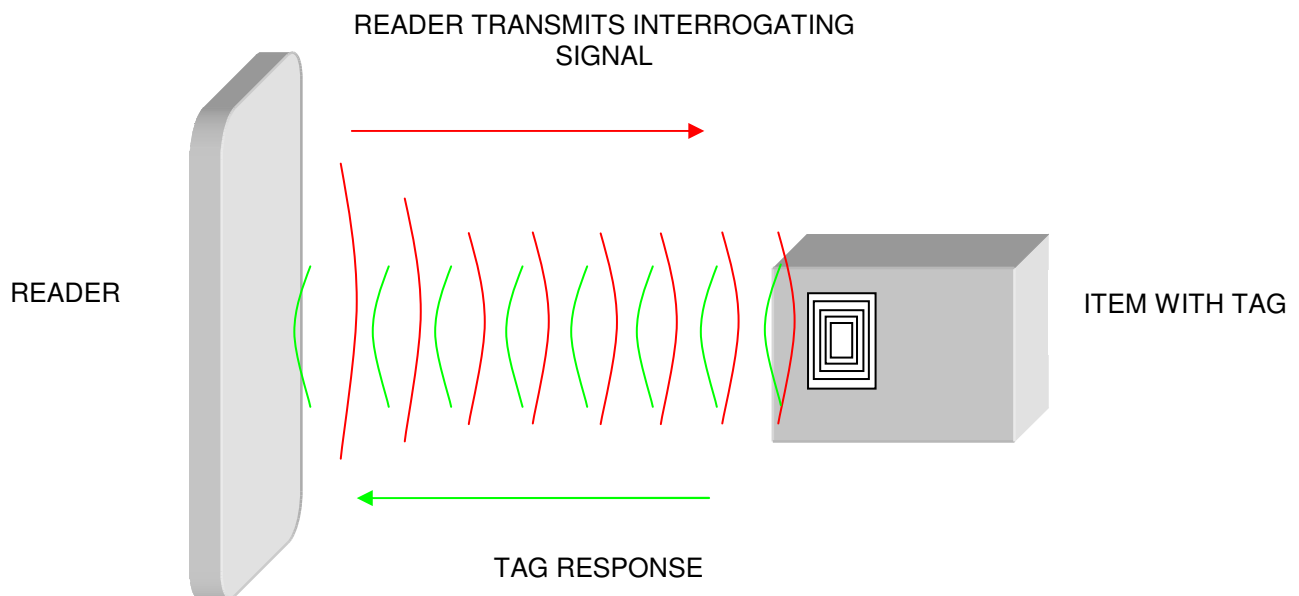


Figure 1 Reader interrogating tag

1.3 How does it work – a basic guide

Transponders come in three variations; passive, semi passive and active. The frequency of operation also varies with the type of application as detailed in the next few sections.

1.3.1 Passive

A passive tag, Figure 2, has no internal power source; a built-in aerial uses the radio frequency signal from the reader to generate enough voltage to power the internal circuitry and transmit the stored data back to the reader to decode.

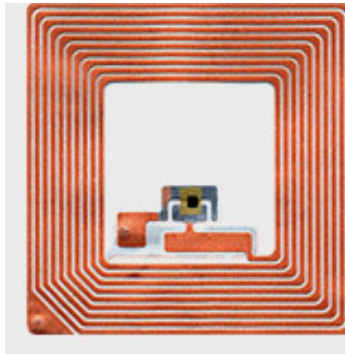


Figure 2 Flat RFID tag showing antenna coil (Generic type)

These tags are used where low cost is an important consideration. Tags can be produced on a thin, flexible material in a similar way to production of a printed circuit board. This makes them ideally suited to self-adhesive label applications, e.g. packaging, books, boxes, etc. They are not normally reusable.

For agricultural use, RFID ear tags, Figure 3, are commonly used. The coil and chip is contained within a sealed plastic housing making it robust enough to withstand adverse conditions. As well as the data stored in the tag, the housing also carries the code in print, as a visible 'backup' should the tag fail. They are easily visible and can be recovered at slaughter, if required.



Figure 3 Round ear tag typical of livestock applications 1

Another method for agricultural use is the bolus, Figure 4. The RFID transponder is sealed in a dense, non-toxic casing, usually ceramic, and the bolus inserted into the animal via its mouth using an applicator. The bolus lodges in the animal's rumen and its weight ensures that it stays in place and not passed through the gut. A disadvantage in their use is that there is no visibility and the only way of testing for the presence of a tag is by checking with a reader.



Figure 4 Bolus tag for livestock applications 2

For other animal applications, in particular pets and small animals, an implantable transponder, Figure 5, can be inserted under the skin using a hypodermic applicator. These are not normally used in farm animal applications because of the risk of them not being recovered and finding their way into meat products.



Figure 5 Implantable transponder (Generic Type)

1.3.2 Semi Passive

Similar to the passive tag, this variant contains a small internal battery to maintain power to the tag allowing it to respond more quickly to the reader.

1.3.3 Active

Active tags contain an internal power source. They can be used as beacon tags which broadcast the transponder information at pre-defined intervals or as response tags which reply to an interrogating signal.

In general, active tags are used in applications where data must be accessible at long range. They may also include sensors that can record biometric data for remote monitoring.

1.4 Passive (inductive) tag operation

In terms of cost and ease of use, passive tags are the preferred choice for livestock tagging. For animal tagging, both agricultural and domestic, the 134.2kHz frequency band is the standard.

There are two standards that set out how the tags must operate;

- ISO 11784 Radio frequency identification of animals - Code structure
- ISO 11785 Radio frequency identification of animals - Technical concept

ISO 11784 defines the way the data is stored within the 64 bits available on this type of tag.

ISO 11785 more accurately defines the frequency of operation at 134.2kHz and the technical concept of collecting the data from the tags in terms of activation frequency, half and full duplex operation, error correction, modulation, etc.

The ISO documents were drawn up to try to produce a common standard in the way tags store and transfer data so that any readers operating to the same standard are able to decode the information they contain.

At this frequency of operation, the electromagnetic waves are able to penetrate materials such as water and living tissue with minimal attenuation, making them suitable for use in animal tagging. There is a trade-off in the speed and volume of data that can be transferred and the range at which the systems can reliably operate. A typical read range for this type of system is approximately 1m although the actual range depends on the system design and power. Hand held readers require closer proximity, approximately 10-25cm, for accurate reading, whilst panel readers with a larger antenna and more power available have a greater range.

In passive tags, the tag power is generated inductively by the reader. At the frequency used, the distance between the reader and the tag is much less than the wavelength of the RF signal; at 135kHz the wavelength is greater than 2000m. This is known as the 'near field' and the RF field can be considered as predominately magnetic due to the characteristics of the wave impedance.

Power is induced in the tag through an effect similar in operation to that of a transformer. The tag is tuned to the reader frequency to maximise energy transfer. A simple diagram of this method of powering tags is shown in Figure 6.

The coupling of the magnetic field into the tag coil is used to produce the required voltage for the tag circuit to operate. When the tag operates, the stored data is used to switch the tag load, and data is transferred to the reader by a process known as load modulation. This is the usual method of data transfer for inductively coupled (low frequency) tags.

Systems can operate in either half duplex or full duplex mode. Both modes transfer data in both directions (duplex), but in half duplex, data can only be sent in one direction at a time, whereas in full duplex data can be transferred in both directions simultaneously. This can be likened to the difference between a walkie-talkie and a telephone: in a walkie-talkie only one person can speak while the other listens, in a telephone both can communicate at the same time.

In solely full-duplex systems, the reader emits a continuous RF field at a constant frequency and the tag produces a modulation signal while energized by the reader field. Continuous reader operation allows tags to be activated at any time they enter the reader's field and to be decoded in the minimum possible time

In half duplex systems the reader emits a pulsed field to send energy to the tag, and the tag sends back its message in the interval between reader field pulses.

There are arguments in favour of both types of tag, in terms of read range and speed of operation, with manufacturers championing their own type. However, to comply with the ISO 11784 and 11785 standards, a reader must be able to read both these types.

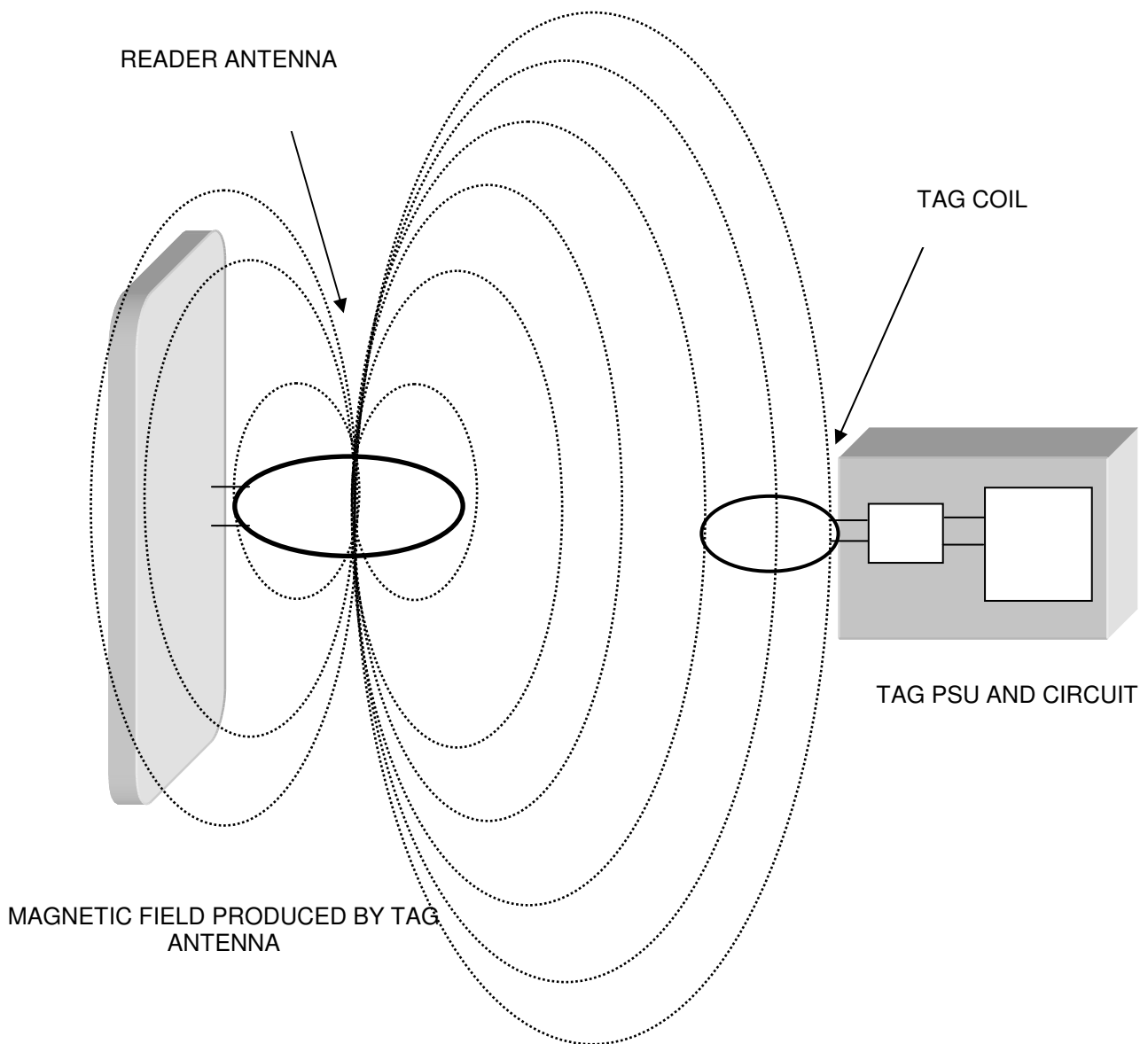


Figure 6 Induced power in an RFID tag

1.5 Processing of data

The data received from the tag must be read and processed correctly for identification of the tag. The standard ISO 11784 defines that, so that all makes of tag complying with the standard will carry the same code structure. It has to be a requirement that each tag carries a unique ID traceable to the tagged animal.

The possibility of an incorrect reading can occur for various reasons;

- i) Decoding errors in reader
- ii) The range of the reader is limited and correct tag interrogation depends on the distance and orientation of the tag in the reader's field. For animal use, the animals can be guided through a race or narrow lane so that they are guaranteed to pass through the field at an acceptable distance.
- iii) The reader field can be distorted or absorbed by local structures. This is less of a problem with the low frequency tags defined by the ISO standards.
- iv) Speed of the tag passing through the field. For animal use and with large fixed panel antennae where the field volume can be large this is unlikely to be a problem.
- v) Two tags in the field simultaneously. Manufacturers can include 'anti-collision' technology in the systems so that tags trying to communicate with the reader do not interfere with one another. In animal use, animals can also be restricted to pass in single file through the field.
- vi) Electromagnetic Interference (EMI) from other equipment disrupting the operation of the system.
- vii) Tag failure or loss.

Apart from total loss or failure of the tag, the other points can be addressed by careful design and installation of the systems. The systems would also, of course have to recognise either bad or no data so that manual intervention can take place. RFID manufacturers have demonstrated systems whereby the gate will only open on a good read to let an animal through. On bad or no data, the animal is diverted to a side pen where manual recording can take place. Tags normally also carry a printed identification number for manual cross checking.

Another problem is duplication of data, especially if two readers are operating in the same area. In a single reader this is overcome by software 'recognising' the same tag but not recording a duplicate. If two readers are operating in the same area, they can be synchronised so that data is shared and duplicates recognised by each reader.

This data must be transferred to a computer running a suitable program which will correlate the data for transfer to a central database either directly, if connected via a LAN/WAN or internet link, or for non-networked PCs at a later time when network access is available. Manufacturers of the tag readers normally supply this type of software with the systems.

2 Compliance of RFID Tag Reader Systems

2.1 CE Marking

All electrical and electronic products for sale within the European Union are required to carry CE marking. This mark is a manufacturer's declaration that the product complies with the essential requirements of all relevant Directives. EMC is only one of these. Health, safety and environmental protection legislation are others. Products carrying this mark can legally be placed on sale in all member countries and it allows free movement of the product throughout the EU EEA (European Economic Area).

The scope of this study only extends to the EMC requirements.

2.2 Electromagnetic Compatibility (EMC)

The definition of EMC according to Article 1 part 4 of Council Directive 89/336/EEC is;

“Electromagnetic compatibility means the ability of a device, unit of equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.”

And, in addition, according to the UK Statutory Instrument 2005 No. 281 EMC Regulations (the UK legal implementation of the EU EMC Directive);

“Apparatus must be so constructed that:

- The electromagnetic disturbance it generates does not exceed a level allowing other relevant apparatus to operate as intended;

and

- It has a level of intrinsic immunity which is adequate to enable it to operate as intended,

when it is

- properly installed and maintained ;

and

- used for the purpose for which it was intended.”

The purpose of this study is to assess the EMI levels present in areas where animal tag readers are likely to be used. From the results of the study it will be possible to determine if the current standards adequately address the possible threats in the environment of use.

2.3 Standards

It should be noted that both the EU Directive and the UK Statutory Instrument make no reference to any specific standards in relation to compliance.

Standards are viewed as a route to compliance, and meeting ‘harmonised’ standards, i.e. standards published in the Official Journal of the European Union (OJEU) and therefore accepted throughout the EU, applicable to equipment gives a “presumption of conformity” to the Directive.

Standards are, of course, continuously evolving and when shortcomings in existing standards are highlighted, changes can be incorporated to amend the requirements of the standards in order that compliance to the essential requirements of the Directive can be ensured.

Compliance via the Standards route is not necessarily a foolproof method. There have been cases where equipment has been tested to, and met, apparently applicable standards, but when used (in their normal environment) emissions or immunity effects have been noted, hence the equipment does not meet the protection requirements.

These aberrations can be put into two categories;

- i) A shortcoming of the standards applied (emissions and/or immunity)
- ii) Insufficient consideration of the environment of use and the possible EMC victims/threats present (emissions and immunity)

In either case, the responsibility for the product's EMC performance falls to the manufacturer of the product. Failure to meet the requirements of the EU Directive can lead to legal action. This is especially true of the emission requirements, where radio services or other co-located equipment is affected, but also applicable to the immunity requirements, where equipment fails to operate reliably in its environment of use due to external sources of interference.

Hypothetical examples of this could be;

- Equipment tested to existing harmonised standards but producing radio frequency emissions outside of the standard frequency range that cause effects on broadcast services or other co-located equipment. A real example was that of a hairdryer tested up to 300MHz (EN55014 Household Appliances standard) which caused interference on digital TVs. This case went as far as court proceedings.
- Equipment complying with industrial level emissions requirements closely located with very sensitive equipment and causing interference effects
- Equipment rated at residential and light industrial levels for immunity used within an industrial environment (where the level of threat is greater) and suffering unreliable operation due to interference from external sources

Standards, therefore, offer generally suitable guidelines for compliance based on currently accepted frequency ranges and levels of electromagnetic disturbance developed over time, to try to simulate real world conditions. Although it may not seem like it to the manufacturer, the standards aim is to be realistic, realisable and repeatable, and in general, harmonized standards use the same frequency ranges and levels of disturbance. What standards cannot do is guarantee the EMC performance of equipment 100%. To introduce emissions and immunity testing ensuring that equipment would comply under every conceivable variation of frequency and disturbance level would place an excessive commercial burden on manufacturers through increased build and testing costs.

That said, if the electromagnetic characteristics of the environment of use of the equipment is adequately known, then testing may be extended from the standard values, either in frequency range or disturbance levels, to simulate disturbances found to be present in the location(s) that the equipment will be used in. An understanding of the threats present should lead to equipment design and installation practices to mitigate any EMC effects and hence lead to more reliable operation of equipment.

2.4 Standard Test Requirements

2.4.1 Control of the RF Spectrum

The RF spectrum is intensively used for a multitude of purposes requiring the use of specific frequencies; radio and television broadcasting, mobile telephones, mobile radios, emergency services, military, aircraft and airports, for example. Because of this high volume usage and concentration of services in a small region of the radio spectrum, unrestricted transmission of RF is not allowed due to the risk of unregulated transmissions interfering with legitimate ones. Standard frequencies are allocated for particular usage. This is known as spectrum management, and in the UK it was regulated by the Radiocommunications Agency, a regulatory body that merged with 4 others in 2003 to form OFCOM. It is OFCOM's responsibility to ensure that the radio spectrum is optimally used and kept under control so that there are no conflicting transmissions. It is also their business to license frequencies for use by commercial companies

Although RFID systems are radio transmitters, they are defined as Short Range Devices (SRDs) and do not have to be licensed, but are assigned various frequency bands with a limit to the allowed transmission power in each range. The reason for frequency band allocation is so that operation of these devices does not compromise other radio spectrum users, for example broadcasting, mobile radio, police and emergency services, etc. In Europe, the standards governing the regulations for the administration of radio and telecommunications are produced by the European Telecommunications Standards Institute (ETSI). These standards are used to produce European regulations.

Table 1 below gives an indication of RFID allocated frequency ranges with allowed power.

| Frequency ranges for RFID-Systems | | |
|-----------------------------------|--|---|
| Frequency range | Comment | Allowed field strength / transmission power |
| < 135 kHz | Low frequency, inductive coupling | 72dBµA/m |
| 6.765-6.795 MHz | Medium frequency (ISM), inductive coupling | 42dBµA/m |
| 7.400-8.800 MHz | Medium frequency, used for EAS (electronic article surveillance) only | 9dBµA/m |
| 13.553-13.567 MHz | Medium frequency (13.56 MHz, ISM), inductive coupling, wide spread usage for contactless smartcards (ISO 14443, MIFARE, LEGIC...), smartlabels (ISO 15693, Tag-It, I-Code...) and item management (ISO 18000-3). | 42dBµA/m |
| 26.957-27.283 MHz | Medium frequency (ISM), inductive coupling, special applications only | 42dBµA/m |
| 433 MHz | UHF (ISM), backscatter coupling, rarely used for RFID | 10-100mW |
| 868-870 MHz | UHF (SRD), backscatter coupling, new frequency, systems under development | 500mW, Europe only |
| 902-928 MHz | UHF (SRD), backscatter coupling, several systems | 4 W - spread spectrum, USA/Canada only |
| 2.400-2.483 GHz | SHF (ISM), backscatter coupling, several systems, (vehicle identification: 2.446-2.454 GHz) | 4 W - spread spectrum, USA/Canada only, 500mW, Europe |
| 5.725-5.875 GHz | SHF (ISM), backscatter coupling, rarely used for RFID | 4 W USA/Canada, 500mW Europe |

Table 1 RFID Frequency ranges 3

Field strength is measured in logarithmic units, dB, relative to a reference level. In this case, dBµA/m, the reference level is 1µA/m that is equal to 0dBµA/m (calculation is $20\log_{10}1$)

2.4.2 ETSI Standards

RFID systems fall under the description of Short Range Devices as defined in the ETSI standards;

- EN 300 330-1 Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz; Part 1: Technical characteristics and test methods
- EN 300 330-2 Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz; Part 2: Harmonized EN under article 3.2 of the R&TTE Directive

and associated references;

- EN 301 489-1 Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
- EN 301 489-3 Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 40 GHz

These standards define the allowable transmit power of the device and the transmission frequency and characteristics (spectrum management).

In addition, and relevant to this study, are the EMC requirements of the devices defined within EN 301 489-1, with specific conditions as described in EN 301 489-3. The EMC requirements lay down minimum requirements of performance, for both emissions and immunity, required in order that the equipment may be declared compliant with the EMC considerations of the EU RTTE Directive 1999/5/EC (as amended) and hence the EU EMC Directive 89/336/EEC (as amended).

Compliant equipment carries the CE mark allowing for unrestricted trade within the EU.

The EMC tests required for compliance of short-range devices to the requirements of EN 301 489-1 are listed in Table 2 (emissions) and Table 3

| Test required | Reference standard | Level |
|---|--------------------|--|
| Emissions | | |
| Conducted emissions (mains power) | EN55022 Class B | Average limits 0.15 to 0.5MHz 66-56dB μ V 0.5 to 5MHz 56dB μ V 5-30MHz 60dB μ V Quasi peak limits 0.15 to 0.5MHz 56-46dB μ V 0.5 to 5MHz 46dB μ V 5-30MHz 50dB μ V Transmit band of equipment excluded |
| Conducted emissions (telecommunication ports) | EN55022 Class B | Average limits 0.15 to 0.5MHz 74-64dB μ V 0.5 to 30MHz 64dB μ V Quasi peak limits 0.15 to 0.5MHz 84-74dB μ V 0.5 to 30MHz 74dB μ V Transmit band of equipment excluded |
| Radiated emissions | EN55022 Class B | Quasi peak limits 30-230MHz 30dB μ V/m 230-1000MHz 37dB μ V/m Transmit band of equipment excluded |
| Harmonic Current emissions | EN61000-3-2 | Class A device (>75W only) |
| Voltage fluctuations and flicker | EN61000-3-3 | Specified by standard depending on equipment |

Table 2 EN 301 489-1 test requirements – Emissions

| Test required | Reference standard | Level |
|---------------------------------|--------------------|--|
| Immunity | | |
| Electrostatic Discharge | EN61000-4-2 | +/-4kV contact discharge +/-8kV air discharge |
| Radiated RF Immunity | EN61000-4-3 | 3V/m 80 - 1000MHz and 1400 - 2000MHz 80% 1kHz amplitude modulated Transmit band of equipment excluded |
| Electrical Fast Transient/Burst | EN61000-4-4 | +/-1kV mains power +/-0.5kv dc power (if connected to distributed dc supply, not battery power) +/-0.5kV signal/control/telecom ports |
| Surge Transient | EN61000-4-5 | Power lines +/-2kV line to ground +/-1kV line to line Indoor telecommunication lines >10m +/-0.5kV line to ground Telecommunication lines to outdoor cables +/- 1kV line to ground |
| Conducted RF Immunity | EN61000-4-6 | 3Vrms 0.15 - 80MHz 80% 1kHz amplitude modulated Transmit band of equipment excluded |
| Voltage Dips and Interrupts | EN61000-4-11 | Reduction of 30% for 0.5 cycles (10ms) Reduction of 60% for 5 cycles (100ms) Interruption >95% for 250cycles (5 secs) |

Table 3 EN 301 489-1 test requirements – Immunity

3 Testing

In order to determine whether the standard immunity test requirements are adequate to define a satisfactory level of operation for the equipment, site testing at a sample of representative sites was performed to determine typical ambient levels of interference. Testing of a sample of RFID equipment in the laboratory was performed to characterise its immunity to interference.

3.1 EMI Levels

The site testing performed for this study deals with conducted and radiated emissions. These levels are measured in the following units;

| | |
|---------------------|--|
| Conducted emissions | dB μ A |
| Radiated emissions | dB μ A/m or dB μ V/m (depending on whether magnetic or electric field is measured) |

EMI levels referenced by the immunity section of the standards EN61000-4-3 and EN61000-4-6 are set using the following units;

| | |
|--------------------|-------|
| Conducted immunity | V rms |
| Radiated immunity | V/m |

To make an easy comparison between levels of immunity required and the EMI levels measured on site, we can convert the immunity levels as follows;

| | | | | | |
|--------------------|--|----------|-----------------|----------|------------------|
| Conducted immunity | To convert V to dB μ V, $20\log(V \times 10^6)$. | | | | |
| | To convert of dB μ V to dB μ A, subtract 43.5 (nominal impedance of 150 Ω , converted to dB, $20\log 150$) | | | | |
| | 3V rms | equal to | 130dB μ V | equal to | 86.5dB μ A |
| | 10V rms | equal to | 140dB μ V | equal to | 96.5dB μ A |
| Radiated immunity | To convert dB μ V/m to dB μ A/m, subtract 51.5 Ω (impedance of free space, 377 Ω , converted to dB, $20\log 377$) | | | | |
| | 3V/m | equal to | 130dB μ V/m | equal to | 78.5dB μ A/m |
| | 10V/m | equal to | 140dB μ V/m | equal to | 88.5dB μ A/m |

3.2 Site Testing

3.2.1 Aberdeen and Northern Marts (ANM), Inverurie, Aberdeenshire

A test report detailing findings from this site test can be found in Appendix A.

3.2.2 Summary

The measurements performed at the Mart area showed that the electromagnetic environment was not severe (measured levels were found to be "ordinary"). Maximum levels measured are shown in Table 4 to Table 7.

| Location | Type of measurement | Frequency | Level | Limit (immunity) | Margin |
|--|--------------------------|-----------|-------------------|------------------|--------|
| Site 1 – Tag check podium | | | | | |
| Normal | Radiated, magnetic field | 58kHz | 53.4dB μ A/m | 78.5dB μ A/m | 25.1dB |
| Normal | Radiated, electric field | 906.9MHz | 110.2dB μ V/m | 130dB μ V/m | 19.8dB |
| With 'prodder' | Radiated, magnetic field | 844kHz | 45.5dB μ A/m | 78.5dB μ A/m | 33.0dB |
| With 'prodder' | Radiated, electric field | 51.3MHz | 97.9dB μ V/m | 130dB μ V/m | 32.1dB |
| Comments: The levels noted for the 'prodder' are in addition to the normal measurements. The emission at 906.9MHz is related to mobile telephone transmitters. | | | | | |

Table 4 Summary of ANM Site 1 EMI levels

| Location | Type of measurement | Frequency | Level | Limit (immunity) | Margin |
|---|--------------------------|-----------|------------------|------------------|--------|
| Site 2 – Entrance to Ring 3 | | | | | |
| Normal | Radiated, magnetic field | 1.64MHz | 37.6dB μ A/m | 78.5dB μ A/m | 40.9dB |
| Normal | Radiated, electric field | 912.7MHz | 84.0dB μ V/m | 130dB μ V/m | 46.0dB |
| Comments: The emission at 912.7MHz is related to mobile telephone transmitters. | | | | | |

Table 5 Summary of ANM Site 2 EMI levels

| | | | | | |
|---|--------------------------|----------|-------------------|------------------|--------|
| Site 3 – Exit from Ring 3 | | | | | |
| Normal | Conducted | 1.82MHz | 52.7dB μ A | 86.5dB μ A | 33.8dB |
| Normal | Radiated, magnetic field | 56kHz | 69.6dB μ A/m | 78.5dB μ A/m | 8.9dB |
| Normal | Radiated, electric field | 910.8MHz | 107.7dB μ V/m | 130dB μ V/m | 22.3dB |
| Comments: The emission at 910.8MHz is related to mobile telephone transmitters. | | | | | |

Table 6 Summary of ANM Site 3 EMI levels

| Location | Type of measurement | Frequency | Level | Limit (immunity) | Margin |
|---|--------------------------|-----------|------------------|------------------|--------|
| Site 4 – Entrance to Ring 2 | | | | | |
| Normal | Conducted | 1.34MHz | 46.5dB μ A | 86.5dB μ A | 40.0dB |
| Normal | Radiated, magnetic field | 29kHz | 33.3dB μ A/m | 78.5dB μ A/m | 45.2dB |
| Normal | Radiated, electric field | 910.8MHz | 88.2dB μ V/m | 130dB μ V/m | 41.8dB |
| Comments: The emission at 910.8MHz is related to mobile telephone transmitters. | | | | | |

Table 7 Summary of Site 4 EMI levels

In general, across the frequency ranges tested, the margin between the normal radiated emission levels measured on site and the minimum immunity levels is greater than 40dB (i.e. 100:1 in linear terms) and greater than 30dB (300:1 in linear terms) for conducted RF. Mobile telephone base stations shown higher emissions at around 20dB margin and there is low frequency peak at 56kHz that had a margin of 8.9dB.

Both the low frequency peak at 56kHz and mobile telephone base stations signals are unlikely to cause any interference on RFID equipment at the levels measured on site.

Even under abnormal conditions, during discharge of an electric 'prod' to a fence, the emissions did not come within 30dB of the minimum immunity limits.

There is no evidence that the electromagnetic environment at the Mart will affect operation of the RFID equipment, although use of a 'prod' should be controlled and discouraged close to any electronic equipment in general.

3.2.3 United Auctions, Kildean, Stirling

A test report detailing findings from this site test can be found in Appendix B

3.2.4 Summary

The Mart area was not electromagnetically severe. Maximum levels measured are shown in Table 8.

| Location | Type of measurement | Frequency | Level | Limit (immunity) | Margin |
|---|--------------------------|-----------|------------|------------------|--------|
| Site 1 – Tag check podium | | | | | |
| Normal | Radiated, magnetic field | 186kHz | 50.4dBµA/m | 78.5dBµA/m | 28.1dB |
| Normal | Radiated, electric field | 912.7MHz | 84.9dBµV/m | 130dBµV/m | 45.1dB |
| Comments: The emission at 912.7MHz is related to mobile telephone transmitters. | | | | | |

Table 8 Summary of EMI levels

In general, across the frequency ranges tested, the margin between the normal levels measured on site and the minimum immunity levels is greater than 30dB. There is low frequency peak at 186kHz that had a margin of 28.1dB.

Radiated emissions at 186kHz, unless at a very high level do not pose a substantial threat as they decay quickly as the distance from the source increases.

There is no evidence that the electromagnetic environment at the Mart will affect operation of the RFID equipment.

3.2.5 Scotbeef (Abattoir), Bridge of Allan

A test report detailing findings from the site test at Scotbeef, can be found in Appendix C

3.2.6 Summary

The abattoir area showed some electromagnetic activity. Maximum levels measured are shown in Table 9, Site 1 Sheep stunning area and Table 10, Site 1 Sheep stunning area

| Location | Type of measurement | Frequency | Level | Limit (immunity) | Margin |
|--|--------------------------|-----------|------------------|------------------|--------|
| Site 1 – Sheep stunning area | | | | | |
| Normal | Conducted | 3.88MHz | 76.6dB μ A | 86.5dB μ A | 9.9dB |
| Normal | Conducted | 18.9MHz | 50.0dB μ A | 86.5dB μ A | 36.5dB |
| Normal | Radiated, magnetic field | 2.77MHz | 77.3dB μ A/m | 78.5dB μ A/m | 1.2dB |
| Normal | Radiated, electric field | 39.7MHz | 89.6dB μ V/m | 130dB μ V/m | 40.4dB |
| Normal | Radiated, electric field | 949.6MHz | 90.2dB μ V/m | 130dB μ V/m | 39.8dB |
| Comments: The emission at 3.88MHz is the highest peak level and the emission at 18.9MHz is the highest continuous level related to the electric stunning system. The emission at 949.6MHz is related to mobile telephone transmitters. | | | | | |

Table 9 Summary of Scotbeef Site 1 EMI levels

| Location | Type of measurement | Frequency | Level | Limit (immunity) | Margin |
|---|--------------------------|-----------|------------------|------------------|--------|
| Site 2 – Cattle stunning area | | | | | |
| Normal | Radiated, magnetic field | 804kHz | 53.5dB μ A/m | 78.5dB μ A/m | 25.0dB |
| Normal | Radiated, magnetic field | 113kHz | 53.8dB μ A/m | 78.5dB μ A/m | 24.7dB |
| Normal | Radiated, electric field | 912.7MHz | 86.6dB μ V/m | 130dB μ V/m | 43.4dB |
| Comments: The emission at 912.7MHz is related to mobile telephone transmitters. | | | | | |

Table 10 Summary of Scotbeef Site 2 EMI levels

In general, across the frequency ranges tested, the margin between the normal electric field radiated emission levels measured on site and the minimum immunity levels is greater than 40dB.

However, at Site 1, the sheep stunning area, levels with a margin as low as 1.2dB were measured at the lower frequency magnetic field emissions and 9.9dB on conducted RF noise on the power cables. Although these are still below the minimum limits for immunity levels, it is an indication that substantial interferences are present.

The electromagnetic interference measured at Scotbeef was more significant than that found at the Marts due the electrical machinery in operation at the site.

The levels do indicate, though that equipment meeting the required immunity standards should operate satisfactorily provided normal installation precautions are taken.

3.3 Laboratory Testing

Laboratory testing was performed on a panel antenna reader and a hand held 'stick' reader.

A test report detailing findings from this site test can be found in Appendix D.

3.3.1 Standard Tests

The purpose of the study was to investigate the possibility of interference affecting the performance of RFID readers, and testing concentrated on the immunity aspects of EMC testing.

Most of the immunity tests are non-destructive, the levels involved are such that they may cause equipment to malfunction, but on removal of the disturbance the equipment will either recover operation on its own or an operator can reset the equipment to a normal state.

Exceptions to this are Electrostatic Discharge (ESD) and Surge testing. Both of these tests can be fatal to equipment if not sufficiently immune. ESD testing can damage sensitive components in a circuit and surge testing can damage power supply components.

Due to the limited availability of equipment for test and the possibility of damage to the reading equipment the surge tests were limited to half standard levels only (as per the equipment's owner wishes).

Immunity tests can be divided into two general types; continuous and transient phenomena as listed in Table 11 below.

| Phenomenon | Continuous or Transient | Possible Sources |
|---------------------------------|--|--|
| Electrostatic Discharge | Transient | Accumulation of charge on a person during very dry weather, wearing of artificial fibre fabrics, artificial fibre carpets, etc |
| Radiated RF Immunity | Continuous | Radio transmissions, power machinery, etc |
| Electrical Fast Transient/Burst | Continuous | Motors, welding, etc |
| Surge Transient | Transient | Start up/shut down of power machinery, lightning |
| Conducted RF Immunity | Continuous | Electromagnetically noisy equipment with cables running close to equipment or connected to same power source |
| Voltage Dips and Interrupts | Reduction of 30% for 0.5 cycles (10ms) Reduction of 60% for 5 cycles (100ms) Interruption >95% for 250 cycles (5s) | Discontinuities in the power supply |

Table 11 Continuous and transient disturbances

Many of the current EMC standards differentiate these types of phenomena in the criterion of acceptance they allow during immunity testing.

Transient phenomena are of short duration and occur either as a single or occasionally repeated disturbance. Interruption of the equipment operation is allowed provided that no damage to the equipment occurs, no data are lost and normal operation is resumed after the disturbance is removed. In the case of RFID tag reading it would be possible that a single reading could be lost if the disturbance coincided with the reading process.

Continuous phenomena are either present continuously (e.g., local radio transmitters) or for long duration (e.g., operation of large machinery) and if the disturbance is high enough to cause equipment to malfunction then the function of the equipment is lost for as long as the disturbance is present. It is unlikely that local radio transmitters would cause this problem but electromagnetically noisy machinery co-located with the equipment could possibly interrupt the operation. In the case of RFID tag reading, the worst-case scenario would be that function could be lost for as long as the noise source was operating and multiple readings missed. In non-critical equipment, an effect like this can be permitted, providing that the equipment recovers when the disturbance is removed. However, in the case of RFID tag reading, particularly in a mart environment, loss of function for even a few minutes could result in a considerable number of animals not being read with the consequent slowing up of the auction and perhaps having to resort to manual recording methods.

Table 12 below shows the likelihood of transient and continuous phenomena being present.

| Phenomenon | Likelihood |
|---------------------------------|--|
| Electrostatic Discharge | Low. Potential for accumulation of charge is low, the environment in the marts and abattoir is not conducive to static build up – moist area, concrete/stone floors. |
| Radiated RF Immunity | High. Local radio and telephone transmitters, co-located equipment, particularly in an abattoir environment |
| Electrical Fast Transient/Burst | High. Co-located equipment, particularly in an abattoir environment |
| Surge Transient | Medium. Co-located equipment, particularly in an abattoir environment, possibility of lightning strike to HV overhead power lines |
| Conducted RF Immunity | High. Co-located equipment, particularly in an abattoir environment |
| Voltage Dips and Interrupts | Medium. Rural area power supply may suffer dropouts. |

Table 12 Likelihood of phenomena occurring

3.4 EMC Immunity Tests

The immunity tests required are detailed in Table 3, EN 301 489-1 Test Requirements.

These tests and levels are detailed as follows. A description of the test and the rationale for its use is included.

For each test a criterion of susceptibility is defined based on the following definitions taken from ETSI EN 301 489-3;

| | |
|-------------------|---|
| Equipment Type | Type I, transfer of messages, digital signals |
| Equipment Class 2 | Medium reliable SRD communication media, e.g. causing inconvenience to persons, which cannot simply be overcome by other means. |
| Equipment Class 3 | Standard reliable SRD communication media, e.g. causing inconvenience to persons, which can simply be overcome by other means. |

The RFID equipment class perhaps falls between the two levels in that a failure can be overcome by the use of manual methods. However, the inconvenience would be considerable, therefore in cases like this the higher level should take precedence, therefore apply Class 2 requirements.

For Class 2 SRDs, the criteria of susceptibility are;

| | | |
|-------------|-------------|---|
| Criterion A | During test | Operate as intended No loss of function No unintentional responses |
| | After test | Operate as intended No loss of function No degradation of performance No loss of stored data or user programmable functions |
| Criterion B | During test | May lose one or more functions No unintentional responses |
| | After test | Operate as intended Lost function(s) shall be self-recoverable No degradation of performance No loss of stored data or user programmable functions |

3.4.1 EN61000-4-2 – Electrostatic Discharge

3.4.1.1 Test description

For equipment that is not floor standing, tests are performed with the equipment mounted on a ground plane but separated from it by a 0.5mm insulating sheet.

Electrostatic discharges are applied to selected points on the equipment. Points are selected to include parts of the equipment that may be particularly susceptible to ESD, e.g., connectors, gaps between panels, display windows, the enclosure, buttons, etc. The points are normally confined to parts of the equipment that are accessible to users.

The electrostatic discharge pulse is shaped to simulate the way static is discharged from a person.

ESD can be applied to the equipment in three ways;

- i. Contact – ESD gun probe is applied directly to conducting surfaces of the unit. The probe is pointed so that it can pierce any coating applied (unless the coating is defined as an insulating coating). Simulates a discharge directly on the equipment, e.g. from personnel.
- ii. Air – ESD gun probe is brought up quickly to non-conductive parts of the equipment so that a discharge happens as the probe approaches. The probe is rounded like a finger. Simulates a discharge directly on the equipment, e.g. from personnel.
- iii. Indirect discharge – Discharges are applied to what are known as vertical and horizontal coupling planes (VCP and HCP). The HCP is the ground plane that the equipment is mounted on, the VCP is a copper plane mounted vertically and adjacent to the HCP. This simulates a discharge to a grounded object close to the equipment.

3.4.1.2 Test results summary

No effects on the equipment, panel reader or stick reader, were noted during the application of ESD.

3.4.2 EN61000-4-3 – Radiated RF Immunity

3.4.2.1 Test description

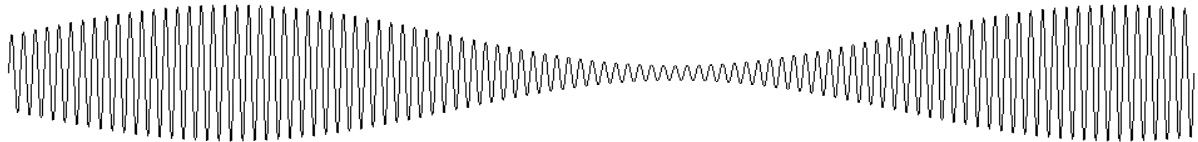
Testing to this standard requires the use of an anechoic or semi-anechoic chamber since the test involves the transmission of RF across a wide frequency range. Legislation prohibits unlicensed transmission at these levels since it may interfere with licensed broadcast and radio use.

The equipment is placed in a screened semi-anechoic chamber and illuminated with an RF field. The standard level of this field is 3V/m. The RF Field levels used are pre-calibrated to the method described in the specification and the frequency is swept over the range 80-1000MHz. During the test the field is amplitude modulated to a depth of 80% by a 1kHz sine wave.

The criterion of susceptibility for this test is Criterion A

The aim of this test is to simulate the effect of a local RF transmitter, deliberate, e.g. radio, or unintentional, e.g. locally generated emissions from other equipment. The modulation applied simulates a source where the emissions are not pure continuous wave (CW) emissions. This increases the likely effect on equipment as the modulation on the RF carrier is demodulated within electronic circuits. The RF carrier is removed but the modulating frequency can be impressed on power supplies or signal lines causing incorrect operation of equipment. The effects of modulation on the RF carrier wave are shown in Figure 7.

Amplitude Modulated Carrier Wave (carrier wave x modulating signal)



Pulse Modulated Carrier Wave

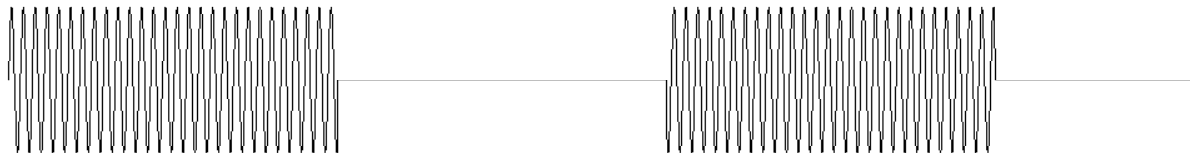


Figure 7 Amplitude and Pulse modulation

The 1kHz sinusoidal modulation does not accurately represent all sources of RF. For instance mobile telephone transmissions are typically pulse modulated. However research has shown that the effect of the 1kHz sinusoidal modulation has effects comparable to other modulations.

A comparison of modulation methods and their effects is detailed in Annex A of EN61000-4-3: 2002. The conclusions favouring sine wave only modulation are as follows;

- Narrow band detection response in analogue systems reducing background noise problems
- Universal applicability, i.e. no attempt to simulate the behaviour of the disturbing source
- Same modulation at all frequencies
- Always at least as severe as pulse modulation

The final recommendation is that sine wave modulation is used unless there are specific reasons requiring a different type of modulation.

3.4.2.2 Test results summary

At the level required by the standard, 3V/m, the panel reader EUTs did show some effects;

- i) Large panel reading FDX tag, intermittent tag read in the applied frequency range of 80-115MHz
- ii) Small panel reading HDX tag, no tag read in the applied frequency range of 80-101MHz

These effects would need to be rectified for full compliance to the requirements of the standard.

It was noted that the reading of the FDX tag was more susceptible to disturbance than the HDX tag and the distance between the antenna and tag for a successful read was less.

There was a slight difference in construction between the large panel reader and the small panel reader in that the large panel had the exciter/control module attached to the panel itself and connected via a short cable, while on the small panel reader it was separate and attached via a long cable. This extra length of cable is the most likely cause of the reduction in immunity of the reader.

Increasing the field showed marked effects on the panel readers with tag reading being inhibited totally over some frequency ranges.

The threshold of the effect was measured at a minimum of 3.5V/m, which is only slightly above the level of compliance. This could be of some concern where the equipment is installed in areas of significant RF interference. It should be noted that the test level of 3V/m is not particularly severe. It equates to normal residential and light industrial levels.

No effects were noted for the stick reader.

3.4.3 EN61000-4-4 – Electrical Fast Transients/Bursts

3.4.3.1 Test description

Electrical Fast Transients/Bursts can be applied to the equipment using two methods.

- i. Direct injection via a coupling network: used to inject disturbance onto the 230V mains
- ii. Indirect injection via a capacitive clamp: used to inject disturbances onto signal cables

The standard test levels are +/-2kV applied to mains power inputs (direct injection) and +/-1kV applied to signal cables, >3m in length, (capacitive clamp injection).

The criterion of susceptibility for this test is Criterion B

The disturbance injected on the lines consists of 15ms bursts of short pulses as shown in Figure 8.

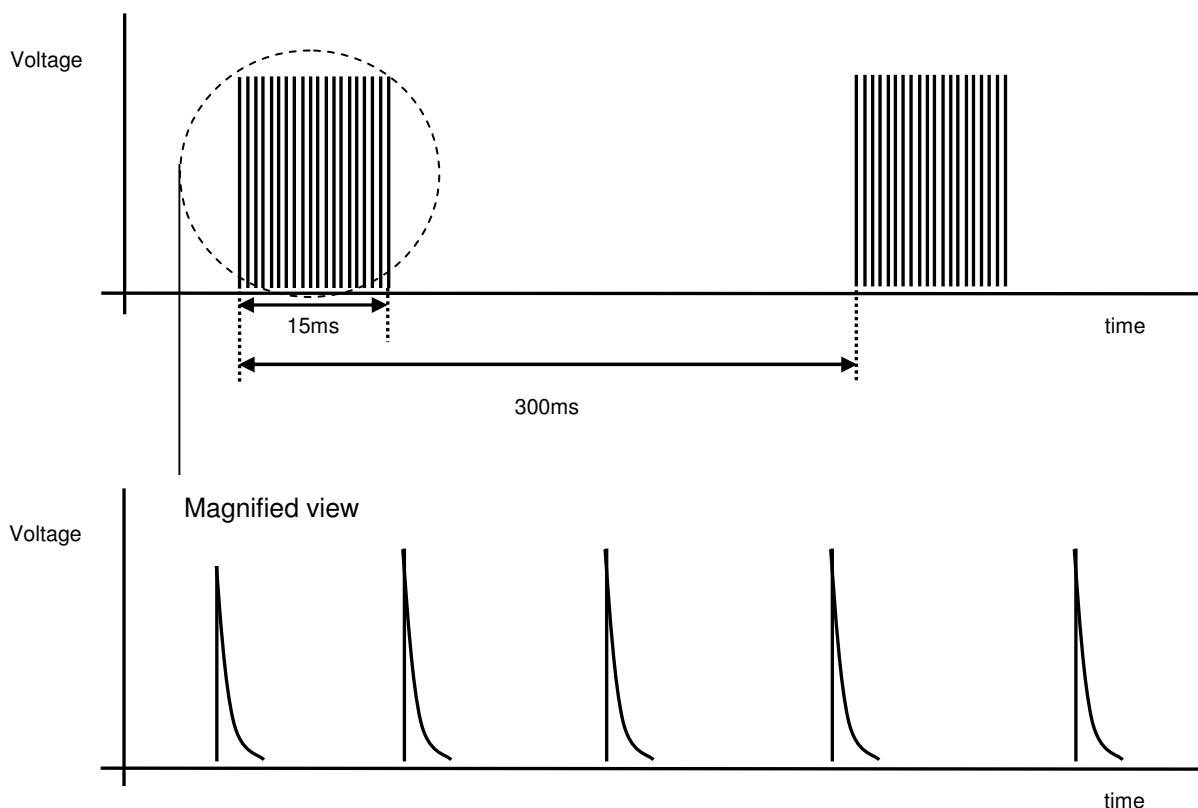


Figure 8 Electrical Fast Transient/Bursts

The aim of this test is to simulate the effect of high voltage, short duration, low energy transients, e.g. generated by switching of inductive loads, relay contacts, etc. This type of disturbance can propagate either by a direct link from the source of the disturbance to the equipment via power cables, or by induction onto signal or power cables running close to the source or its cables.

3.4.3.2 Test results summary

At the levels required by the standard, and to the next higher level, the panel tag reader met the standard criteria for susceptibility for EFT/B.

No tests were required for the stick reader as it was hand held and powered by internal battery.

3.4.4 EN61000-4-5 – Surge Transients

3.4.4.1 Test description

Surge transients are applied to the equipment via a generator and a coupling network that superimposes a high voltage surge onto the normal AC power. The generator can apply the surges at selected points on the ac signal, normally at 0°, 90°, 180°, 270° of the phase angle (see Figure 9).

Surge transients are applied at voltages of $\pm 0.5\text{kV}$, 1kV and 2kV between the following points;

- i. Live line and Earth – 0.5kV, 1kV and 2kV
- ii. Neutral line and Earth – 0.5kV, 1kV and 2kV
- iii. Live and Neutral – 0.5kV and 1kV

The criterion of susceptibility for this test is Criterion B

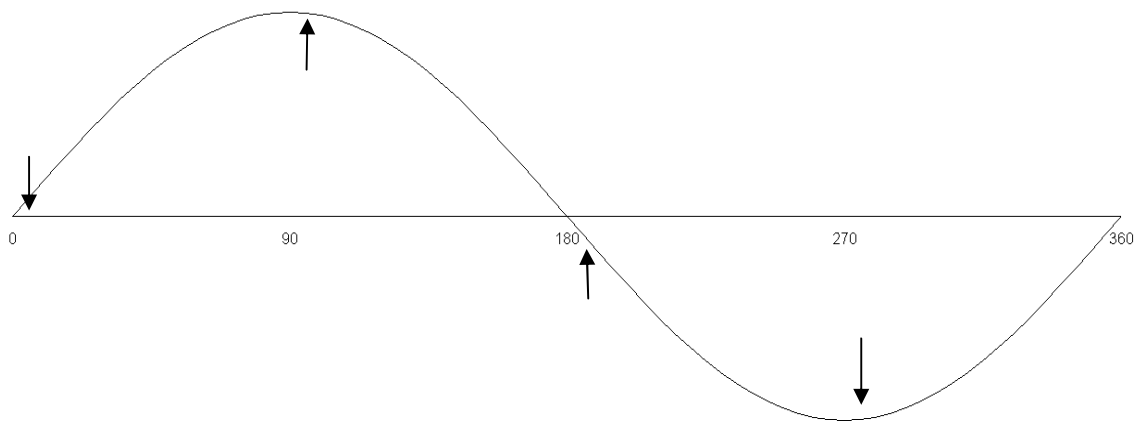


Figure 9 Surge transients, positions on AC power waveform

3.4.4.2 Test results summary

One mains powered sample was available. Since surge testing can damage the EUT, it was decided only to test to half the required level to avoid any risk of losing the EUT.

Surge testing is a check on how the equipment power supply copes with surges on the mains and is a confirmation of the ability of the equipment including any suppression devices to absorb or divert any of these transients.

Power surges are transient effects and should have no effect on the actual process of reading a tag. If a surge interrupts equipment operation a tag read may be lost until the equipment recovers.

At the levels tested the panel tag reader showed no susceptibilities.

No tests were required for the stick reader as it was hand held and powered by internal battery.

3.4.5 EN61000-4-6 – Conducted RF Immunity

3.4.5.1 Test description

Conducted RF disturbances can be applied to the equipment using two methods.

- i. Direct injection via a coupling/decoupling network (CDN) which presents a constant impedance to the injection signal: used to inject disturbance onto the 230V mains (or suitable cables)
- ii. Indirect injection via a current or electromagnetic clamp: typically used to inject disturbances onto signal or other cables

The standard test level is 3Vrms (130dB μ V) applied to mains power inputs (direct injection) and to signal cables >3m in length, (clamp injection). The applied RF disturbance is swept from 150kHz to 80MHz and is amplitude modulated to a depth of 80% by a 1kHz sine wave similar to radiated RF immunity, EN61000-4-3.

The criterion of susceptibility for this test is Criterion A

The aim of this test is similar to radiated RF immunity. In this case, however, at the frequencies of interest, the primary method of noise coupling is conducted via cables. This type of disturbance can propagate either by a direct link from the source of the disturbance to the equipment via power cables, or by induction onto signal or power cables running close to the source or its cables. This is much the same mechanism as the RFID tags themselves obtain power from the reader.

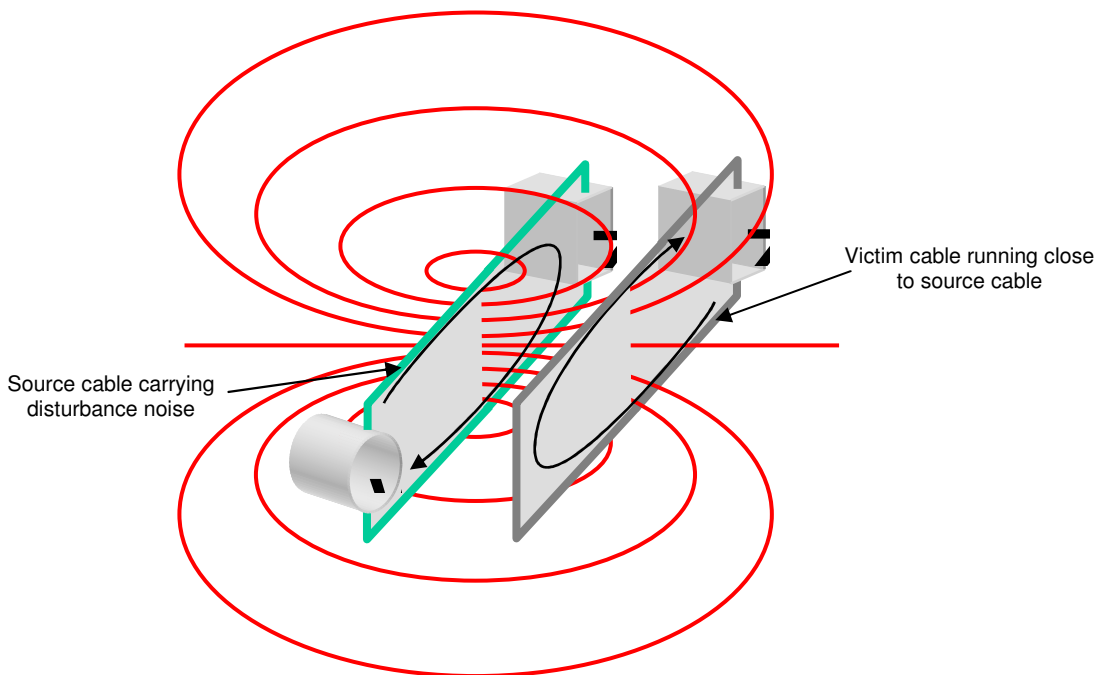


Figure 10 Coupling between cables in proximity

The field produced by the source of the noise is induced onto nearby cables, especially when running distances in parallel, for instance in a cable duct or tied in a bundle.

3.4.5.2 Test results summary

At the level required by the standard, 3V rms, the panel reader did show some effects;

- i) AC input: susceptible to disturbance 150kHz to 195kHz
- ii) DC input: susceptible to disturbance 150kHz to 230kHz

These effects would need to be rectified for full compliance to the requirements of the standard.

For the extended frequency range, it was noted that the EUT was susceptible to any disturbance below 150kHz. The threshold of susceptibility was below 1Vrms.

This is understandable since the EUT operates the tag read at a nominal frequency of 134kHz and it is likely that any disturbance of the field, especially by the 1kHz modulated RF applied, will interfere with the operation of the equipment.

The antenna panel cable is less susceptible to the RF disturbance since it is a screened cable and the equipment meets the requirements of the standard when the RF disturbance is applied to that cable. However, the equipment still shows susceptibilities when frequencies below the 150kHz standard limit are applied.

If the disturbance level is raised to 10V (7V applied when using the current clamp), all cables/inputs show susceptibilities. Again the panel cable is less susceptible than the others due to its screening.

No tests were required for the stick reader as it was hand held and powered by internal battery.

3.4.6 EN61000-4-11 – Voltage Dips and Interrupts

3.4.6.1 Test description

This test is applied to the equipment by connecting the mains power through a test generator. The test generator can be programmed to interrupt the mains power by either or both removal of a set number of power cycles and by reduction of the mains voltage by a set amount. The standard test levels are;

- i. 30% reduction (from nominal 230V) for 0.5 cycles or 10ms (+ and – cycles, Figure 11)
- ii. 60% reduction for 5 cycles or 100ms (Figure 11).
- iii. >95% reduction (interruption) for 250 cycles or 5 seconds (Figure 12).

The criterion of susceptibility for this test is;

| | |
|--------------|--|
| Criterion B | 30% for 10ms |
| Criterion B | 60% for 100ms (with battery back up) |
| Special case | 60% for 100ms and >95% for 5secs (without battery back up), volatile user data and any RF link may be lost |

In all cases however, no unintentional responses should occur and stored data should not be lost.

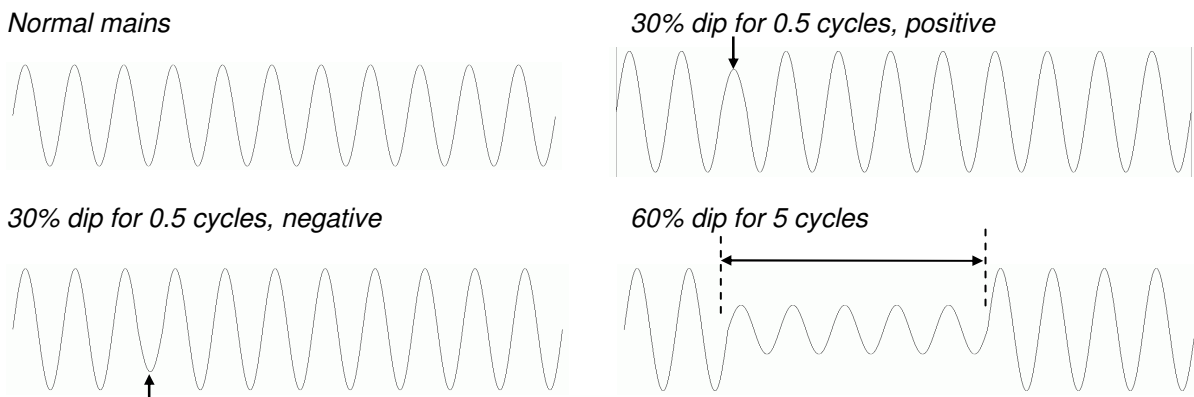


Figure 11 Voltage dips

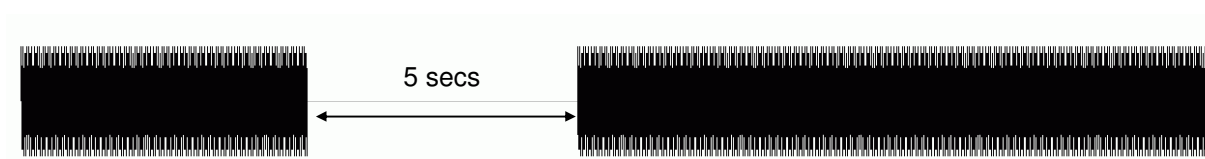


Figure 12 Voltage interruptions

The aim of this test is check the equipment performance under short-term reduction of mains power (dips) or brief interruption of the supply (interruption). This can occur due to faults in the mains power distribution network.

3.4.6.2 Test results summary

At the required levels, the panel tag reader showed no susceptibilities.

In addition, long-term variations were also tested. The EUT operated satisfactorily at 264V AC (240V +10%, worst case) and down to 90V AC.

No tests were required for the stick reader as it was hand held and powered by internal battery.

3.4.7 Gap Analysis

Compliance with the EMC and the EMC part of the RTTE Directives should ensure that equipment will operate satisfactorily in its intended environment of use. That is, it will not interfere with the operation of any other co-located equipment and will not be susceptible to interference from external sources in the environment of use.

The levels defined by the standards are set to be typical of levels of interference found in normal areas of work. They are not intended to ensure that the equipment will operate uninterrupted under extraordinary conditions. To do that would place an intolerable burden on manufacturers in both cost and design time.

Where there is some doubt as to the disturbance levels present in the environment where the equipment will operate, a gap analysis can be performed to determine the differences between test levels required for compliance to the EMC Directive and the levels of possible threats in the actual environment of use. In this way, any shortcomings in the test levels can be identified, and testing modified to cover this. For example, increased levels of disturbance or extending frequency ranges.

The measurements performed on site deal particularly with conducted and radiated RF. Table 13 shows a gap analysis of the EMC requirements for conducted and radiated RF stated in ETSI EN 301 489-1 with levels of RF interference found on site.

| Test | EN 301 489-1 Levels | Site Findings | Comments |
|-----------------------|--|--|---|
| Radiated RF immunity | 3V/m 80 - 1000MHz, 1.4 – 2GHz 80% 1kHz AM | No local EMI exceeding the immunity levels was found at any of the 3 sites | Equipment meeting the requirements of the standards should operate satisfactorily |
| Conducted RF immunity | 3Vrms 0.15 - 80MHz 80% 1kHz AM | No local EMI exceeding the immunity levels was found at any of the 3 sites | Equipment meeting the requirements of the standards should operate satisfactorily |

Table 13 Gap Analysis

4 Summary of the study and recommendations

The aim of the study was to examine the effects of EMI in RFID equipment used for animal identification.

The results of site measurements indicated that Auction Marts are generally electromagnetically benign. They are normally situated in rural environments away from industrial sources of interference and no heavy electrical equipment is in normal use. The findings there suggest that any equipment meeting the requirements of the EU EMC Directive (using EN 301 489-1 as the standard for presumption of conformity) should operate satisfactorily within that environment.

The measurements obtained at the abattoir, although showing some significantly higher readings at lower frequencies, did not show levels of EMI in excess of the minimum immunity requirements specified in the standard, although some measured levels were found to be close to the immunity requirements. Again, equipment meeting the requirements of the EU EMC Directive should operate satisfactorily within that environment.

Laboratory testing of equipment samples did however show inherent susceptibilities in the EID systems tested. These measurements proved the importance of compliance in general and more specifically EMC.

Two aspects will need to be considered to ensure that EID systems will not be interfered when the implementation of such systems will become mandatory:

EMC compliance: all implemented systems should be able to demonstrate that they comply with the essential requirement of the EMC Directive. In such instances, it is recommended that demonstration is achieved by testing and that the testing is performed by an ISO17025: 2005 accredited test house (UKAS accredited test house).

Design/installation: As detailed in Appendix E, some aspects of design/installation practices play an important role to ensure that equipment will not be adversely affected by interference when installed. Often, such practices are ignored, potentially leading to malfunction/interferences. Such practices should be enforced as part of the overall compliance process and most importantly verified.

This study has brought to light a crucial point that is recommended for further study

Market surveillance: As explained in this report, there are currently no legal requirements to perform compliance testing on products (EID systems). Manufacturers may wish not to test their products and still affix the CE marking without any evidence of compliance. It is therefore recommended that a market audit should be performed on EID systems to verify the validity of the CE marking (presumption of conformity to all applicable directives). The audit will concentrate on testing EID systems for Electromagnetic Compatibility (EMC Directive) and potentially extended to low voltage safety (Low Voltage Safety Directive). Such testing should be performed in accredited test laboratories (ISO 17025:2005 accredited). Compliance with the RTTE Directive 1999/5/EC and the UK Statutory Instrument SI2000 No.730 (implementation of the Directive in UK legislation) covers both LV & EMC

Appendix A – Site Test Report, ANM, Inverurie

**Report on Radio Frequency Site
Measurements
at
Aberdeen and Northern Marts
Inverurie
Report (copy 1 of 3)
for
Scottish Executive Environment
and Rural Affairs Department
Contract FF/05/19**

Document number 2212TR1

Project number 7568

Author:

G. Whyte Senior EMC Engineer

Checked:

B. Tait Principal Engineer, BSc, MIET

Approved:

B. Tait Principal Engineer, BSc, MIET

| Issue | Description | Issue by | Date |
|-------|-------------|----------|------------|
| 1 | First Issue | GW | 30/08/2006 |

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The results contained in this report are only applicable to the apparatus tested.

Executive Summary

This report details tests performed in support of the study commissioned by Scottish Executive Environment and Rural Affairs Department (SEERAD) to evaluate the effect of electromagnetic interference in transceivers (readers) used to identify animals electronically. The systems are normally known as Electronic Identification (EID) or RF Identification (RFID) systems.

As part of this project site testing was performed at typical locations where EID is intended be used in the tracking and recording of animal movements, for example auction sites and abattoirs, to identify typical local electromagnetic emissions and their possible threat to the correct operation of EID/RFID systems.

This report details the tests performed at an Auction Mart, ANM Group, Thainstone Centre, Inverurie. Testing was carried out during a normal working day while there was a large scale auction of beef cattle and sheep in progress. Local RF emissions measurements were recorded over a range of frequencies (9kHz to 1000MHz) in various sub-ranges according to the antenna used. Measurements in each frequency sub-range were taken over a period of time (typically around 10 minutes) in order that any variations in the emissions due to operation of any local electrical equipment could be recorded.

The tests show that at the Mart there were no significant sources of RF interference other than typical ambient sources such as radio, television and mobile phones. This was to be expected since there were no (apparent) sources of interference observed in the area of the Mart, such as heavy machinery, motors, etc.

This test report forms part of the overall report (2211CR1) that will contain a more in-depth analysis of the results and a draft Guidelines for Build and Installation that is intended to offer some methods used to minimise the effects of EMI on equipment and installations.

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Report Change History

| Issue | Modification Details |
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Duncan Todd, Scottish Agricultural Organisation Society (SAOS) for assistance and introductions

List of Terms and Abbreviations

| | |
|--------|---|
| AC | Alternating Current |
| ARA | Active Receive Antenna |
| CISPR | Comité International Spécial des Perturbations Radioélectriques |
| DC | Direct Current |
| EID | Electronic Identification |
| EMC | ElectroMagnetic Compatibility |
| EMI | ElectroMagnetic Interference |
| EN | European Norm |
| ETSI | European Telecommunications Standards Institute |
| EU | European Union |
| IT | Information Technology |
| PC | Personal Computer |
| RF | Radio Frequency |
| RFID | Radio Frequency Identification |
| SAOS | Scottish Agricultural Organisation Society |
| SEERAD | Scottish Executive Environment and Rural Affairs Department |
| SRD | Short range Radio Device |
| YES | York EMC Services Ltd |

5 Introduction

5.1 Test Location

Testing was performed on site to investigate local electromagnetic signals present at the areas where RFID systems are likely to be used.

The tests were performed at;

Aberdeen and Northern Marts

Thainstone Centre

Inverurie

Aberdeenshire

AB51 5XZ

The tests were performed in the period 20-21 April 2006 and included a live sheep/cattle auction on 20 April 2006 and the main cattle auction on 21 April 2006.

Some preliminary testing was performed on 20 April at different locations within the market stock area to get an overall view of the electromagnetic environment, and then at the entrance to the main auction ring while the auction was in progress.

During the live cattle auction, equipment was sited at the animal entrance to Auction Ring 2. This position was chosen as a likely area where fixed RFID equipment would be used. In addition, since three auction rings were in use, Ring 2 was chosen as likely to be worst-case, being located between Rings 1 and 3.

5.2 Referenced Standards

EID/RFID equipment falls under the description of a short range radio device and therefore into the scope of the following standards.

| | |
|-------------------|--|
| ETSI EN 300 330-1 | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 1 Technical characteristics and test methods |
| ETSI EN 300 330-2 | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 2 Harmonized EN under article 3.2 of the R&TTE Directive |

These standards specify the characteristics and performance of the transmitter/receiver with respect to field strength, power, etc.

However, the relevant standards applicable to the EMC tests are referenced by;

ETSI EN 301 489-1 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements

This gives the general EMC tests applicable to all devices.

ETSI EN 301 489-3 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3 Specific conditions for short range radio devices (SRD) operating on frequencies between 9kHz and 40GHz.

This gives specific requirements and allowances for SRDs.

These standards refer to the specific requirements for equipment operation. During site investigations of ambient conditions, the ranges used in these standards will be referred to.

6 Testing

For emissions, the nominal CISPR bandwidth requirements are;

- 200Hz from 9kHz to 150kHz
- 9kHz from 150kHz to 30MHz
- 120kHz from 30MHz to 1000MHz

When performing compliance testing for emissions, measurements are performed using Quasi Peak and Average detectors for conducted emissions (RF interference present on power lines and other cabling) and Quasi Peak for radiated emissions. These detectors allow a differentiation between broadband and narrow band emissions by the 'smoothing out' of very short duration transient signals, for example those caused by switching of a load. A drawback of using these detectors is the time taken for the measurements, in particular the Quasi Peak measurement that requires 1 second at the frequency of measurement to obtain a reading. In order that a sequence of measurements could be taken over a period of time, spectrum analysers were used in peak detection mode. Although this does not exactly correspond to the CISPR compliance measurements, peak detection gives the worst possible case in that all emissions are noted, including short duration transients.

The spectrum analyser is also limited in its range of measurement bandwidths, being restricted to 1kHz, 10kHz, 100kHz, etc. The bandwidths that were the closest approximations to the CISPR bandwidths were used.

During the testing, results in each sub range of frequencies were recorded over a period of time (typically approximately 10 minutes per scan range). This allowed for variations in the local EM environment due to the local plant equipment operation to be recorded. The results presented are the maximum levels recorded during that time.

6.1 Current Clamp Tests

These tests are intended to measure the RF interference present on cabling (power and/or signal cables) used in the facility. This RF interference is typically generated by any electrical and electronic equipment connected to the power system or signal cabling, and if it is excessive, operation of sensitive equipment also connected can be affected.

This type of interference can be transferred either directly from the source to the victim by direct connection of cabling or induced from source cables to victim cables due to proximity, e.g., where cables are routed together in long runs.

Tests were performed in the frequency ranges 9kHz to 30MHz.

6.2 Loop Antenna Tests

These tests are intended to measure local radiated H-Field (magnetic) emissions. This RF noise is typically generated by equipment using high currents, e.g. transformers, motors or generators, co-located in the area.

Tests were performed in the range 9kHz to 30MHz. Two loop antennae are used to cover the frequency range.

Radiated emissions can be polarised by the way in which the source of the emissions is constructed, for example by the orientation of cables. Measurements are therefore performed with the antenna positioned in two axes in order to pick up emissions polarised (mainly) in either direction. These are nominally called parallel and perpendicular, referring to the orientation of the antenna with respect to the equipment being tested.

In the case of these site measurements where no specific equipment is involved, therefore no specific direction that the antenna can be referenced to, the terms parallel and perpendicular are used simply to differentiate the two measurements.

6.3 Active Receive Antenna

These tests are intended to measure local radiated E-Field (electric) emissions. This RF noise is typically generated by equipment using high frequency switching and digital circuits, e.g. IT equipment co-located in the area, and local radio transmissions. Tests were performed in the range 30MHz to 1000MHz.

For E-Field (electric) measurements are performed with the antenna positioned in two axes, horizontal and vertical, in order to pick up emissions that can be polarised by the way in which the source of the emissions is constructed or located.

6.4 Typical Emissions Normally Present

Throughout the whole frequency range there will be various emissions present originating from normal licensed broadcast equipment, e.g. mobile radios, emergency services radios, mobile telephones, AM/FM radio, digital radio, television, etc., as well as other data transmissions and beacons. These emissions may be continuous (e.g. AM/FM radio, television) or intermittent (e.g. mobile radio) and of varying levels depending on distance from the source.

6.5 Test Procedure

Testing was performed using PC controlled spectrum analysers with an antenna or clamp appropriate to the test type and frequency range.

6.5.1 Description of measurement parameters

The measurement frequency range of 9kHz to 1GHz was split into sub ranges applicable to each type of antenna (or current clamp) used. The ranges are as follows;

1. Clamp measurement

Measurements were performed on a local power/data cable accessible at Sites 3 and 4.

Frequency range 150kHz to 30MHz

Measurement bandwidth 10kHz

Sweep time 20s

No. of sweeps 10

2. Clamp measurement

Measurements were performed on a local power/data cable accessible at Sites 3 and 4.

Frequency range 100kHz to 150kHz

(typical operating frequency of RFID equipment is likely to be 134kHz therefore this range was chosen to examine emissions more closely over the operating range)

Measurement bandwidth 1kHz

Sweep time 20s

No. of sweeps 10

3. Magnetic Loop measurement

Frequency range 9kHz to 150kHz, Sites 3 and 4.

(9kHz to 1MHz at Sites 1 and 2, investigative measurements)

Measurement bandwidth 1kHz

(1kHz and 10kHz at Sites 1 and 2, investigative measurements)

Sweep time 10s

No. of sweeps 10

4. Magnetic Loop measurement
 - Frequency range 150kHz to 5MHz, Sites 3 and 4
(1MHz to 5MHz at Sites 1 and 2, investigative)
 - Measurement bandwidth 10kHz
 - Sweep time 20s
 - No. of sweeps 10
5. Magnetic Loop measurement
 - Frequency range 120kHz to 140kHz
Sites 3 and 4. A closer examination of typical
RFID operating frequency range.
 - Measurement bandwidth 1kHz
 - Sweep time 20s
 - No. of sweeps 10
6. ARA antenna measurement
 - Frequency range 30MHz to 1000MHz
Sites 1-4.
 - Measurement bandwidth 100kHz
 - Sweep time 20s
 - No. of sweeps 10

6.6 Test areas

6.6.1 Site 1 – Animal Reception

Animals are unloaded from lorries and held in pens prior to 'booking in'. At this area tags (visually numbered, checked manually) and passports are verified to ensure correct identification of the cattle. The checking at this Mart is performed from a raised platform where the operators can easily identify the ear tags as the animals are guided through a narrow passage.

Measurements were performed in the frequency ranges 9kHz to 1MHz (magnetic or H-Field) and 30-1000MHz (electric or E-Field). Also included were measurements taken while an electric 'prodger' was discharged against the metal fencing. Note: there was no indication that a 'prodger' was often used other than in the case of very stubborn animals. An accidental discharge to the metal fencing would be worst-case for emissions, where the fencing may act like an antenna.

Other electronic equipment in use by the auction staff at this location included;

1. Computer, to record animal data

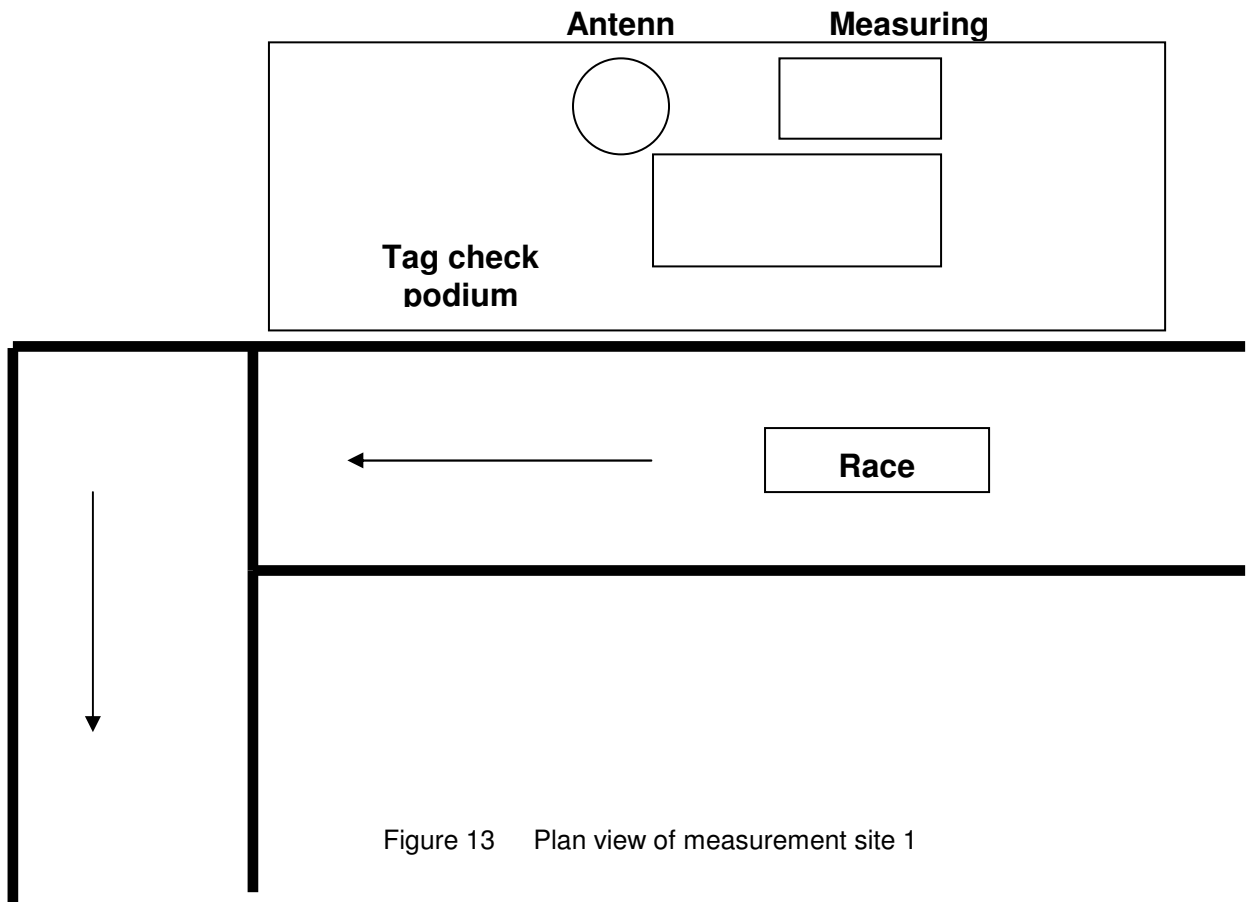


Figure 13 Plan view of measurement site 1



Photo 1. Overview – The tag check podium can be seen in the background (under H)

6.6.2 Plots – Site 1

The plots presented are the levels of the 10 sweeps in each measurement range combined to show the maximum levels recorded.

See over.

6.6.2.1 9kHz to 1MHz – Loop Antenna

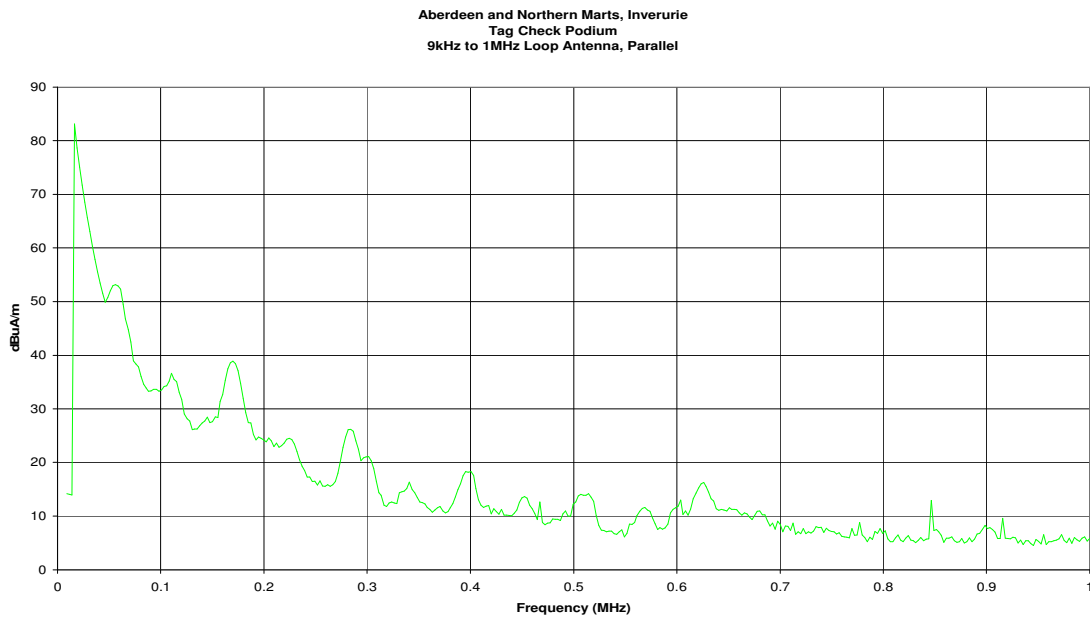


Figure 14 RF Measurement 9kHz to 1MHz, Parallel

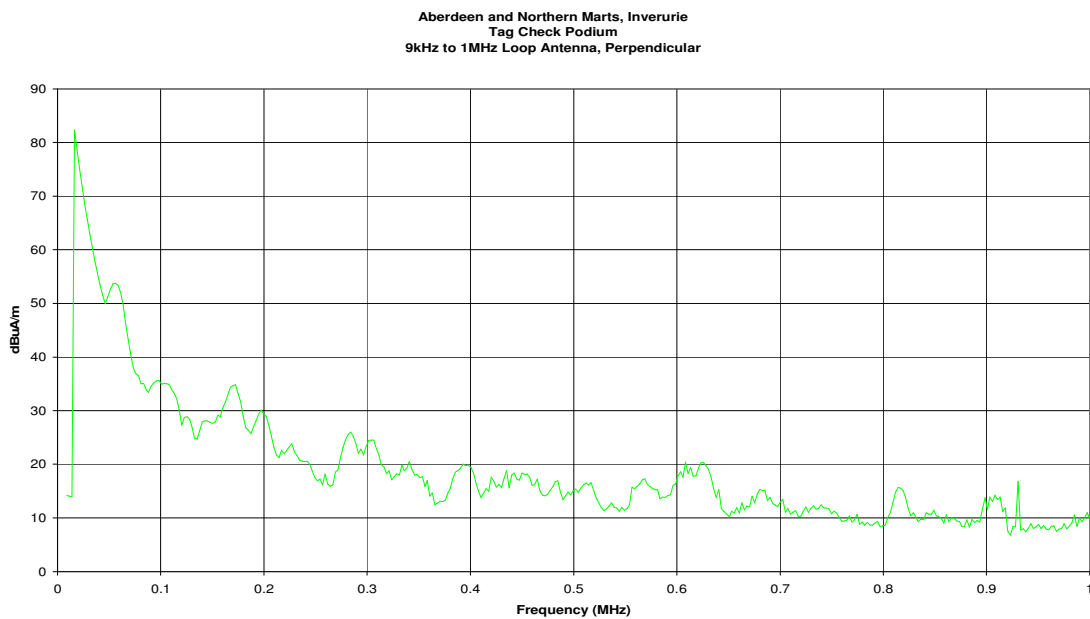


Figure 15 RF Measurement 9kHz to 1MHz, Perpendicular

No significant peaks are noted, the spectrum analyser has a lower frequency limit of 9kHz, thus the apparent increase in level at the beginning of the plot reflects the increase in the measurement noise floor of the analyser rather than true ambient signal levels. Much of the emissions content is likely to be AM radio broadcast (long wave 153–279kHz and medium wave 520-1710kHz).

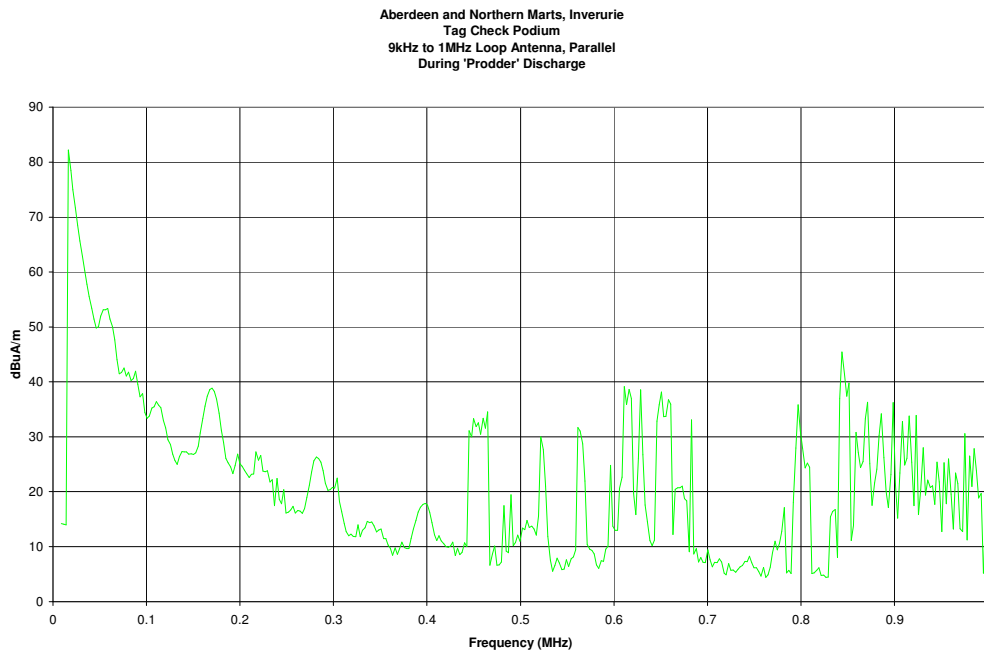


Figure 16 Measurement During 'Prodder' Discharge, Parallel

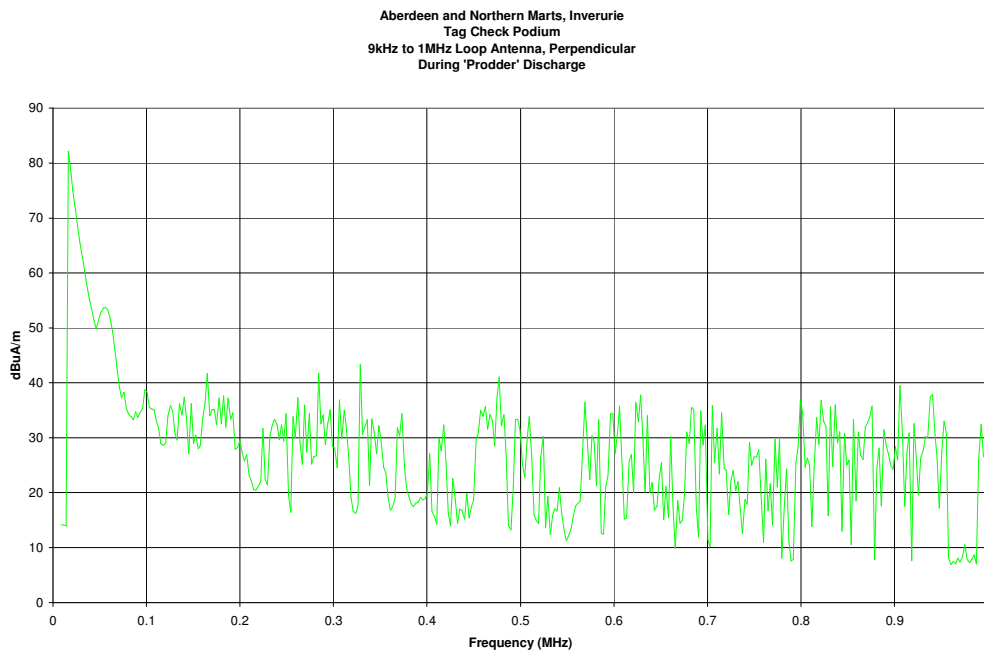


Figure 17 Measurement During 'Prodder' Discharge, Perpendicular

The effects of the 'prodder' discharge against the metal fencing can be seen as RF noise added to the ambient plot across the range. Up to ≈ 35 dB change can be seen.

6.6.2.2 30MHz to 1000MHz – Active Receive Antenna

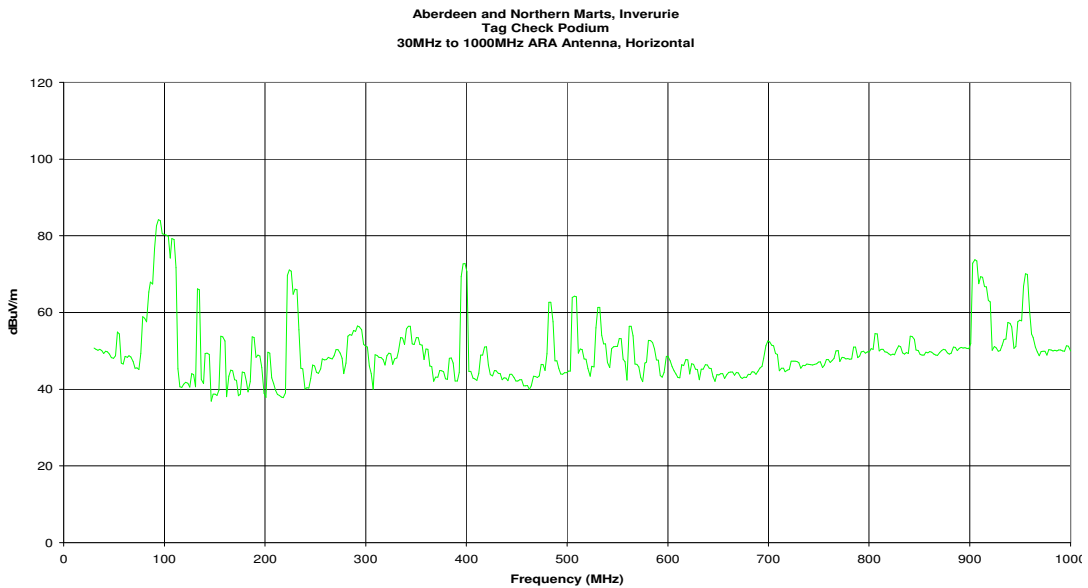


Figure 18 RF Measurement 30MHz to 1000MHz, Horizontal

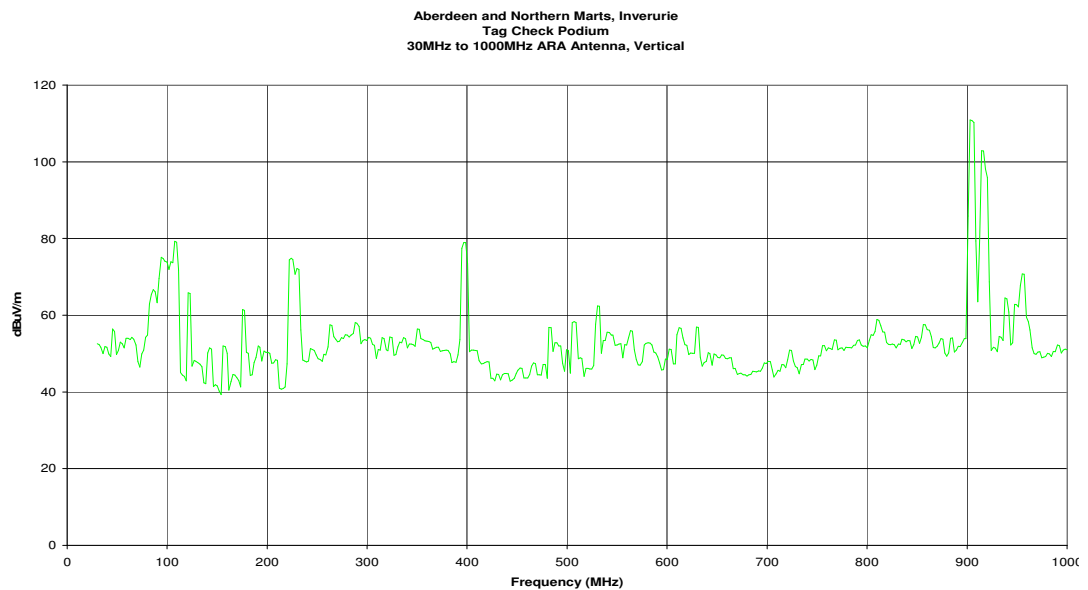


Figure 19 RF Measurement 30MHz to 1000MHz, Vertical

In this range the appearance of local ambient emissions can be seen quite clearly.

- | | | |
|--------------|----------------|---|
| For example; | Around 100MHz: | FM radio |
| | 100-200MHz | Mobile radio |
| | 220-230MHz | Digital Radio broadcast |
| | 400-600MHz | Television broadcast |
| | 900-1000MHz | Mobile telephone (note that the levels are quite high indicating that there is likely to be a mast quite close to the mart) |

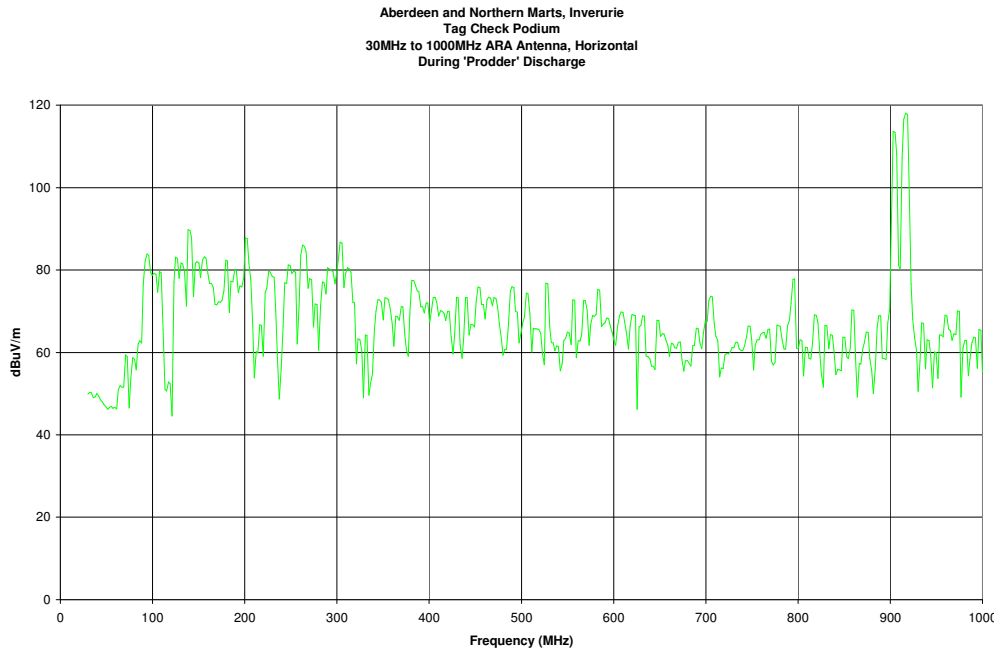


Figure 20 RF Measurement 30MHz to 1000MHz, Horiz, 'Prodder' Discharge

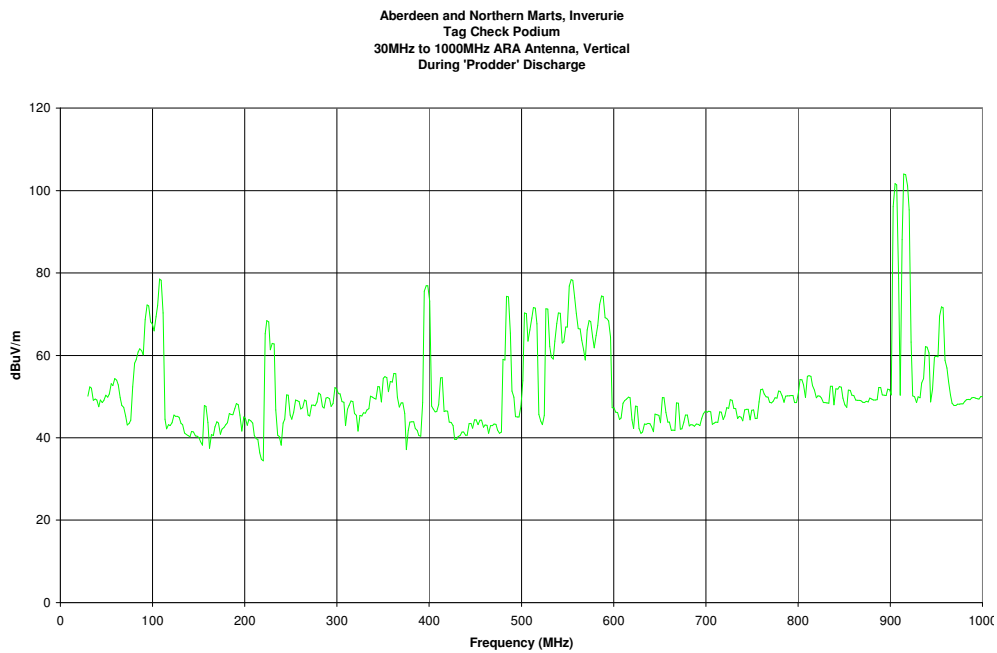


Figure 21 RF Measurement 30MHz to 1000MHz, Vert, 'Prodder' Discharge

The effects of the 'prodder' discharge against the metal fencing can be seen as significant RF noise added to the ambient plot across the range.

6.6.3 Site 2 – Entrance to Auction Ring 3

Animals are queued in pens behind the entrance to the auction ring. As they come up for auction they are herded to a holding pen where the visual tags are manually checked and recorded, then moved to a weighing pen (weight recorded for display on the auction ring electronic board) and into the auction ring.

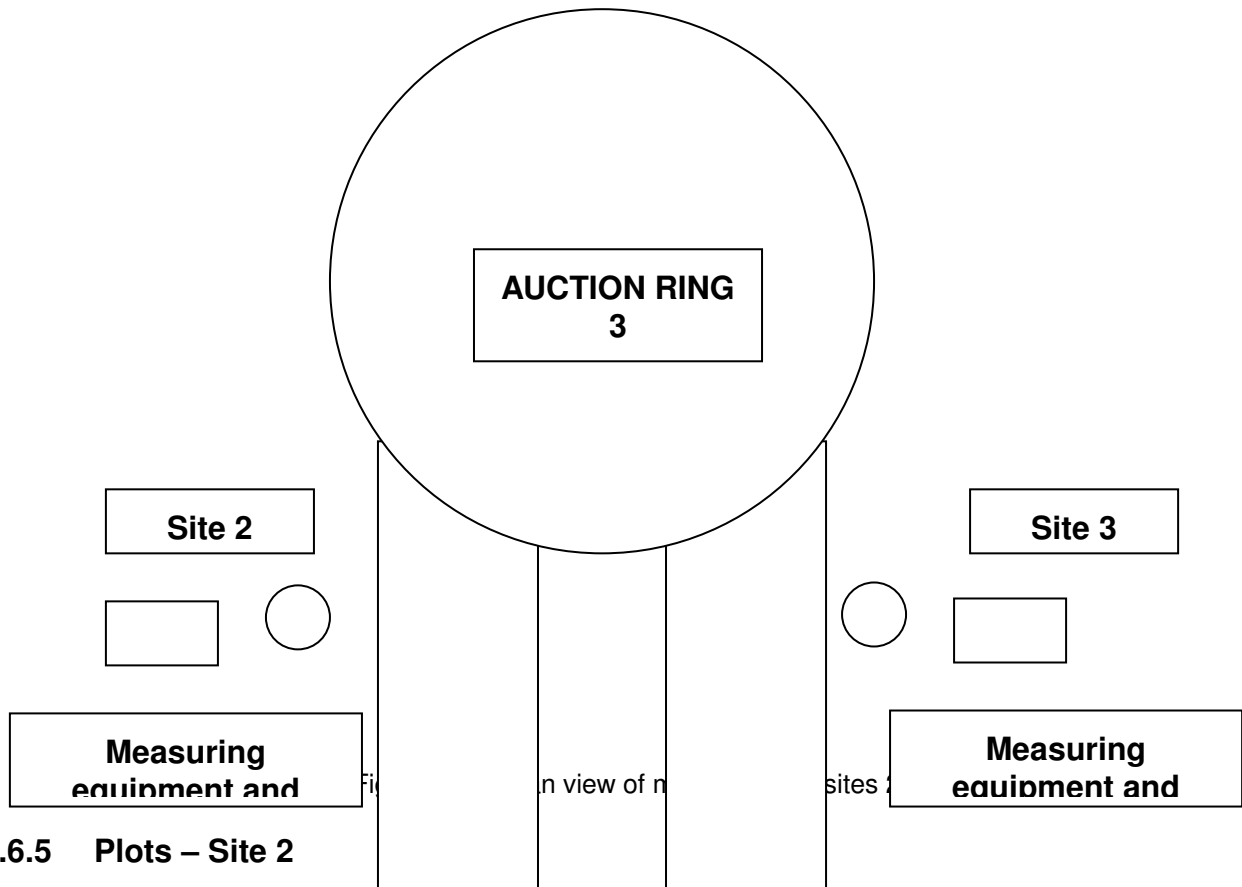
In the case of cattle, animals are sold either singly or in small batches. Each animal is individually tagged. In the case of sheep, animals were sold in larger groups under a common batch number.

No other electronic equipment was in use by the auction staff at this location at the time of test.

6.6.4 Site 3 – Exit from Auction Ring 3

In the case of sheep, animals run through a race and are marked with dye (as sold) on exit from the ring to the pens.

No other electronic equipment was in use by the auction staff at this location at the time of test.



6.6.5 Plots – Site 2

See over.

6.6.5.1 9kHz to 1MHz – Loop Antenna

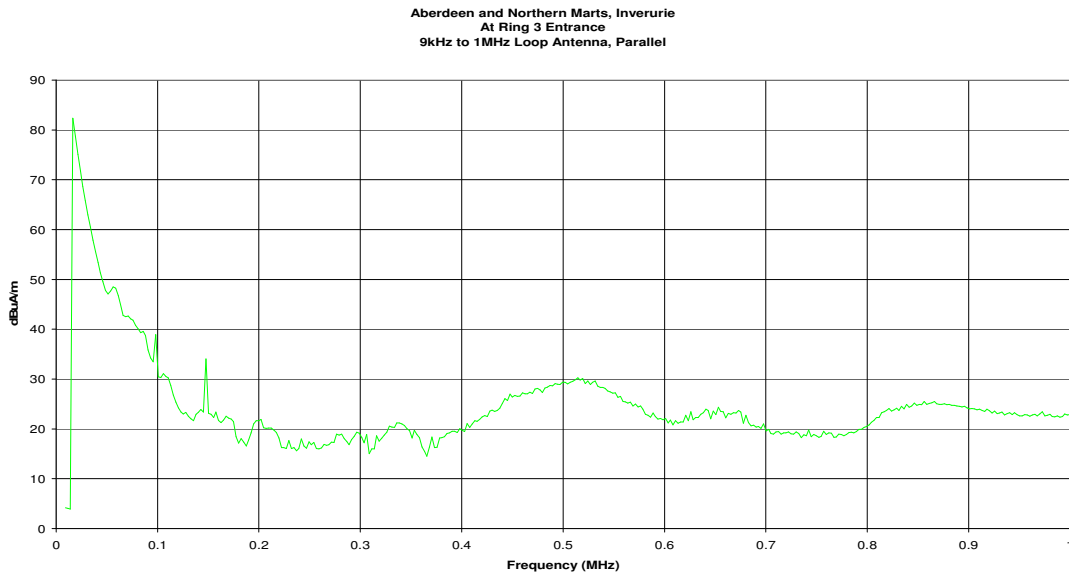


Figure 23 RF Measurement 9kHz to 1MHz, Parallel

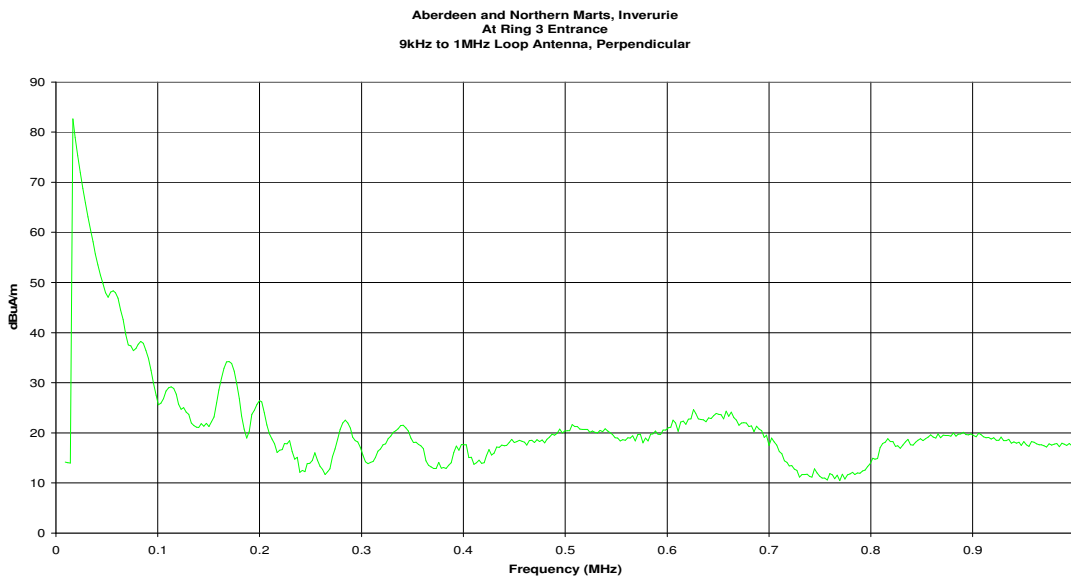


Figure 24 RF Measurement 9kHz to 1MHz, Perpendicular

The spectrum analyser has a lower frequency limit of 9kHz, therefore the apparent increase in level at the beginning of the plot reflects the increase in the measurement noise floor of the analyser rather than true ambient signal levels. Much of the emissions content is likely to be AM radio broadcast (long wave 153–279kHz and medium wave 520-1710kHz) although there is a slight general increase in overall level from around 400kHz.

6.6.5.2 1MHz to 5MHz – Loop Antenna

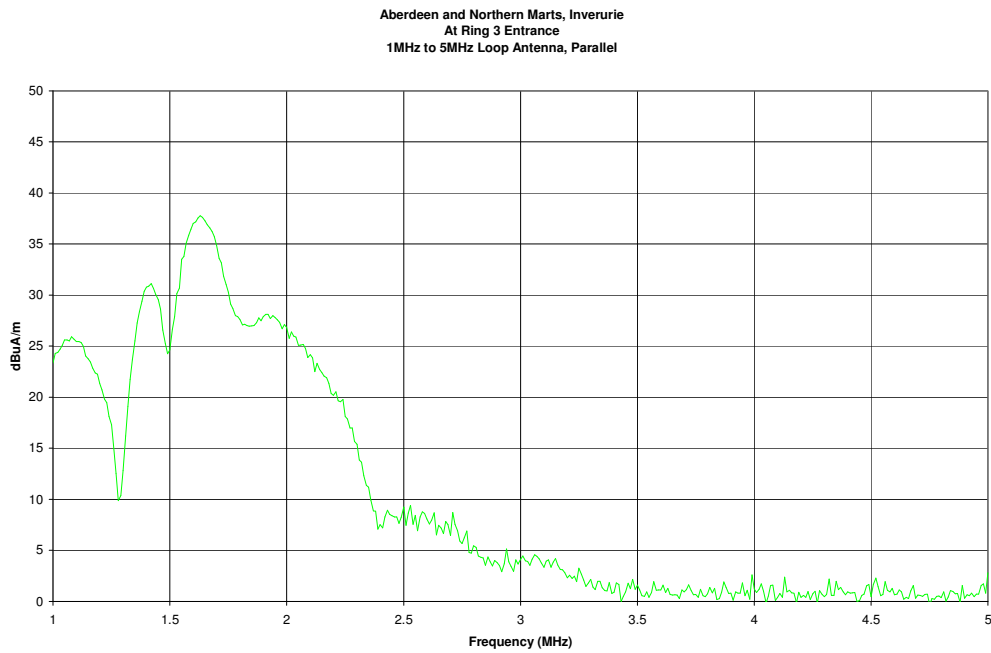


Figure 25 RF Measurement 1MHz to 5MHz, Parallel

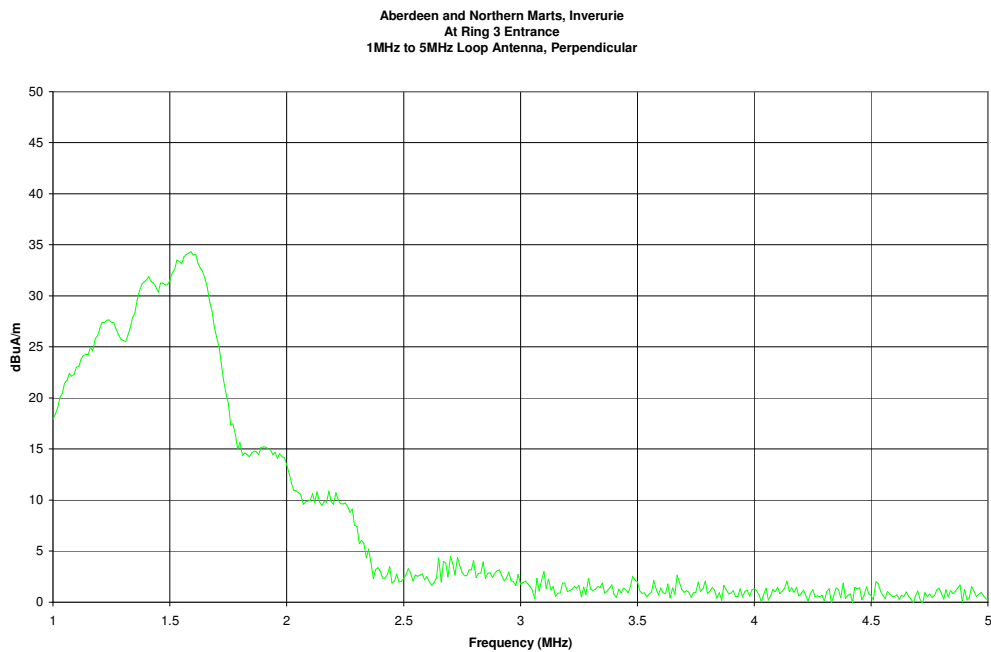


Figure 26 RF Measurement 1MHz to 5MHz, Perpendicular

Much of the emissions content is likely to be AM radio broadcast. (AM radio allocation is 526.5kHz to 1.606MHz).

6.6.5.3 30MHz to 1000MHz – Active Receive Antenna

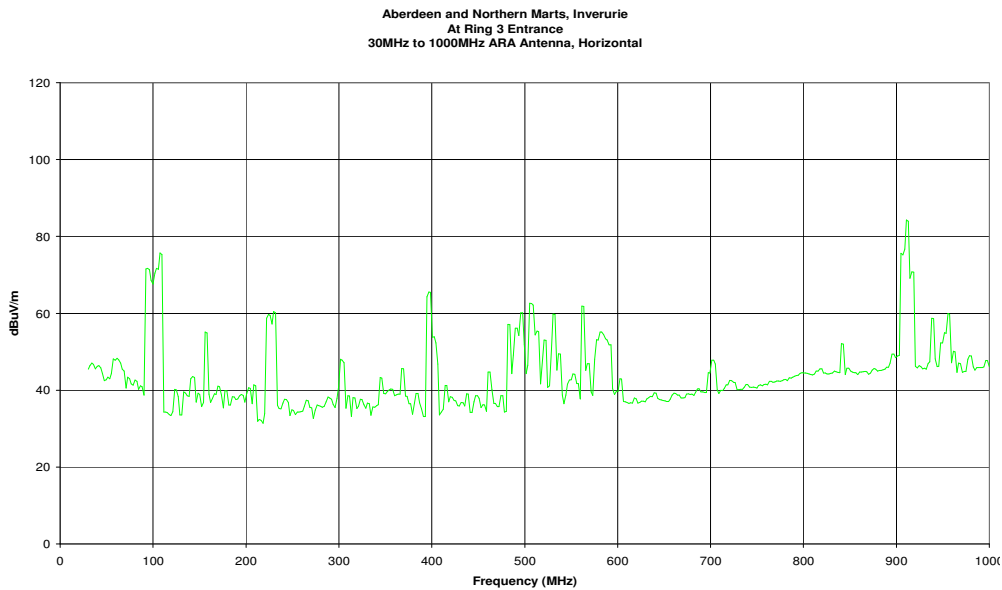


Figure 27 RF Measurement 30MHz to 1000MHz, Horizontal

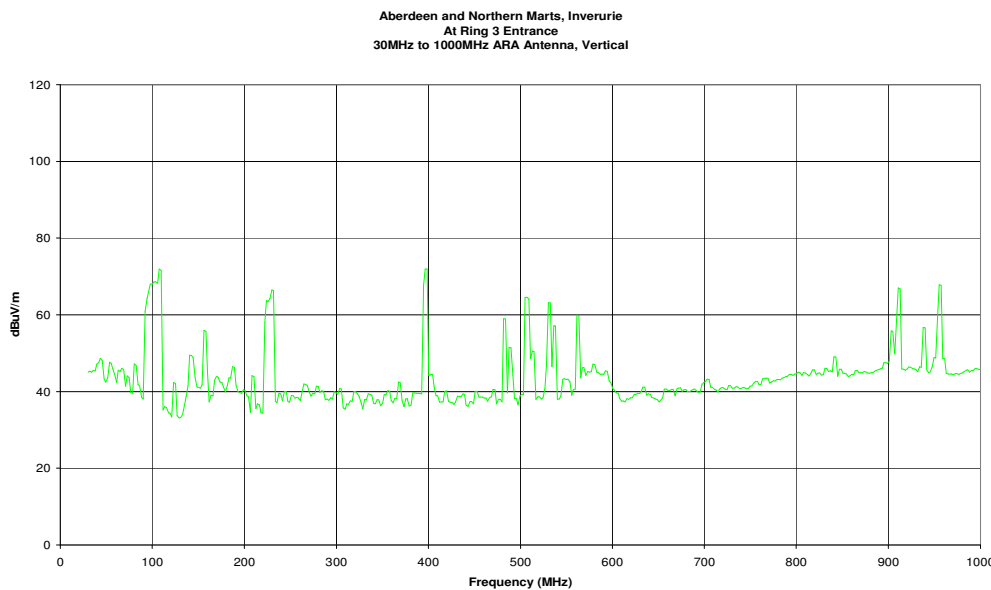


Figure 28 RF Measurement 30MHz to 1000MHz, Vertical

In this range the appearance of local ambient emissions can be seen quite clearly.

- | | | |
|--------------|----------------|---|
| For example; | Around 100MHz: | FM radio |
| | 100-200MHz | Mobile radio |
| | 220-230MHz | Digital Radio broadcast |
| | 400-600MHz | Television broadcast |
| | 900-1000MHz | Mobile telephone (note that the levels are quite high indicating that there is likely to be a mast quite close to the mart) |

6.6.6 Plots – Site 3

See over.

6.6.6.1 9kHz to 150kHz and 150kHz to 30MHz – Current clamp

The current clamp was positioned round a power cable that ran alongside the ring exit to investigate typical RF signals present on the mains power system. It could not be determined what equipment was connected to this mains line. The highest peak noted was 52.7dB μ V at 1.82MHz.

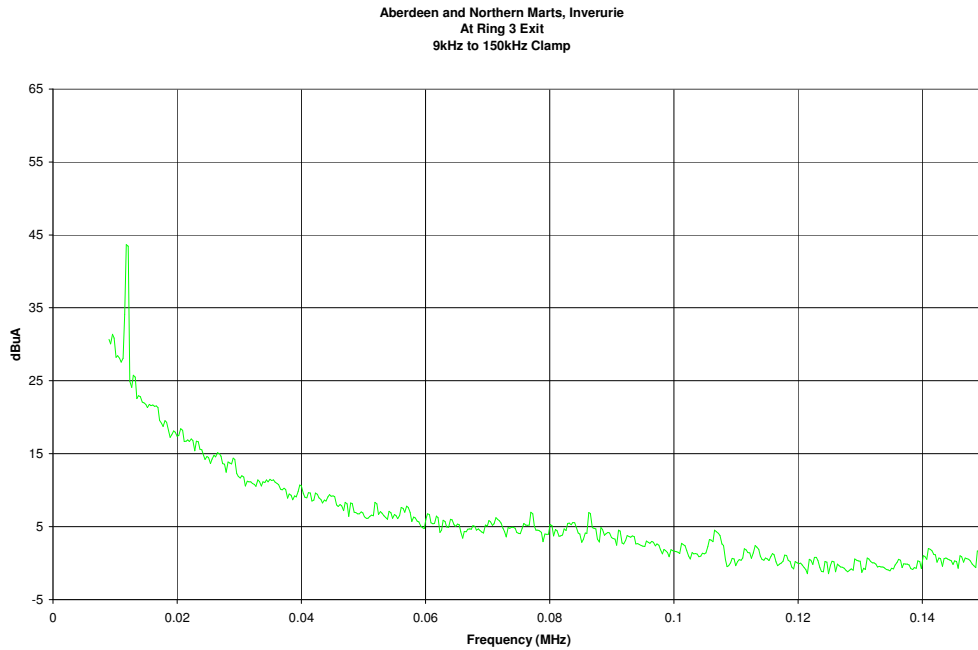


Figure 29 RF Measurement 9kHz to 150kHz, Clamp, 1kHz BW

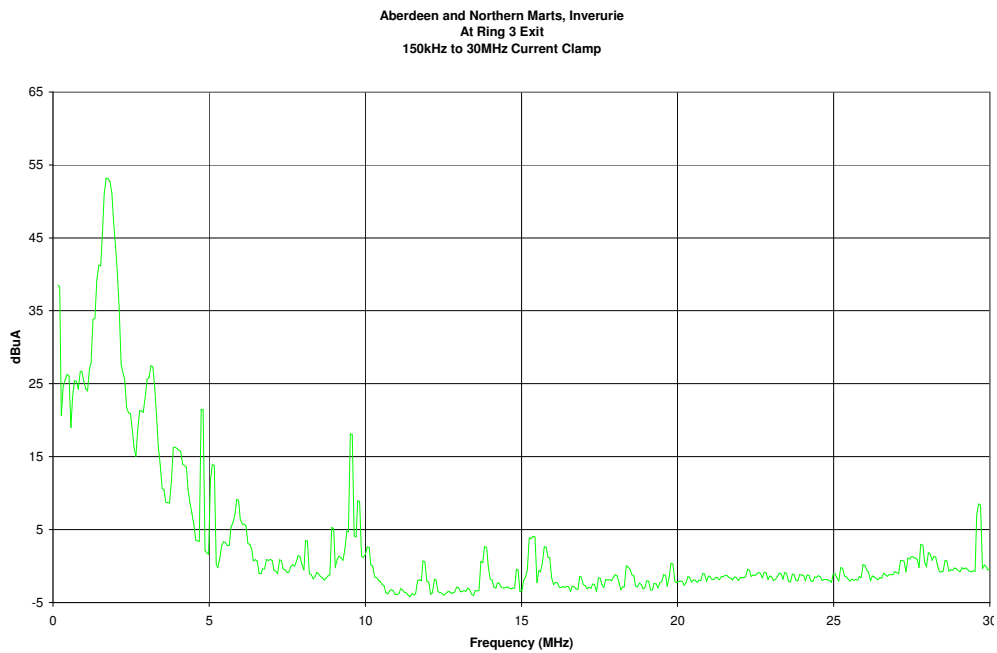


Figure 30 RF Measurement 150kHz to 30MHz, Clamp, 10kHz BW

6.6.6.2 9kHz to 1MHz – Loop Antenna

Measurements using two bandwidths, 1kHz and 10kHz, were performed for investigation. Some harmonically related emissions were noted, possibly originating from fluorescent lights.

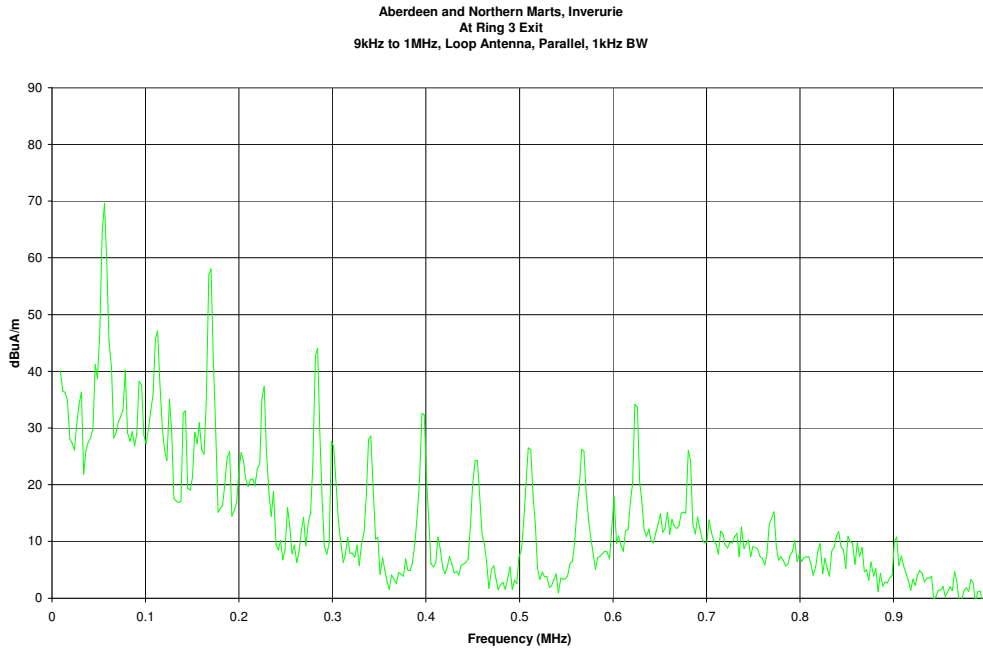


Figure 31 RF Measurement 9kHz to 1MHz, Parallel, 1kHz

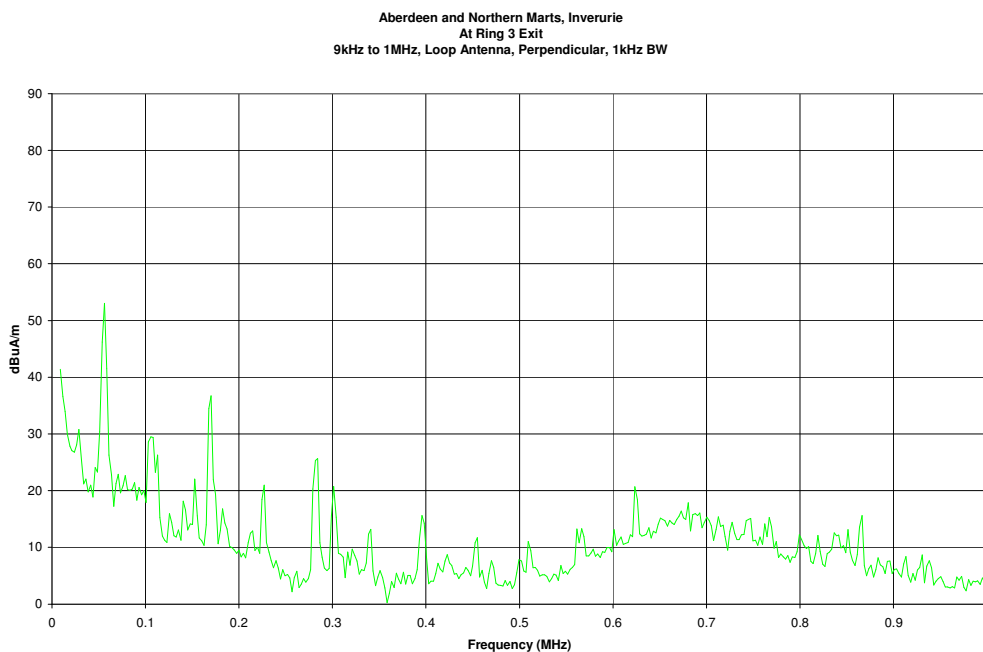


Figure 32 RF Measurement 9kHz to 1MHz, Perpendicular, 1kHz

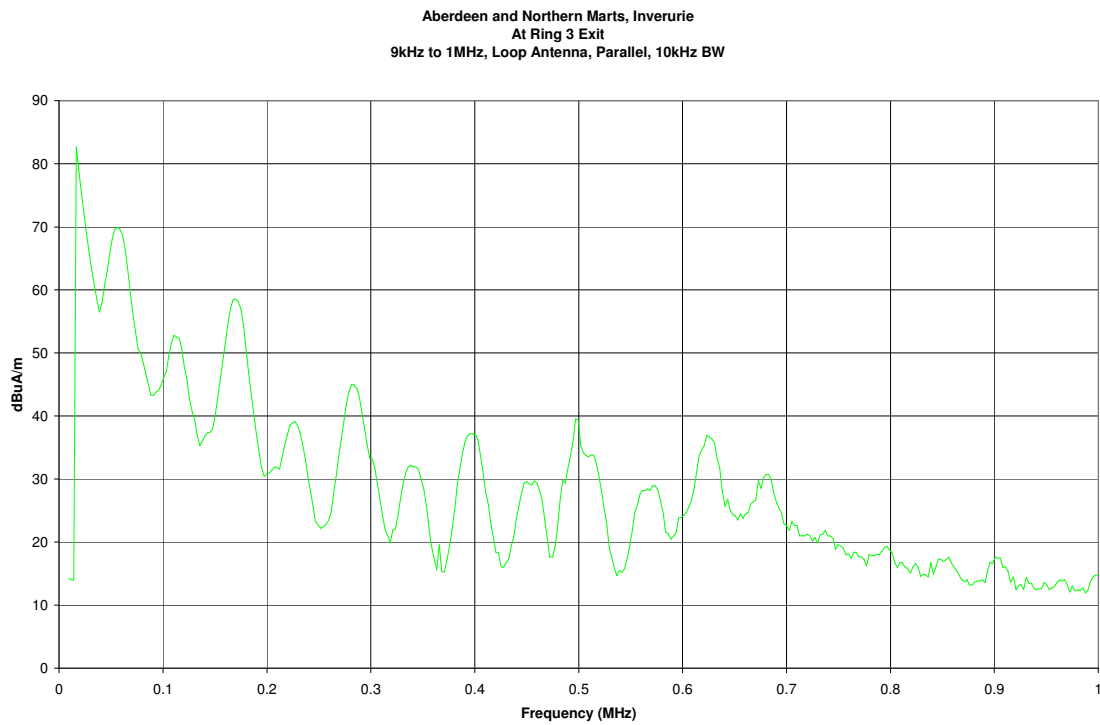


Figure 33 RF Measurement 9kHz to 1MHz, Parallel, 10kHz

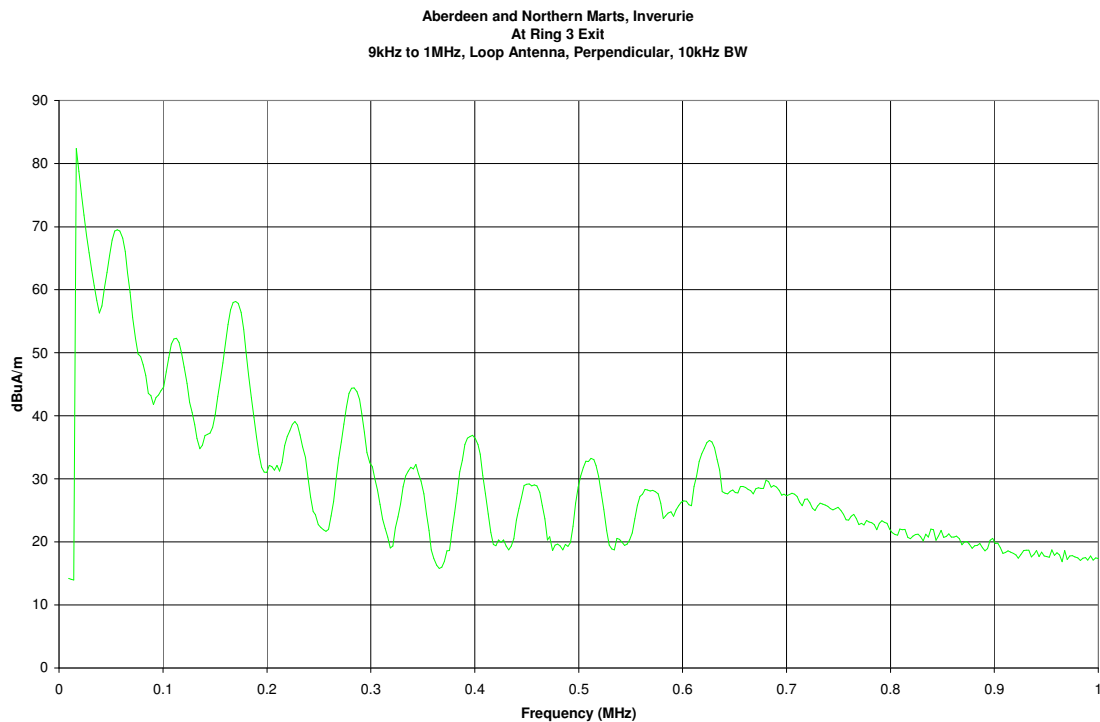


Figure 34 RF Measurement 9kHz to 1MHz, Perpendicular, 10kHz

6.6.6.3 9kHz to 150kHz – Loop Antenna

This range was chosen to cover the operating frequency of typical RFID equipment (134kHz). Measurements were performed at 1kHz bandwidth. The harmonically related peaks are visible

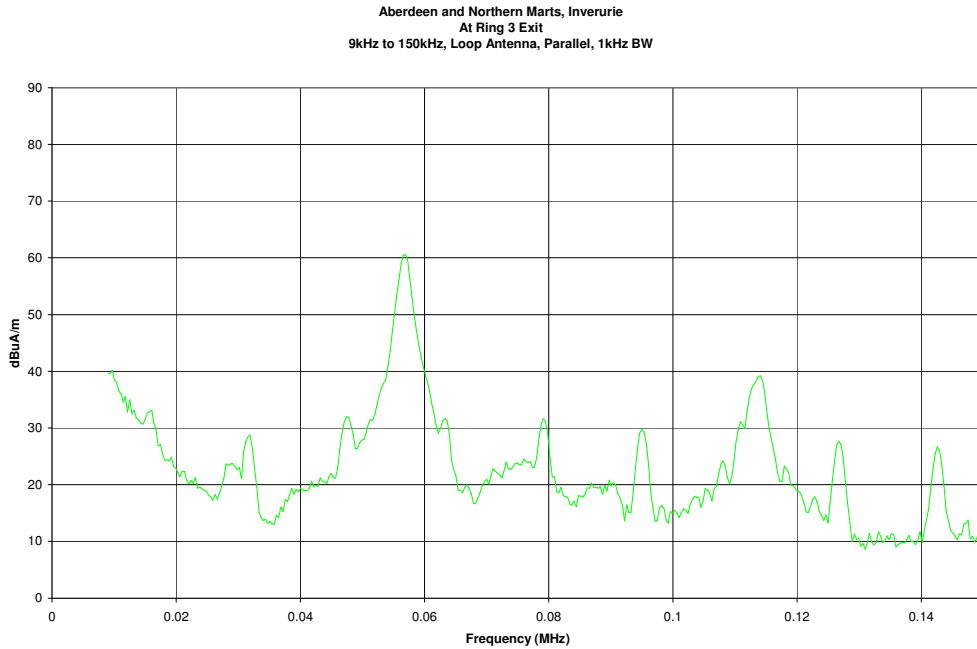


Figure 35 RF Measurement 9kHz to 150kHz, Parallel

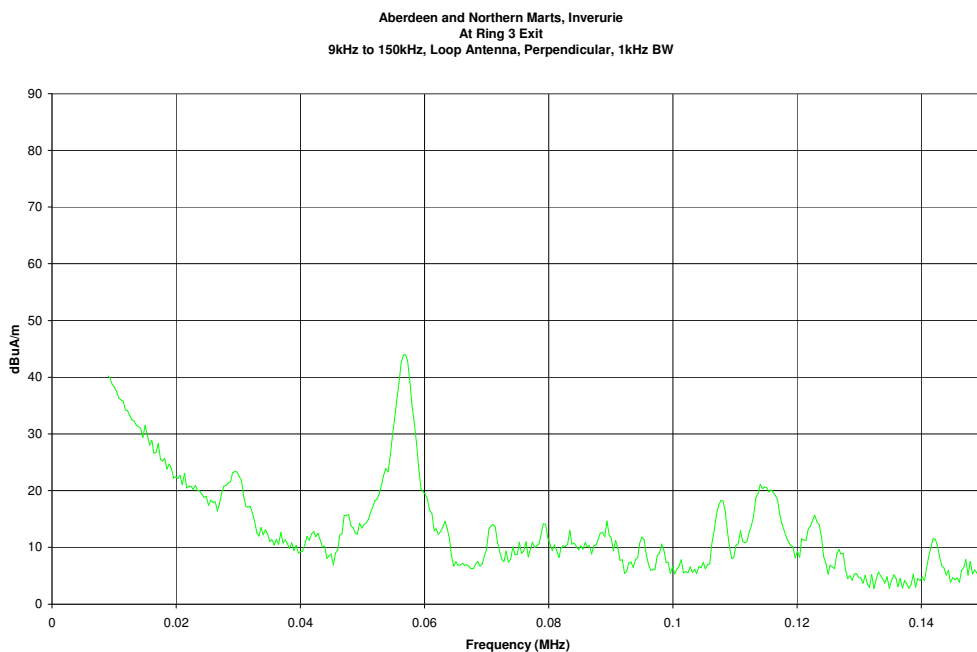


Figure 36 RF Measurement 9kHz to 150kHz, Perpendicular

6.6.6.4 150kHz to 5MHz – Loop Antenna

Measurements were performed at 10kHz bandwidth.

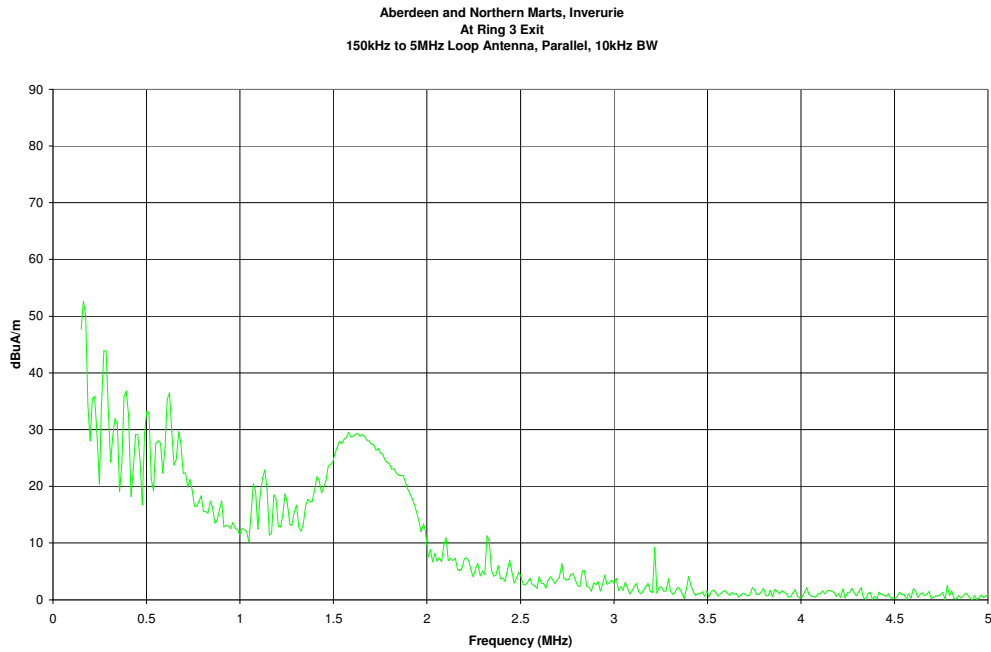


Figure 37 RF Measurement 150kHz to 5MHz, Parallel

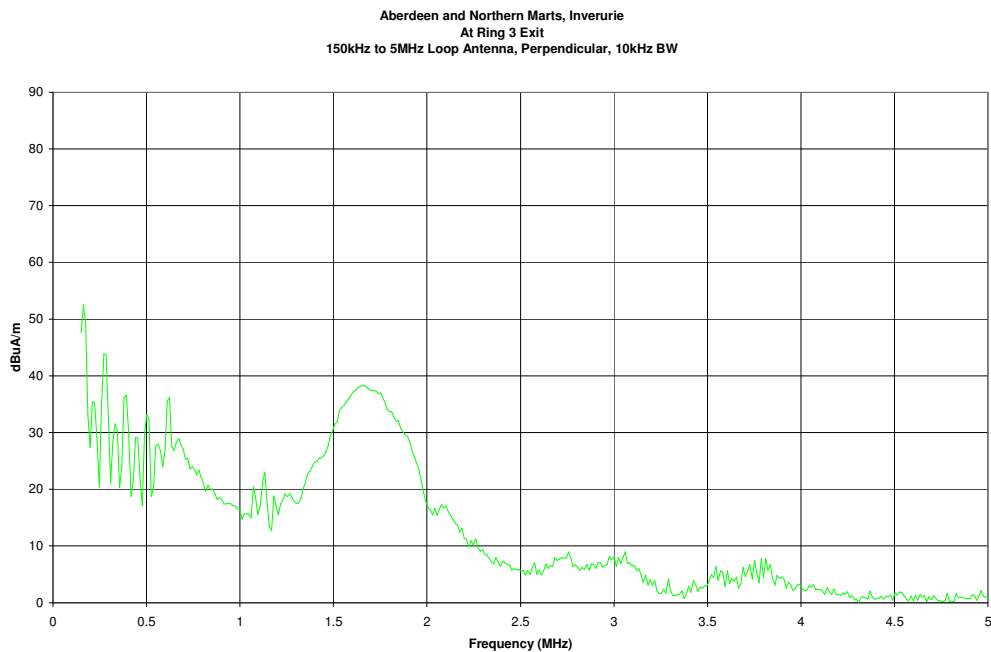


Figure 38 RF Measurement 150kHz to 5MHz, Perpendicular

The harmonically related peaks can be seen around and below 500kHz. The large broadband peak may be radio.

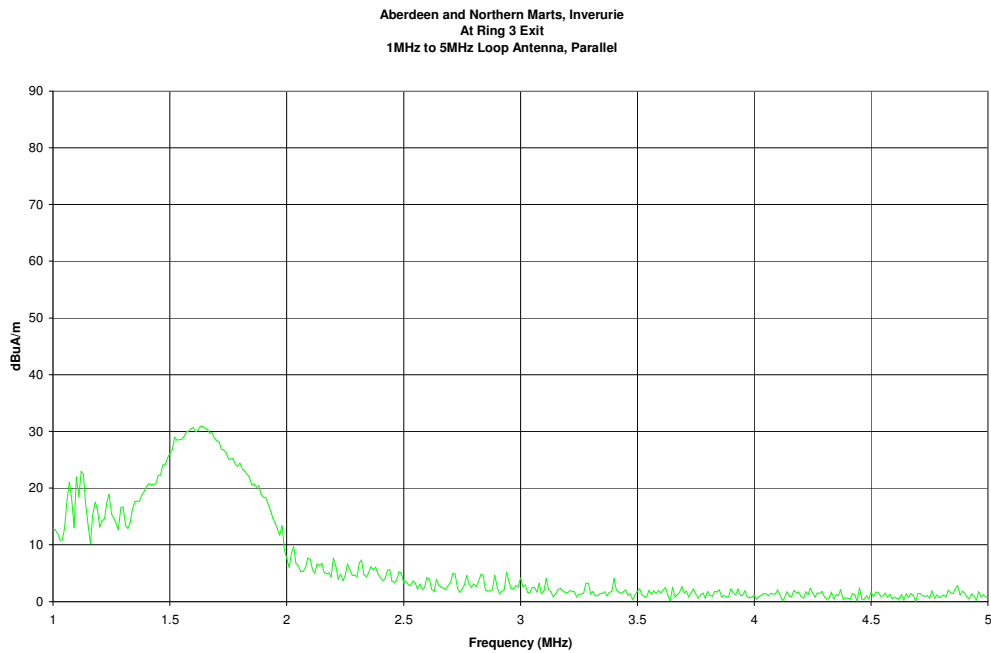


Figure 39 RF Measurement 1MHz to 5MHz, Parallel

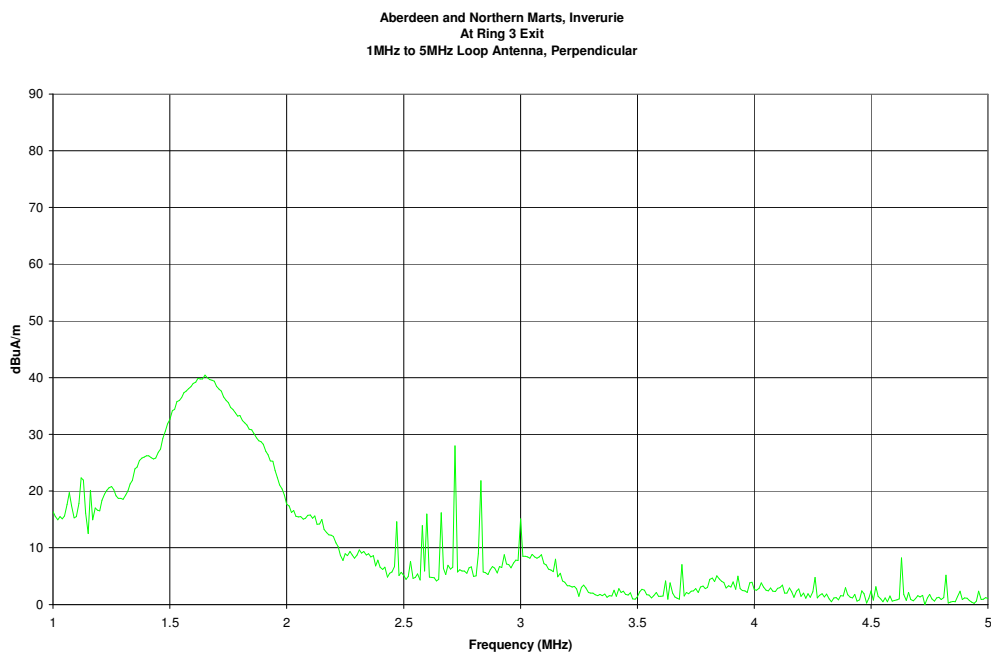


Figure 40 RF Measurement 1MHz to 5MHz, Perpendicular

The broadband peak is likely to be related to AM radio, the peaks between 2.5MHz and 3MHz, fall in a band used for aeronautical uses and also by the MOD, but could not be positively identified.

6.6.6.5 120kHz to 140kHz – Loop Antenna

The frequency range was narrowed down to cover the frequency of operation of the RFID system more closely.

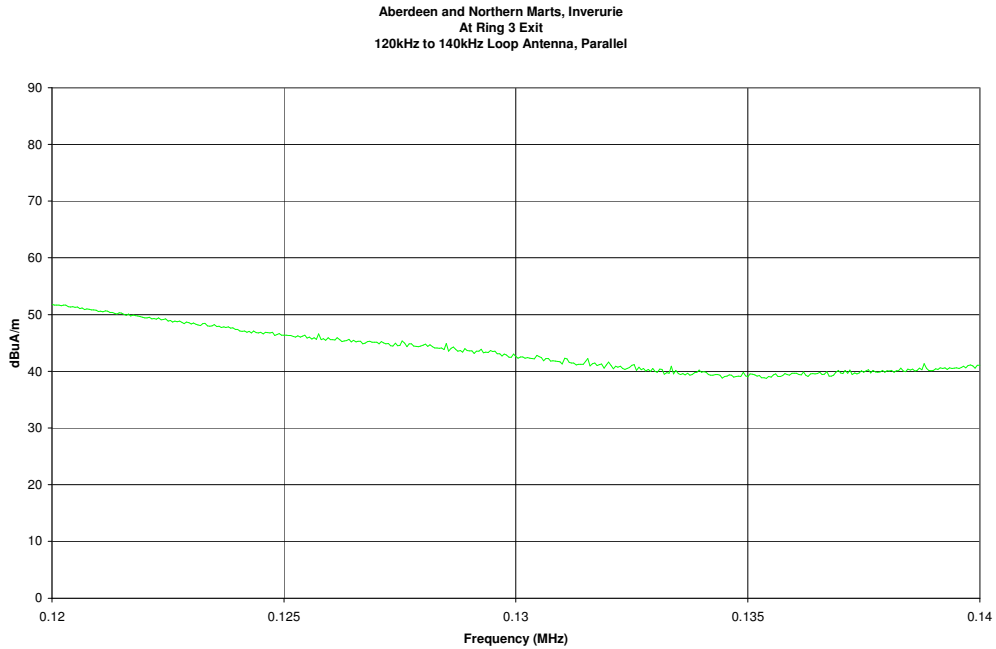


Figure 41 RF Measurement 120kHz to 140kHz, Parallel

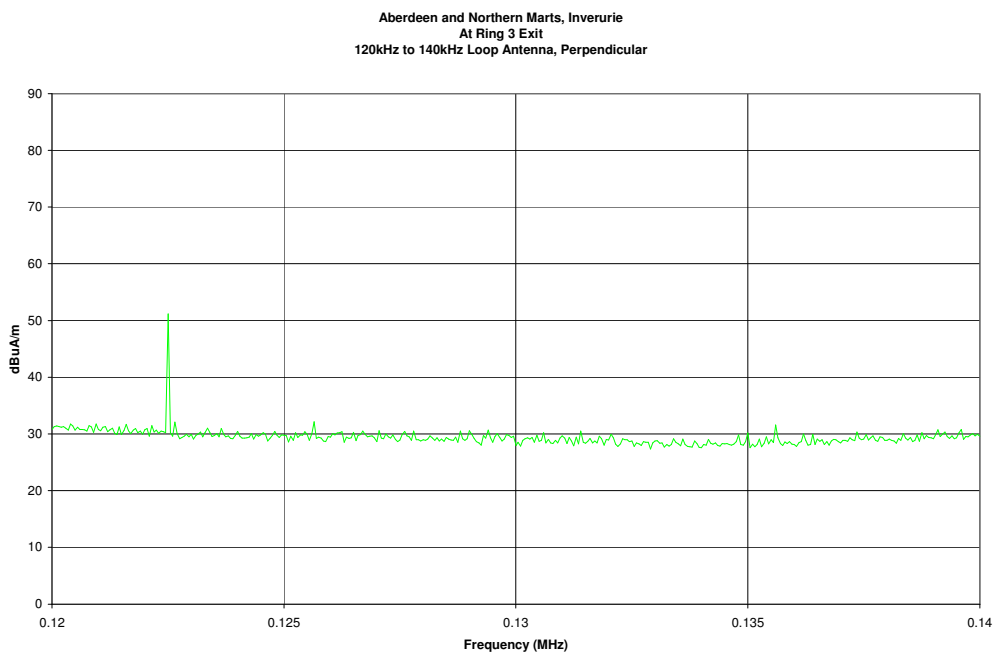


Figure 42 RF Measurement 120kHz to 140kHz, Perpendicular

Figure 41 shows a general increase in level across the measurement band, the peak in Figure 42 appeared as a transient spike only.

6.6.6.6 30MHz to 1000MHz – Active Receive Antenna

This range was chosen as the normal range used in typical EMC standards.

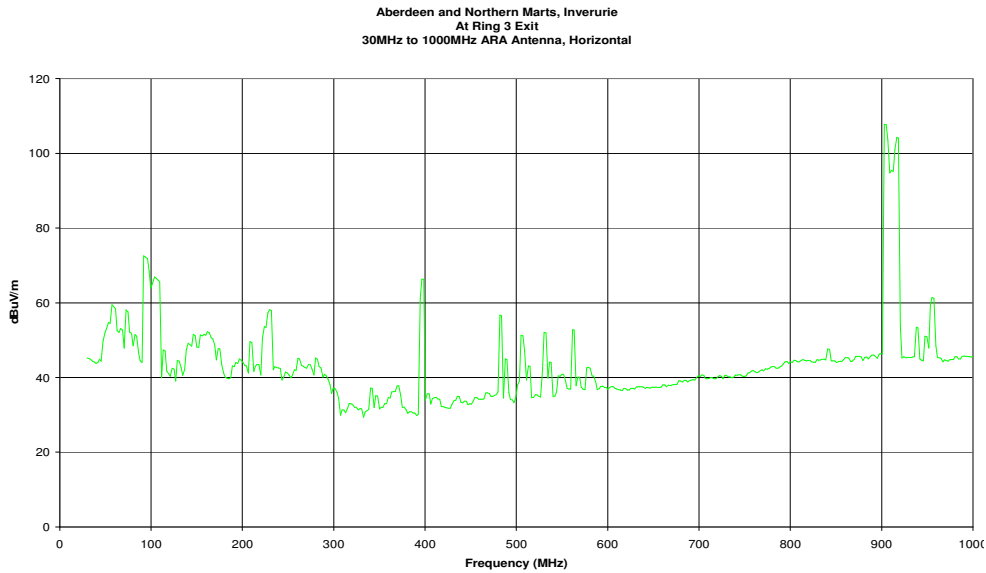


Figure 43 RF Measurement 30MHz to 1000MHz, Horizontal

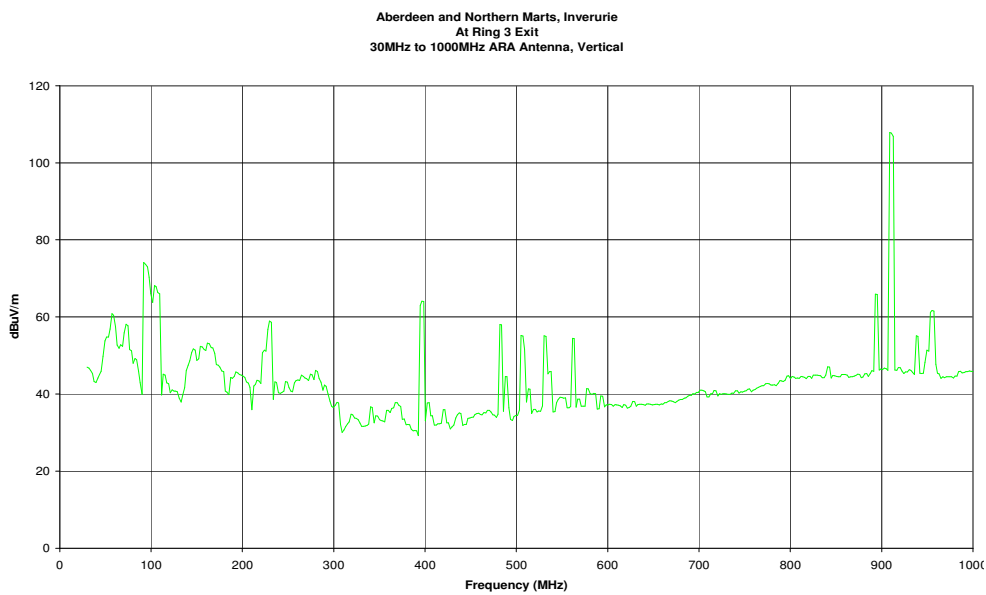


Figure 44 RF Measurement 30MHz to 1000MHz, Vertical

In this range the appearance of local ambient emissions can be seen quite clearly.

- For example; Around 100MHz: FM radio
- 100-200MHz Mobile radio
- 220-230MHz Digital Radio broadcast
- 400-600MHz Television broadcast
- 900-1000MHz Mobile telephone (note that the levels are quite high indicating that there is likely to be a mast quite close to the mart)

6.7 Site 4 - Tests During Main Cattle Auction

Tests were performed during a large scale cattle auction (>1500 animals). Due to the requirements of the auction (continuous throughput of animals) which meant large numbers of animal movements in the stock holding areas, movement of the measuring equipment between several sites was deemed too disruptive to the auction and carried the risk of disturbing the animals with the increased risk to personnel and equipment.

A static site at the entrance pens of Auction Ring 2 was chosen as a typical and worst case site. The pen arrangement at this site also afforded safe separation of equipment and animals.

Other electronic equipment in use by the auction staff at this site included;

1. Laptop computer, networked to record animal data
2. Weighing pen, data entry by keypad, data sent to Ring display board
3. Ring Display Board, digital display board of animal information
4. Public Address system for the auctioneer

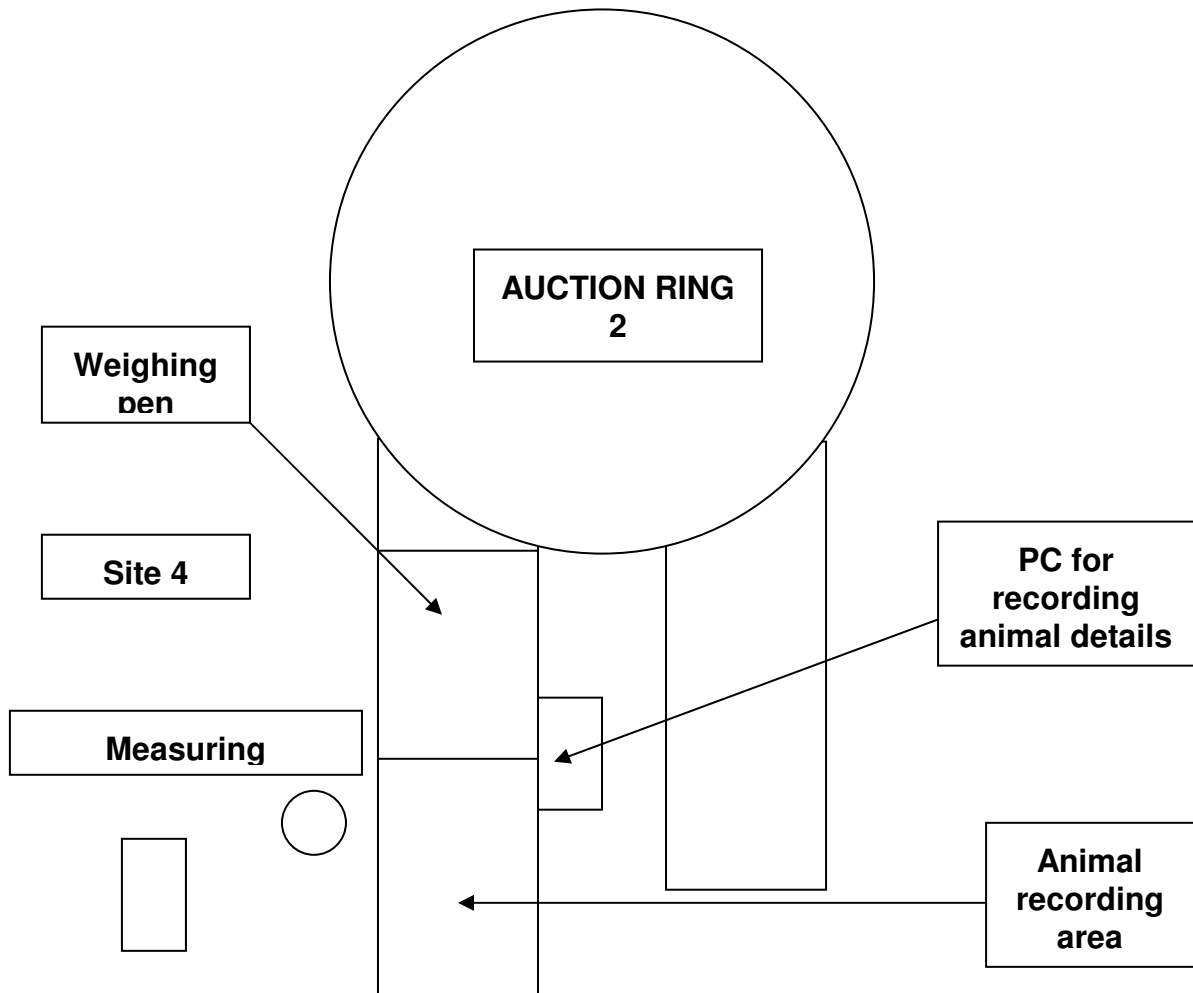




Photo 2. Auction Ring 2



Photo 3. Measurement at weighing pen at entrance to Auction Ring 2



Photo 4. Measurement on Cables at Auction Ring 2

6.7.1 Plots – Site 4

See over.

6.7.1.1 9kHz to 30MHz – Current Clamp

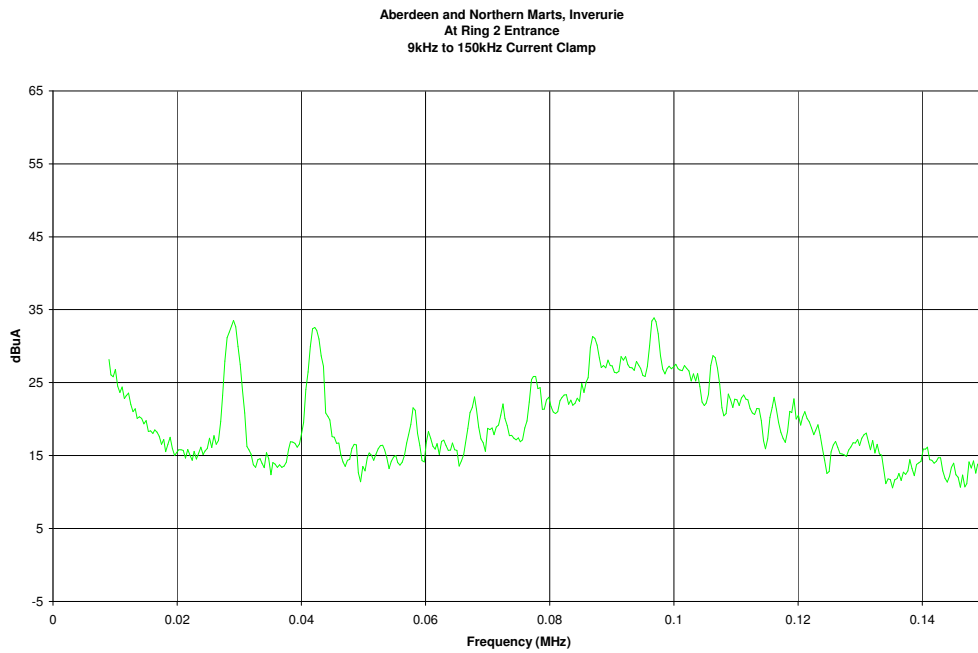


Figure 45 RF Measurement 9kHz to 150kHz, Clamp

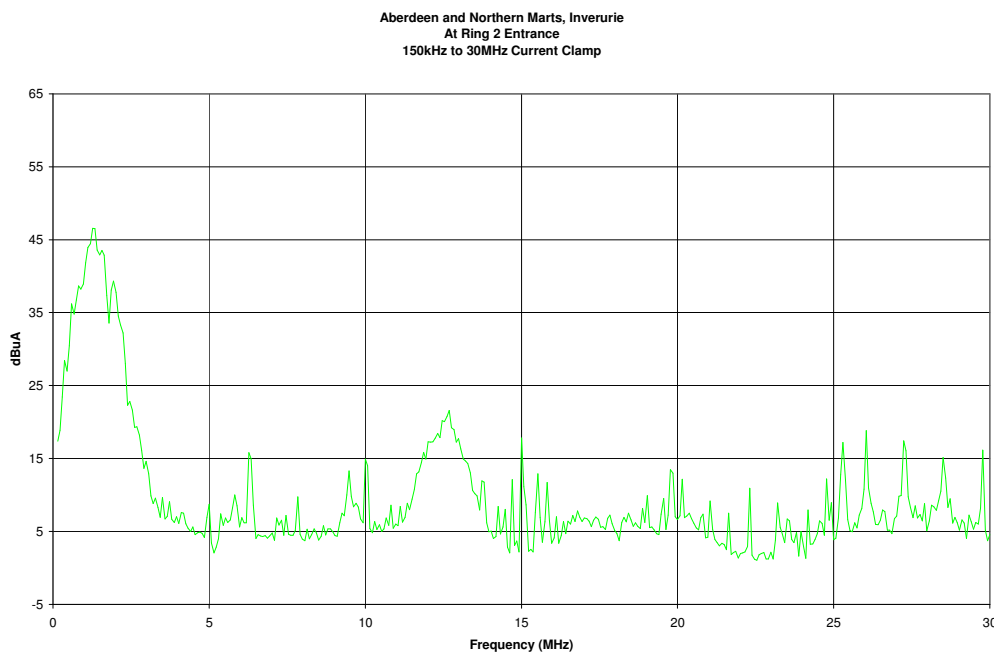


Figure 46 RF Measurement 150kHz to 30MHz, Clamp

Both plots show levels of locally generated EMI on the power/signal lines.

6.7.1.2 9kHz to 150kHz – Loop Antenna

This range was chosen to cover the operating frequency of typical RFID equipment (134kHz). Measurements were performed at 1kHz bandwidth.

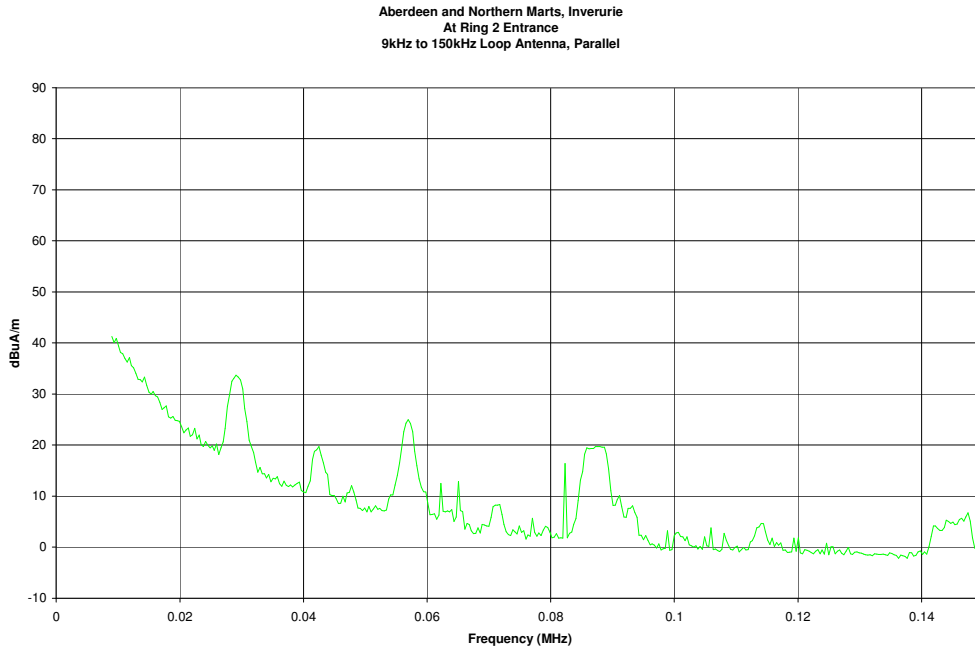


Figure 47 RF Measurement 9kHz to 150kHz, Parallel

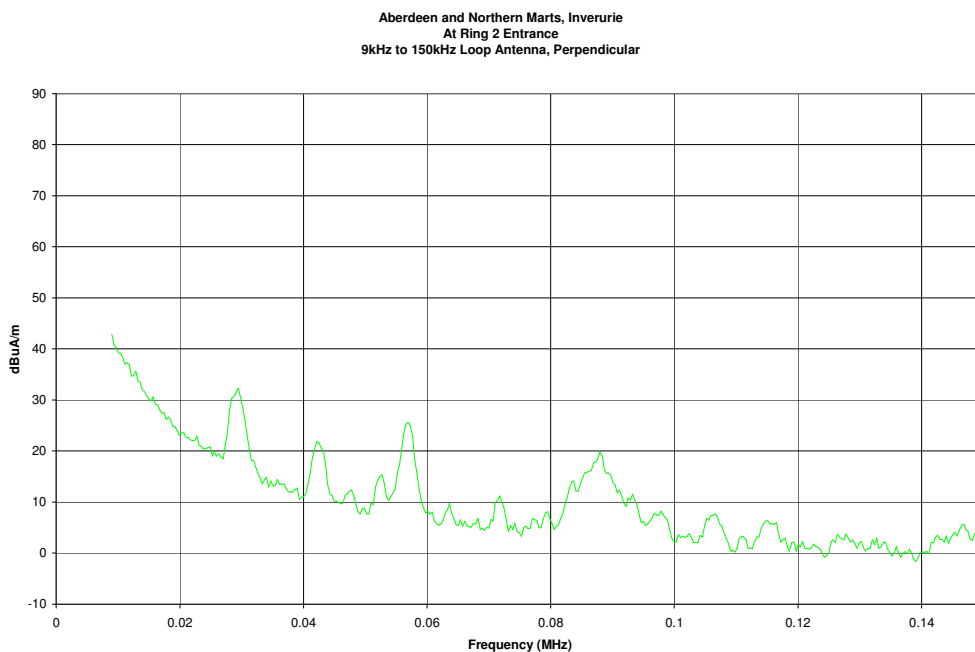


Figure 48 RF Measurement 9kHz to 150kHz, Perpendicular

Some harmonically related peaks are noted in both plots.

6.7.1.3 150kHz to 5MHz – Loop Antenna

Measurements were performed at 10kHz bandwidth.

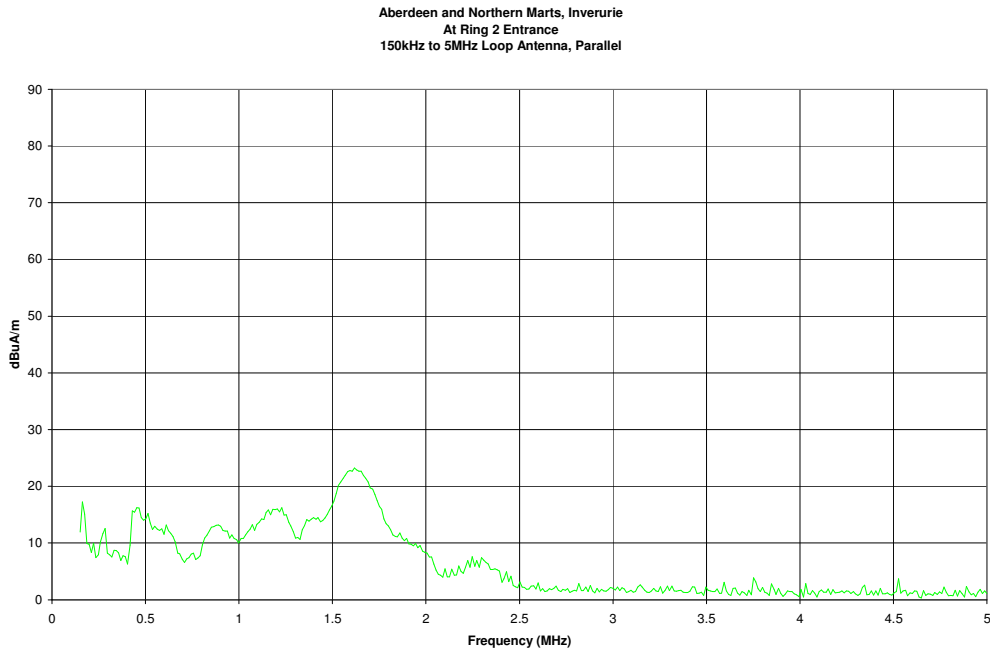


Figure 49 RF Measurement 150kHz to 5MHz, Parallel

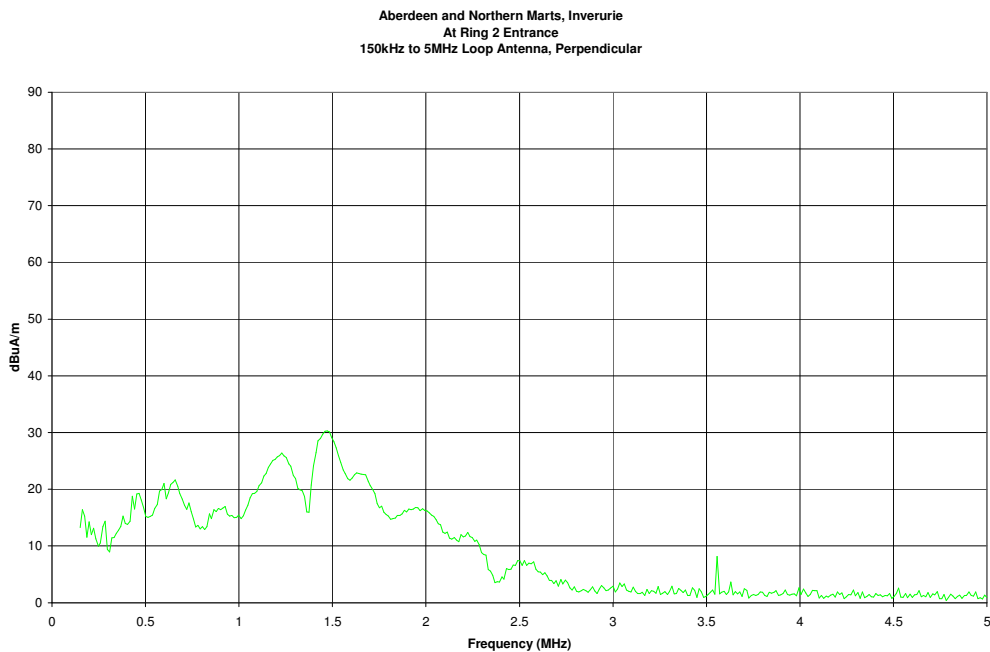


Figure 50 RF Measurement 150kHz to 5MHz, Perpendicular

Peaks reduced compared with other areas, the measurement area must be partially screened from the local signals due to building construction.

6.7.1.4 100kHz to 150kHz – Loop Antenna

A narrower frequency range was used to give more detailed information around the frequency of operation of typical RFID equipment.

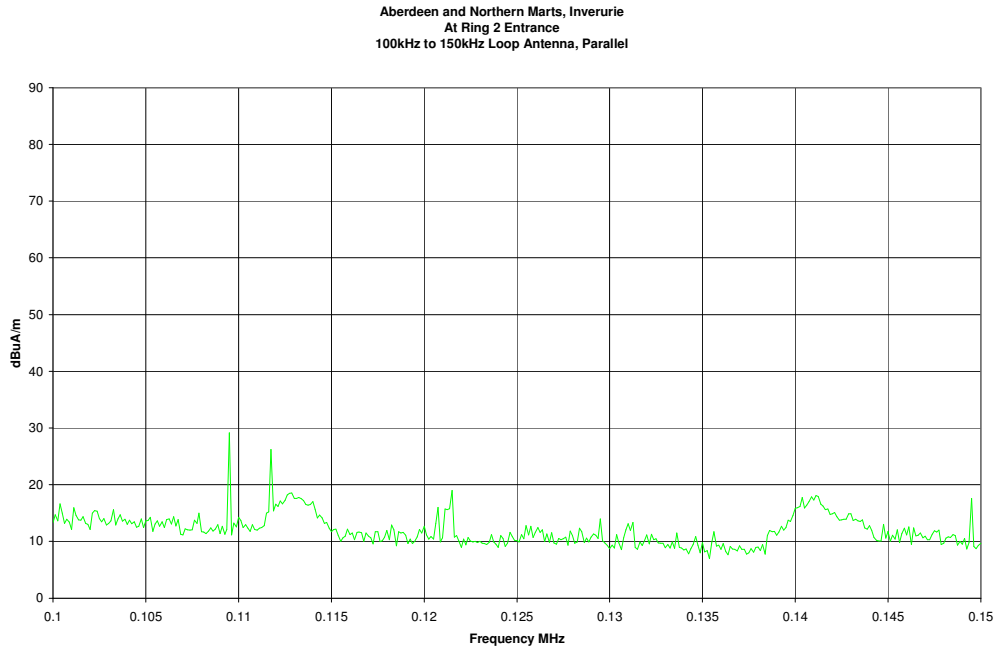


Figure 51 RF Measurement 100kHz to 150kHz, Parallel

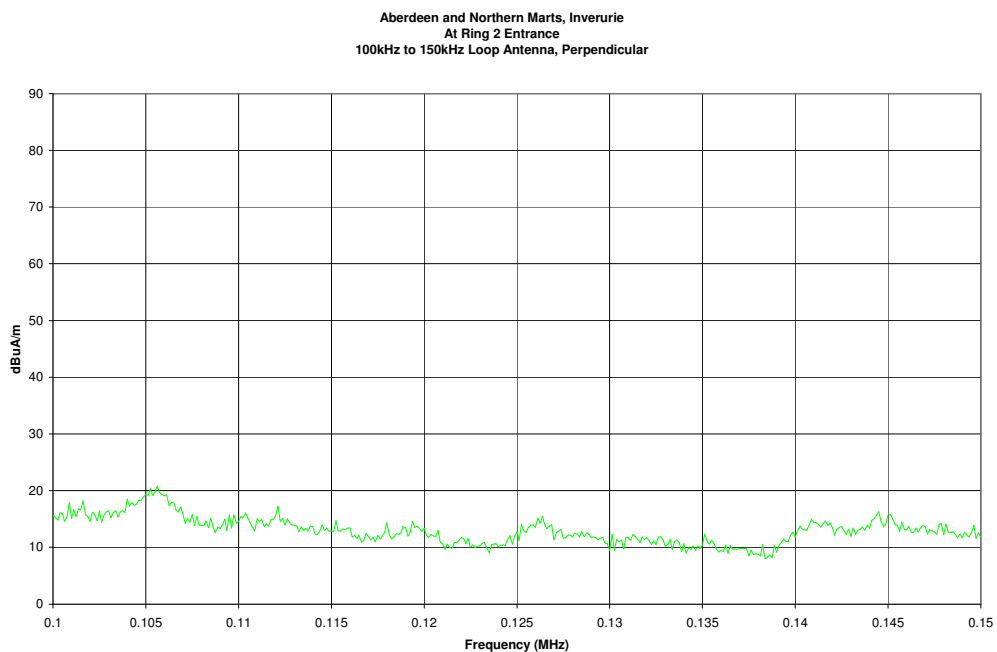


Figure 52 RF Measurement 100kHz to 150kHz, Perpendicular

Low, almost insignificant, levels of RF emissions noted.

6.7.1.5 30MHz to 1000MHz – Active Receive Antenna

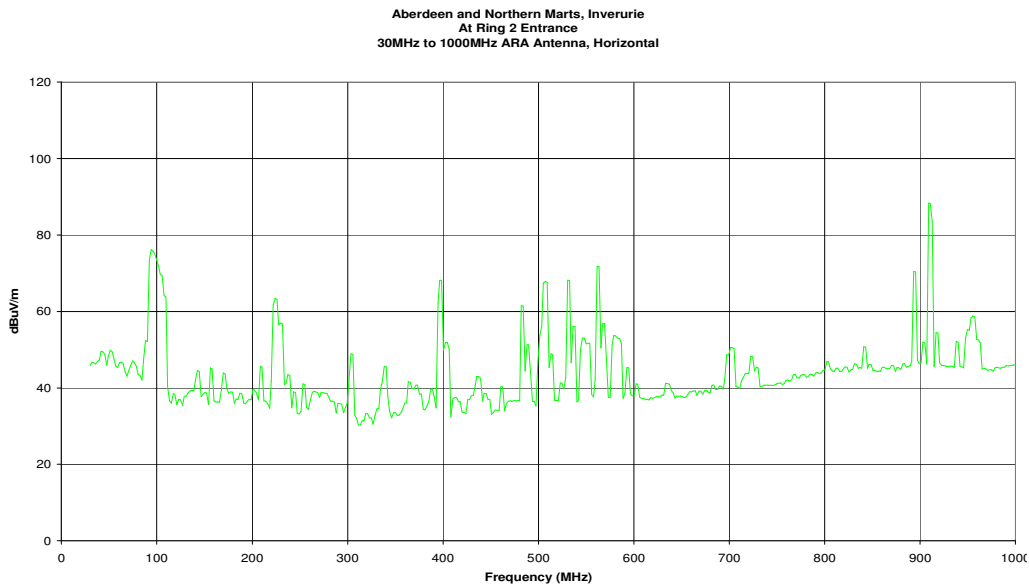


Figure 53 RF Measurement 30MHz to 1000MHz, Horizontal

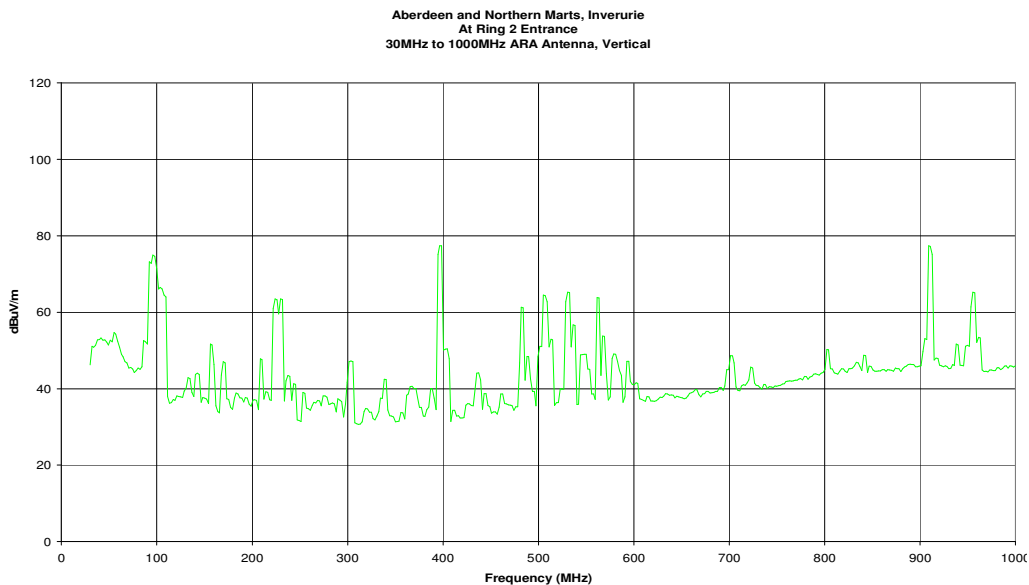


Figure 54 RF Measurement 30MHz to 1000MHz, Vertical

In this range the appearance of local ambient emissions can be seen quite clearly.

- | | | |
|--------------|----------------|---|
| For example; | Around 100MHz: | FM radio |
| | 100-200MHz | Mobile radio |
| | 220-230MHz | Digital Radio broadcast |
| | 400-600MHz | Television broadcast |
| | 900-1000MHz | Mobile telephone (note that the levels are quite high indicating that there is likely to be a mast quite close to the mart) |

7 Test Equipment Used

| Equipment | Manufacturer | Type |
|------------------------|-------------------|---------|
| Spectrum Analyser | Anritsu | MS2667C |
| Spectrum Analyser | Hewlett Packard | HP8594E |
| Current Clamp | Eaton | 93686-1 |
| Loop Antenna | ETS | 6511 |
| Loop Antenna | ETS | 6512 |
| Active Receive Antenna | York EMC Services | ARA 01 |

Table 14 List of Test Equipment Used

References

- ETSI EN 300 330-1 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 1 Technical characteristics and test methods
- ETSI EN 300 330-2 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 2 Harmonized EN under article 3.2 of the R&TTE Directive
- ETSI EN 301 489-1 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
- ETSI EN 301 489-3 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3 Specific conditions for short range radio devices (SRD) operating on frequencies between 9kHz and 40GHz.

Appendix B – Site Test Report, United Auctions, Stirling

**Report on Radio Frequency Site
Measurements
at
Scotbeef, Longleys Plant
Bridge of Allan
Report (copy 1 of 3)
For
Scottish Executive Environment
and Rural Affairs Department
Contract FF/05/19**

Document number 2214TR1

Project number 7568

Author:
G. Whyte Senior Engineer

Checked:
B. Tait Principal Engineer, BSc, MIET

Approved:
B. Tait Principal Engineer, BSc, MIET

| Issue | Description | Issue by | Date |
|-------|-------------|----------|------------|
| 1 | First Issue | GW | 30/04/2006 |

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The results contained in this report are only applicable to the apparatus tested.

Executive Summary

This report details tests performed in support of the study commissioned by Scottish Executive Environment and Rural Affairs Department (SEERAD) to evaluate the effect of electromagnetic interference in transceivers (readers) used to identify animals electronically. The systems are normally known as Electronic Identification (EID) or RF Identification (RFID) systems.

As part of this project site testing was performed at typical locations where EID is intended be used in the tracking and recording of animal movements, for example auction sites and abattoirs, to identify typical local electromagnetic emissions and their possible threat to the correct operation of EID/RFID systems.

This report details the tests performed at a meat processing facility, Scotbeef Meat Packers at Longleys Farm, Bridge of Allan. Testing was carried out during a normal working day. Local RF emissions measurements were recorded over a range of frequencies (9kHz to 1000MHz) in various sub-ranges according to the antenna used. Measurements in each frequency sub-range were taken over a period of time (typically around 10 minutes) in order that any variations in the emissions due to operation of plant equipment could be recorded.

The tests show that some equipment used during the production process produce electromagnetic interference of significant amplitude. This may require that for the installation of fixed RFID systems (for example, panel readers), the manufacturers should ensure that sufficient mitigating measures be taken to reduce any effects due to EMI.

Mitigating measures can take the form of filtering, screening, or positioning of the equipment and cabling. Systems should also, as part of normal manufacture, meet the standards required by the EU for EMC.

This test report forms part of the overall report (2211CR1) that will contain a more in-depth analysis of the results and a draft Guidelines for Build and Installation that is intended to offer some methods used to minimise the effects of EMI on equipment and installations.

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Report Change History

| Issue | Modification Details |
|--------------|-----------------------------|
| 1 | Original issue of report |
| 2 | |
| 3 | |
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| 10 | |

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Murray Hardy, Scotbeef, Longleys Plant, Bridge of Allan for allowing us access to the plant and to the plant staff.

Duncan Todd, Scottish Agricultural Organisation Society (SAOS) for assistance and introductions

List of Terms and Abbreviations

| | |
|--------|---|
| AC | Alternating Current |
| ARA | Active Receive Antenna |
| CISPR | Comité International Spécial des Perturbations Radioélectriques |
| DC | Direct Current |
| EID | Electronic Identification |
| EMC | ElectroMagnetic Compatibility |
| EMI | ElectroMagnetic Interference |
| EN | European Norm |
| ETSI | European Telecommunications Standards Institute |
| EU | European Union |
| IT | Information Technology |
| PC | Personal Computer |
| RF | Radio Frequency |
| RFID | Radio Frequency Identification |
| SAOS | Scottish Agricultural Organisation Society |
| SEERAD | Scottish Executive Environment and Rural Affairs Department |
| SRD | Short range Radio Device |
| YES | York EMC Services Ltd |

8 Introduction

8.1 Test Location

Testing was performed on site to investigate local electromagnetic signals present at the areas where RFID systems are likely to be used.

The tests were performed at;

Scotbeef Meat Packers

Longleys

Bridge of Allan

Stirlingshire

FK9 4NE

The tests were performed on 15 May 2006 during a normal operating day (06:00 to 17:00).

Tests were performed at both the sheep and cattle stunning areas. From discussions with the staff at the facility, these areas were identified as the most probable locations for fixed RFID systems and also the areas where plant equipment that may produce unwanted EMI is in use continuously.

These sites were chosen to represent the worst case measurements with respect to EMI.

At the request of Scotbeef, no photographs were taken at the facility.

8.2 Referenced Standards

EID/RFID equipment falls under the description of a short range radio device and therefore into the scope of the following standards.

| | |
|-------------------|--|
| ETSI EN 300 330-1 | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 1 Technical characteristics and test methods |
| ETSI EN 300 330-2 | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 2 Harmonized EN under article 3.2 of the R&TTE Directive |

These standards specify the characteristics and performance of the transmitter/receiver with respect to field strength, power, etc.

However, the relevant standards applicable to the EMC tests are referenced by;

ETSI EN 301 489-1 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements

This gives the general EMC tests applicable to all devices.

ETSI EN 301 489-3 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3 Specific conditions for short range radio devices (SRD) operating on frequencies between 9kHz and 40GHz.

This gives specific requirements and allowances for SRDs.

These standards refer to the specific requirements for equipment operation. During site investigations of ambient conditions, the ranges used in these standards will be referred to.

9 Testing

For emissions, the nominal CISPR bandwidth requirements are;

- 200Hz from 9kHz to 150kHz
- 9kHz from 150kHz to 30MHz
- 120kHz from 30MHz to 1000MHz

When performing compliance testing for emissions, measurements are performed using Quasi Peak and Average detectors for conducted emissions (RF interference present on power lines and other cabling) and Quasi Peak for radiated emissions. These detectors allow a differentiation between broadband and narrow band emissions by the 'smoothing out' of very short duration transient signals, for example those caused by switching of a load. A drawback of using these detectors is the time taken for the measurements, in particular the Quasi Peak measurement that requires 1 second at the frequency of measurement to obtain a reading. In order that a sequence of measurements could be taken over a period of time, spectrum analysers were used in peak detection mode. Although this does not exactly correspond to the CISPR compliance measurements, peak detection gives the worst possible case in that all emissions are noted, including short duration transients.

The spectrum analyser is also limited in its range of measurement bandwidths, being restricted to 1kHz, 10kHz, 100kHz, etc. The bandwidths that were the closest approximations to the CISPR bandwidths were used.

During the testing, results in each sub range of frequencies were recorded over a period of time (typically approximately 10 minutes per scan range). This allowed for variations in the local EM environment due to the local plant equipment operation to be recorded. The results presented are the maximum levels recorded during that time.

9.1 Current Clamp Tests

These tests are intended to measure the RF interference present on cabling (power and/or signal cables) used in the facility. This RF interference is typically generated by any electrical and electronic equipment connected to the power system or signal cabling, and if it is excessive, operation of sensitive equipment also connected can be affected.

This type of interference can be transferred either directly from the source to the victim by direct connection of cabling or induced from source cables to victim cables due to proximity, e.g., where cables are routed together in long runs.

Tests were performed in the frequency ranges 9kHz to 30MHz.

Current clamp measurements were performed at the sheep stunning area only; no access was available to any cabling in the cattle stunning area where the current clamp could be used.

9.2 Loop Antenna Tests

These tests are intended to measure local radiated H-Field (magnetic) emissions. This RF noise is typically generated by equipment using high currents, e.g. transformers, motors or generators, co-located in the area.

Tests were performed in the range 9kHz to 30MHz. Two loop antennae are used to cover the frequency range.

Radiated emissions can be polarised by the way in which the source of the emissions is constructed, for example by the orientation of cables. Measurements are therefore performed with the antenna positioned in two axes in order to pick up emissions polarised (mainly) in either direction. These are nominally called parallel and perpendicular, referring to the orientation of the antenna with respect to the equipment being tested.

In the case of these site measurements where no specific equipment is involved, therefore no specific direction that the antenna can be referenced to, the terms parallel and perpendicular are used simply to differentiate the two measurements.

9.3 Active Receive Antenna (ARA)

These tests are intended to measure local radiated E-Field (electric) emissions. This RF noise is typically generated by equipment using high frequency switching and digital circuits, e.g. IT equipment co-located in the area, and local radio transmissions. Tests were performed in the range 30MHz to 1000MHz.

For E-Field (electric) measurements are performed with the antenna positioned in two axes, horizontal and vertical, in order to pick up emissions that can be polarised by the way in which the source of the emissions is constructed or located.

9.4 Typical Emissions Normally Present

Throughout the whole frequency range there will be various emissions present originating from normal licensed broadcast equipment, e.g. mobile radios, emergency services radios, mobile telephones, AM/FM radio, digital radio, television, etc., as well as other data transmissions and beacons. These emissions may be continuous (e.g. AM/FM radio, television) or intermittent (e.g. mobile radio) and of varying levels depending on distance from the source.

9.5 Test Procedure

Testing was performed using PC controlled spectrum analysers with an antenna or clamp appropriate to the test type and frequency range.

9.5.1 Description of measurement parameters

The measurement frequency range of 9kHz to 1GHz was split into sub ranges applicable to each type of antenna (or current clamp) used. The ranges are as follows;

7. Clamp measurement 1

Measurements were performed on a local power cable accessible at the sheep stunning area.

| | |
|-----------------------|-----------------|
| Frequency range | 150kHz to 30MHz |
| Measurement bandwidth | 10kHz |
| Sweep time | 20s |
| No. of sweeps | 10 |

8. Clamp measurement 2

Measurements were performed on a local power cable accessible at the sheep stunning area.

| | |
|-----------------------|--|
| Frequency range | 100kHz to 150kHz (typical operating frequency of RFID equipment is likely to be 134kHz therefore this range was chosen to examine emissions more closely over the operating range) |
| Measurement bandwidth | 1kHz |
| Sweep time | 20s |
| No. of sweeps | 10 |

9. Magnetic Loop measurement

Measurements were performed at the sheep stunning and cattle stunning areas.

| | |
|-----------------------|----------------|
| Frequency range | 9kHz to 150kHz |
| Measurement bandwidth | 1kHz |
| Sweep time | 10s |
| No. of sweeps | 10 |

10. Magnetic Loop measurement

Measurements were performed at the sheep stunning and cattle stunning areas.

Frequency range 150kHz to 5MHz

Measurement bandwidth 10kHz

Sweep time 20s

No. of sweeps 10

11. Magnetic Loop measurement

Measurements were performed at the sheep stunning and cattle stunning areas.

Frequency range 5MHz to 30MHz

Measurement bandwidth 10kHz

Sweep time 20s

No. of sweeps 10

12. Magnetic Loop measurement

Measurements were performed at the sheep stunning and cattle stunning areas. Closer examination of typical RFID operating frequency range.

Frequency range 100kHz to 150kHz

Measurement bandwidth 1kHz

Sweep time 20s

No. of sweeps 10

13. ARA antenna measurement

Measurements were performed at the sheep stunning and cattle stunning areas.

Frequency range 30MHz to 1000MHz

Measurement bandwidth 100kHz

Sweep time 20s

No. of sweeps 10

9.5.2 Test areas

In the absence of photographs, Figure 82 and Figure 83 below show an approximate plan view of the test areas

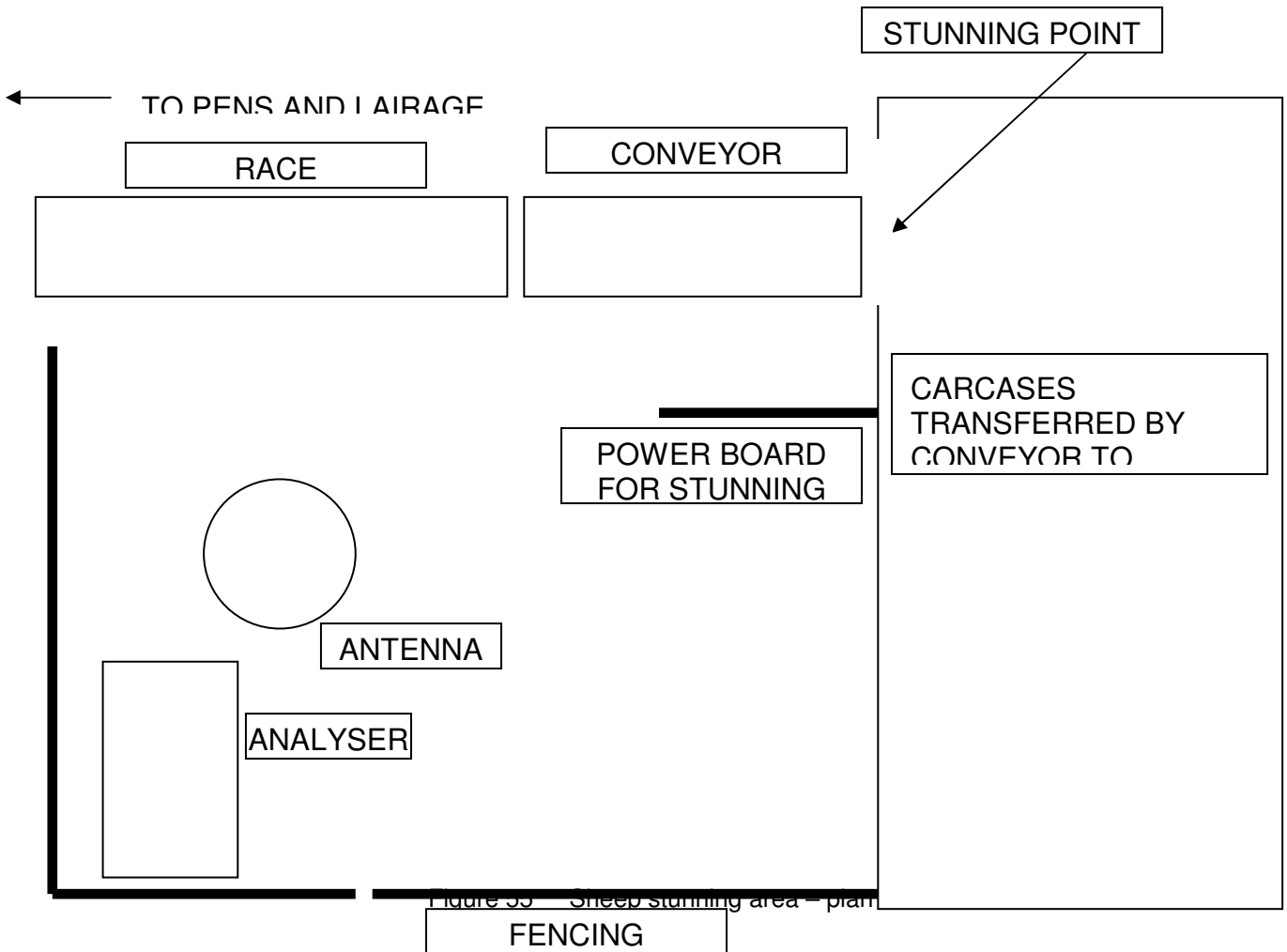
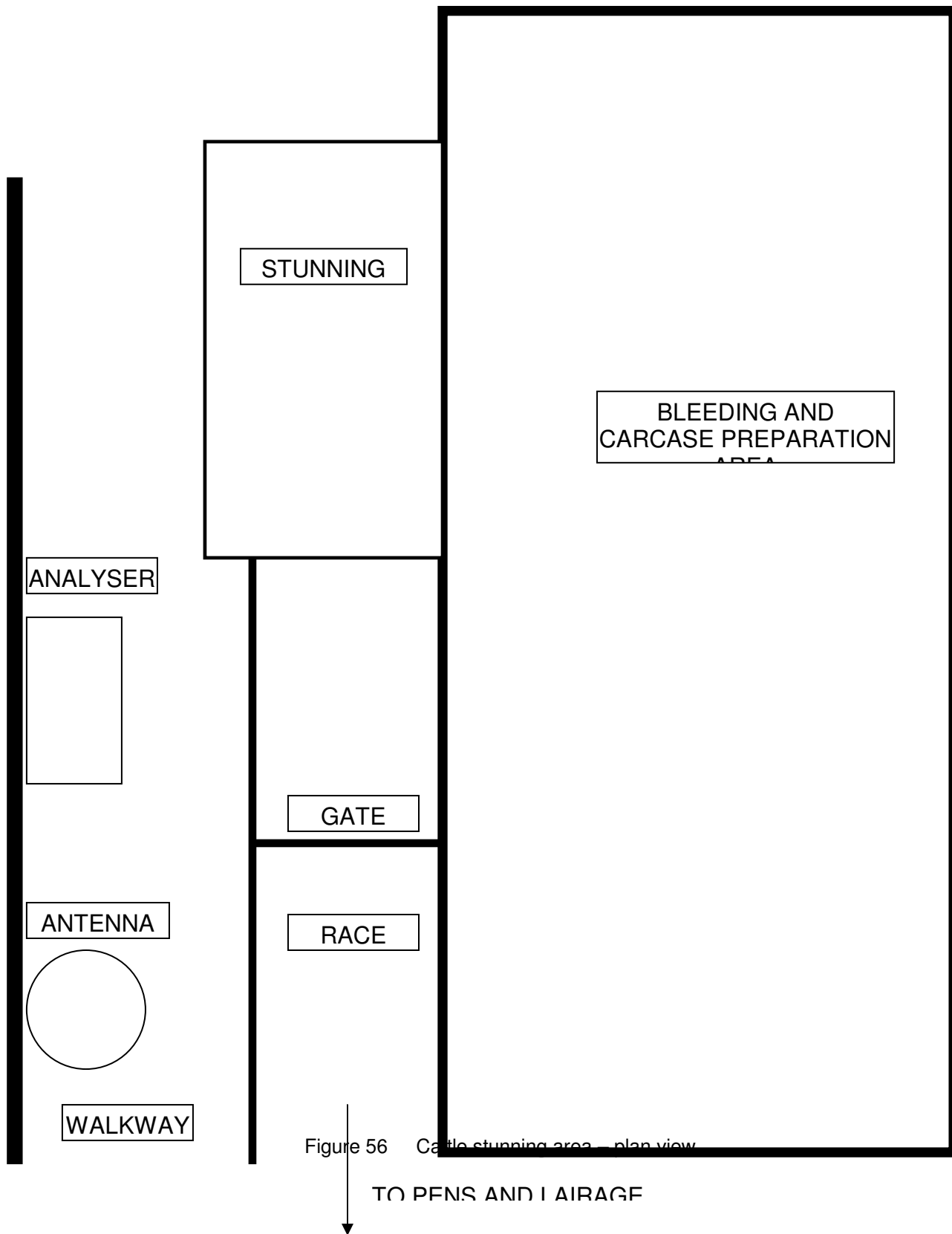


Figure 83 - Sheep stunning area - plan



9.5.3 Co-Located Equipment

From observation, other electrical/electronic equipment in use at this site included;

- i) Electrical stunning equipment, sheep stunning area.
The charging and discharge of this equipment during use produces EMI.
- ii) Motors and conveyor systems, both sheep and cattle stunning areas
Motors, particularly if using a brush and commutator system, are a known source of EMI.
- iii) Electrical pneumatic systems. cattle stunning areas
The electrical switching of valves may produce transient EMI.
- iv) Carcass processing equipment, cattle stunning areas.
Electro-stimulation of carcasses, powered cutting equipment

9.5.4 Plots – Sheep stunning area

The plots presented are the levels of the 10 sweeps in each measurement range combined to show the maximum levels recorded.

9.5.4.1 150kHz to 30MHz – Clamp

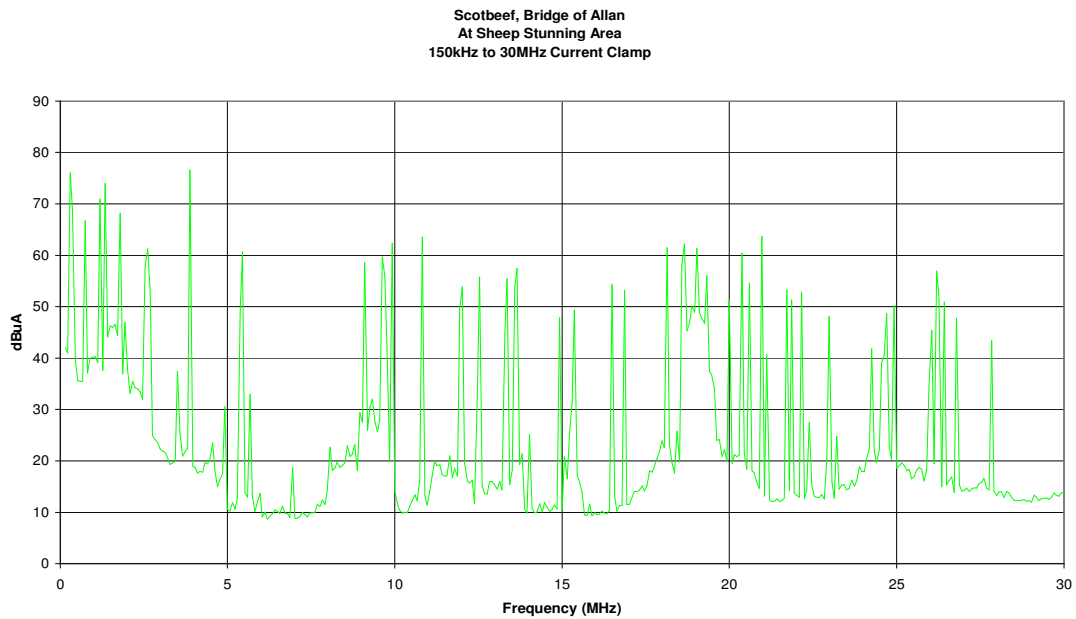


Figure 57 RF Measurement 150kHz to 30MHz, clamp

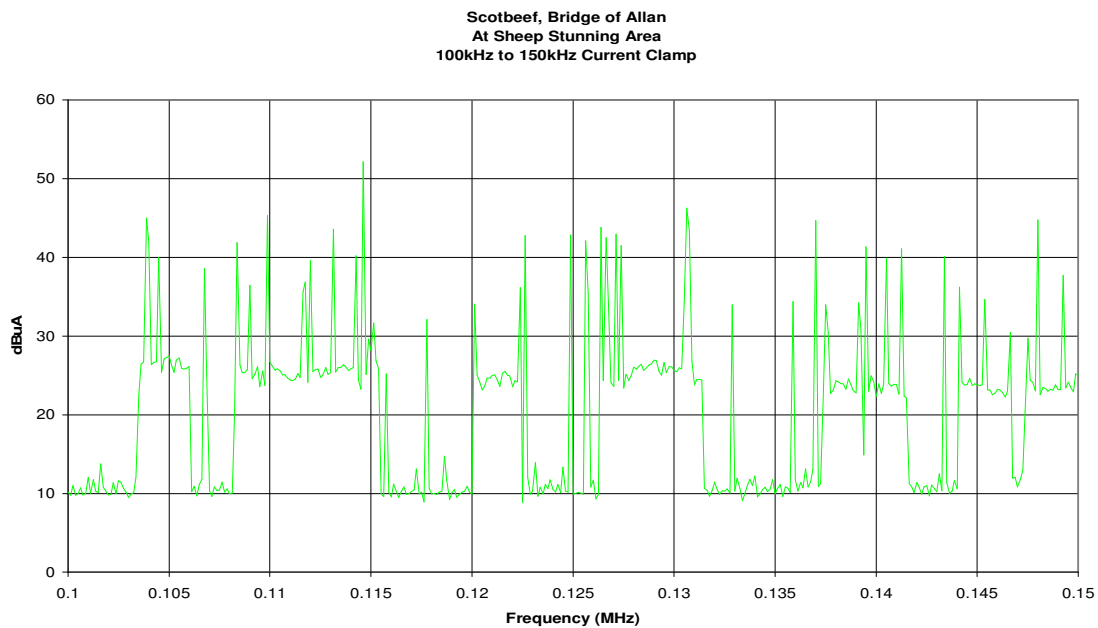


Figure 58 RF Measurement 100kHz to 150kHz, clamp

Figure 84 and Figure 85 below show emissions on the local power cables related to the stunning equipment. In Figure 85, which shows the measurement around the typical frequency of operation of RFID equipment (134kHz), the emissions can be seen to consist of high, short duration peaks combined with longer periods of constant level emissions lasting approximately 1 second and were repeated while the stunning equipment was in use. The longer constant levels will be combined emissions over the 10 sweeps performed.

9.5.4.2 9kHz to 30MHz – Loop Antenna

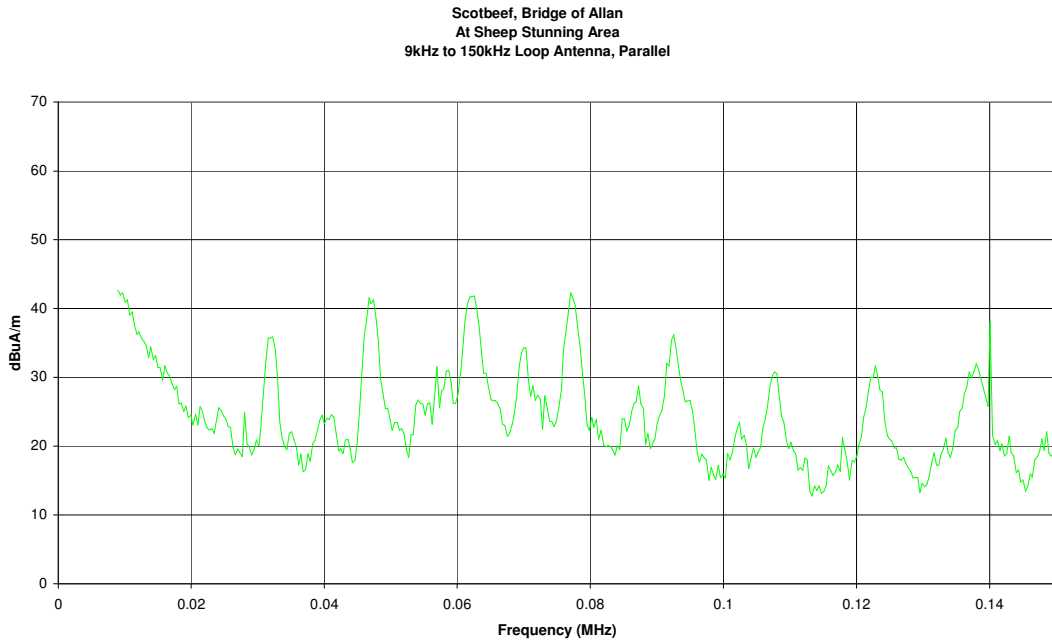


Figure 59 RF Measurement 9kHz to 150kHz, Parallel

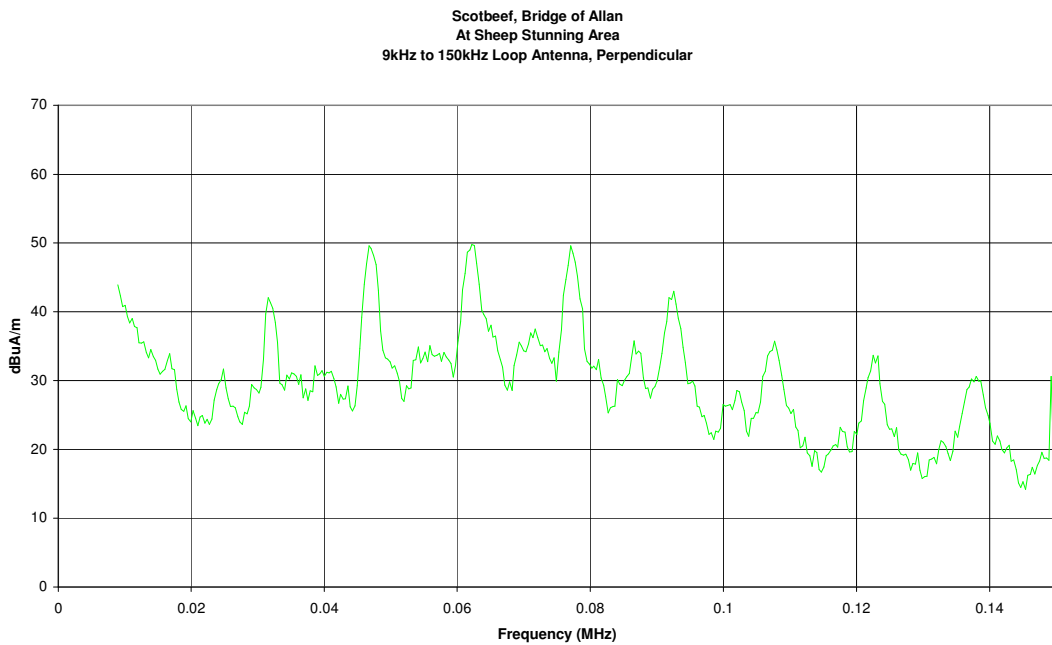


Figure 60 RF Measurement 9kHz to 150kHz, Perpendicular

The plots in Figure 86 and Figure 87 below show a series of harmonically related peaks (between 14 and 16kHz separation) likely to be related to the sheep stunning equipment.

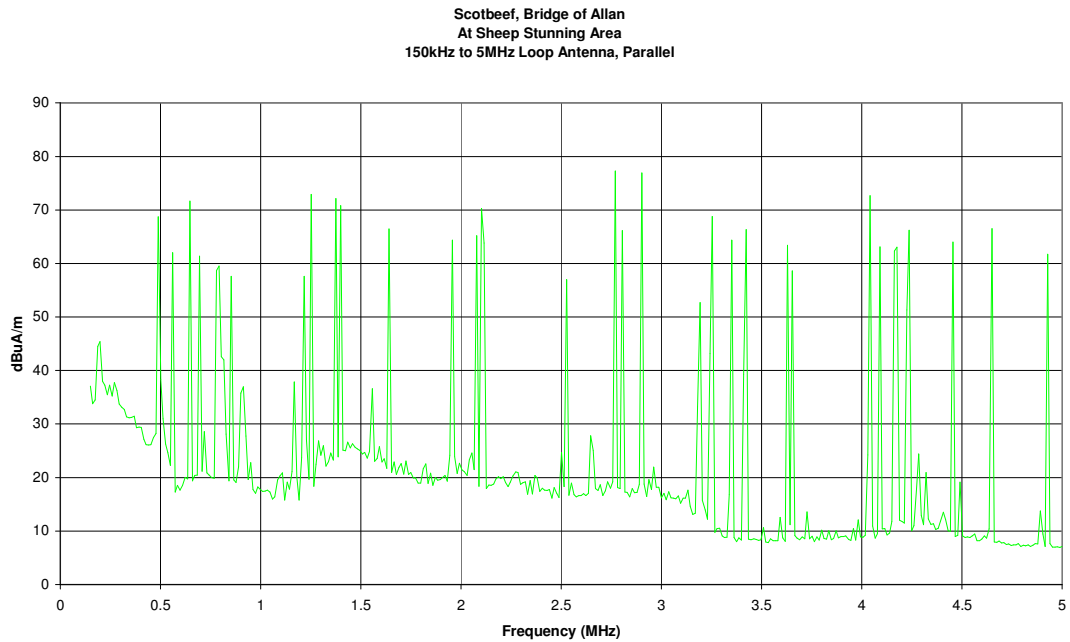


Figure 61 RF Measurement 150kHz to 5MHz, Parallel

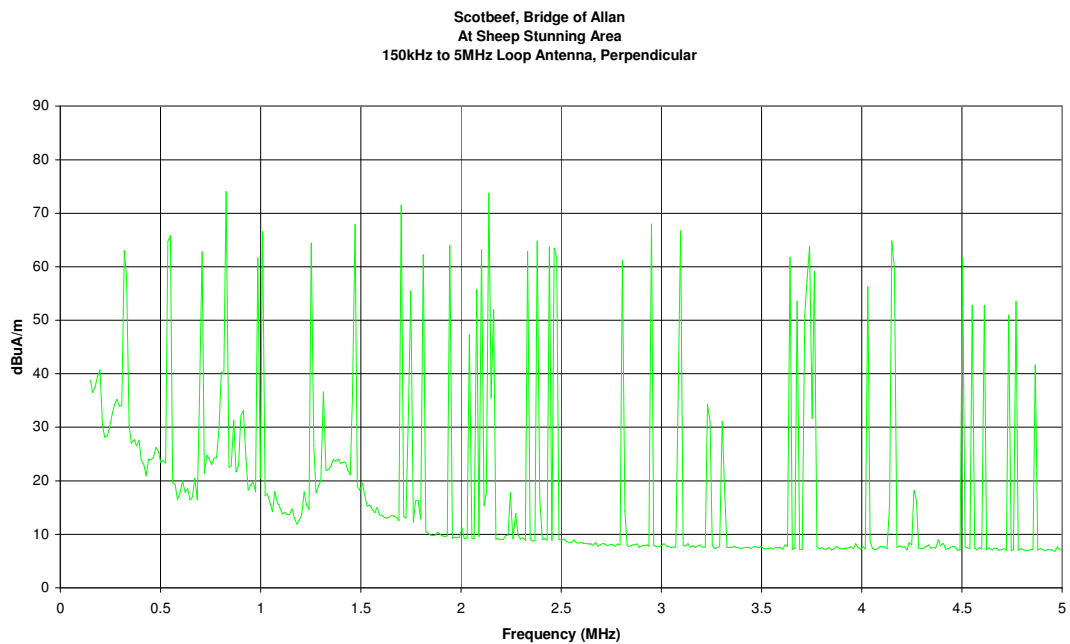


Figure 62 RF Measurement 150kHz to 5MHz, Perpendicular

The plots in Figure 88 and Figure 89 below show RF emissions that occurred during the operation of the stunning equipment, seen as the high peaks on the plots.

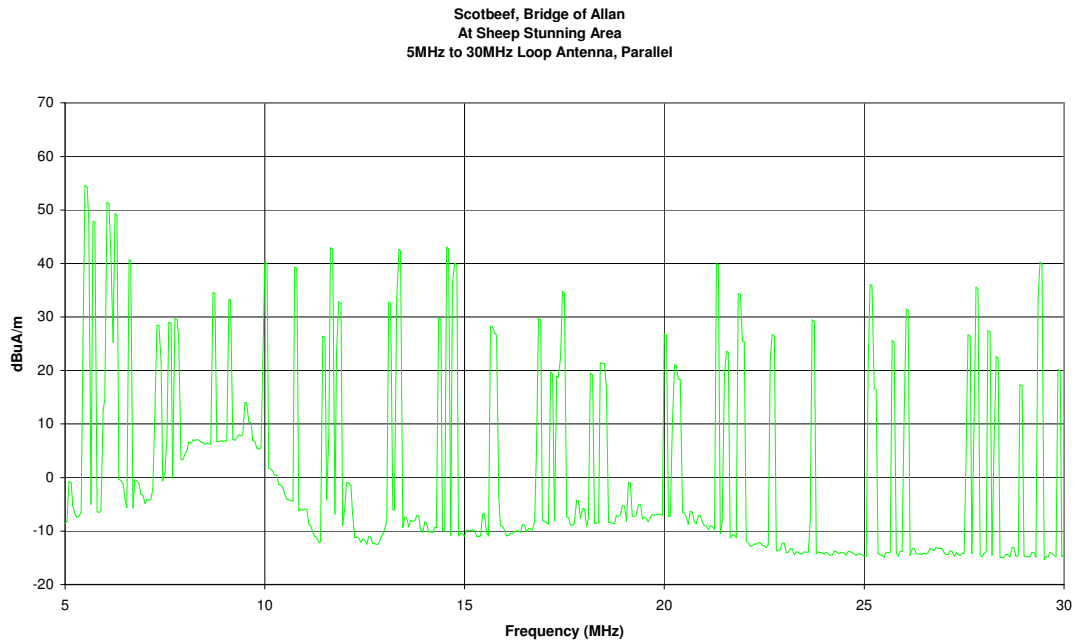


Figure 63 RF Measurement 5MHz to 30MHz, Parallel

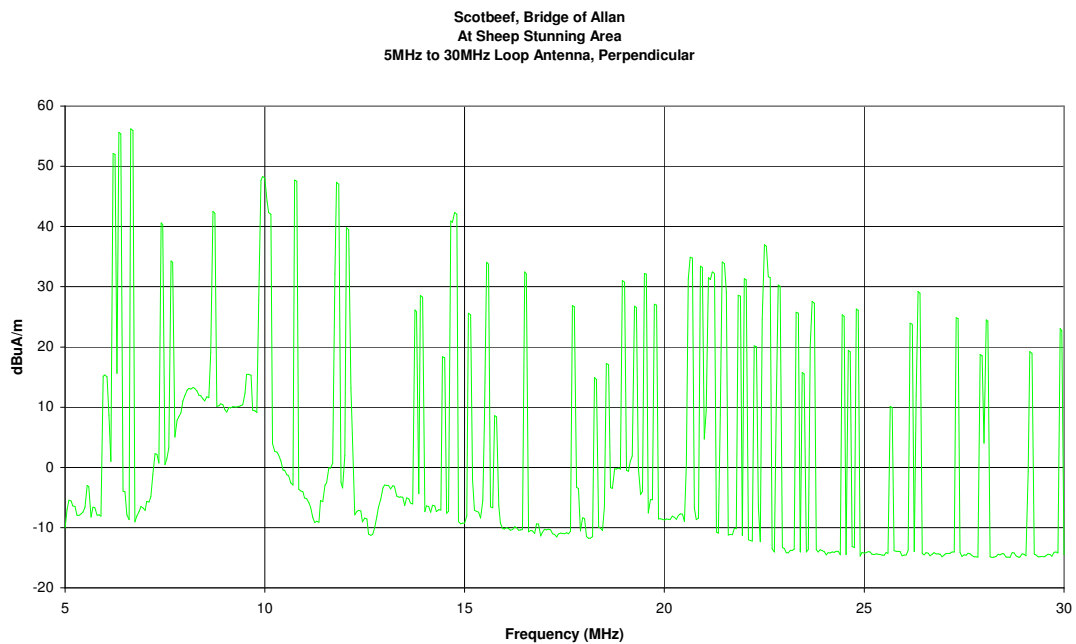


Figure 64 RF Measurement 5MHz to 30MHz, Perpendicular

The plots in Figure 90 and Figure 91 below show RF emissions that occurred during the operation of the stunning equipment, seen as the high peaks on the plots.

9.5.4.3 100kHz to 150kHz – Loop Antenna

Typical RFID systems intended for use in animal identification operate at 134kHz. The measurement frequency range was reduced to investigate local emissions around this frequency in greater detail.

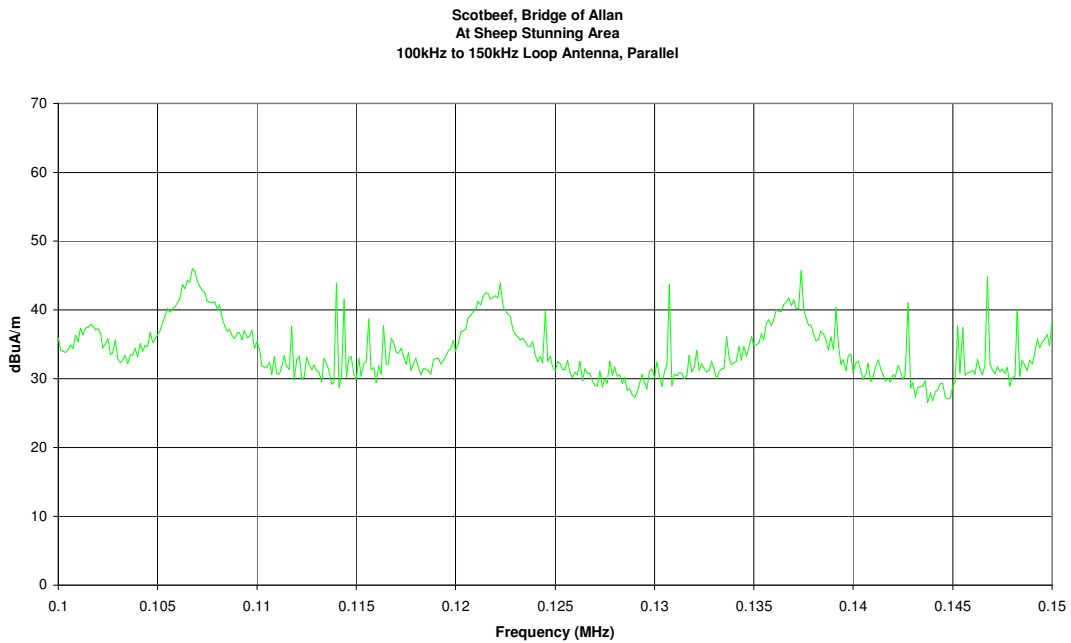


Figure 65 RF Measurement 100kHz to 150kHz, Parallel

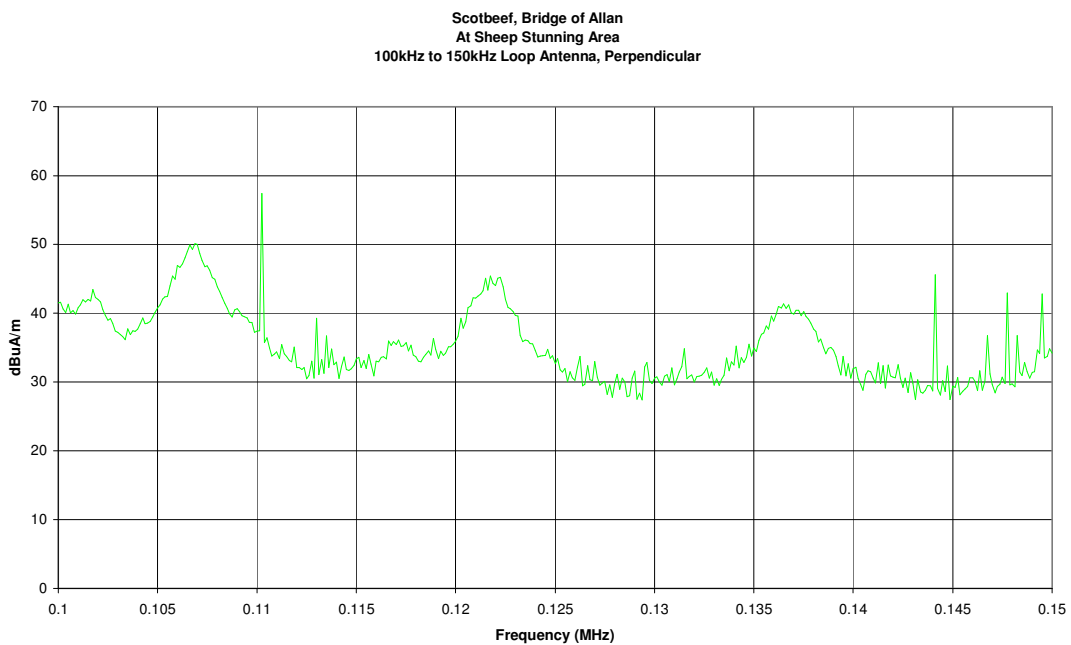


Figure 66 RF Measurement 100kHz to 150kHz, Perpendicular

The plots in Figure 92 and Figure 93 below show the harmonically related peaks related to the stunning equipment, with higher, short duration emissions during operation of the stunning.

9.5.4.4 30MHz to 1000MHz – Active Receive Antenna

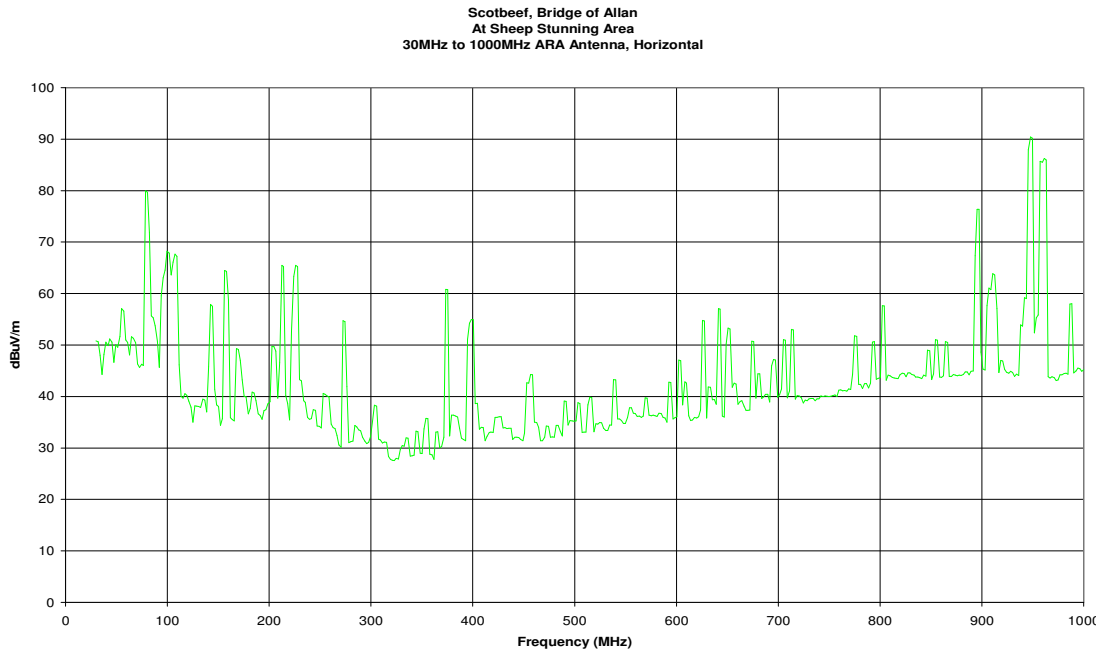


Figure 67 RF Measurement 30MHz to 1000MHz, Horizontal

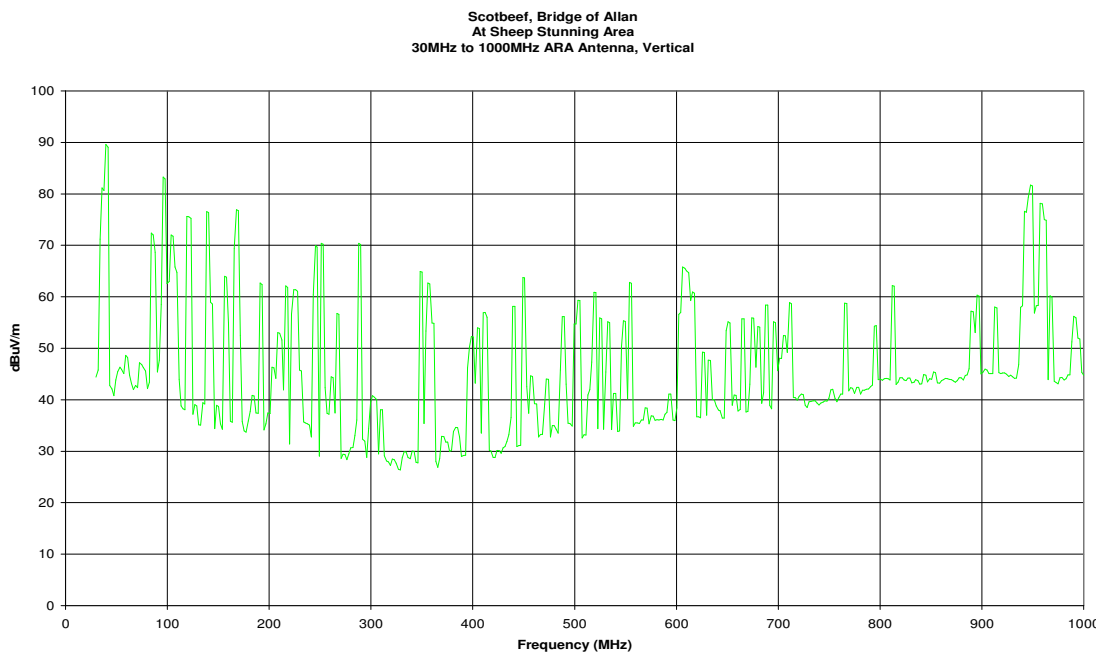


Figure 68 RF Measurement 30MHz to 1000MHz, Vertical

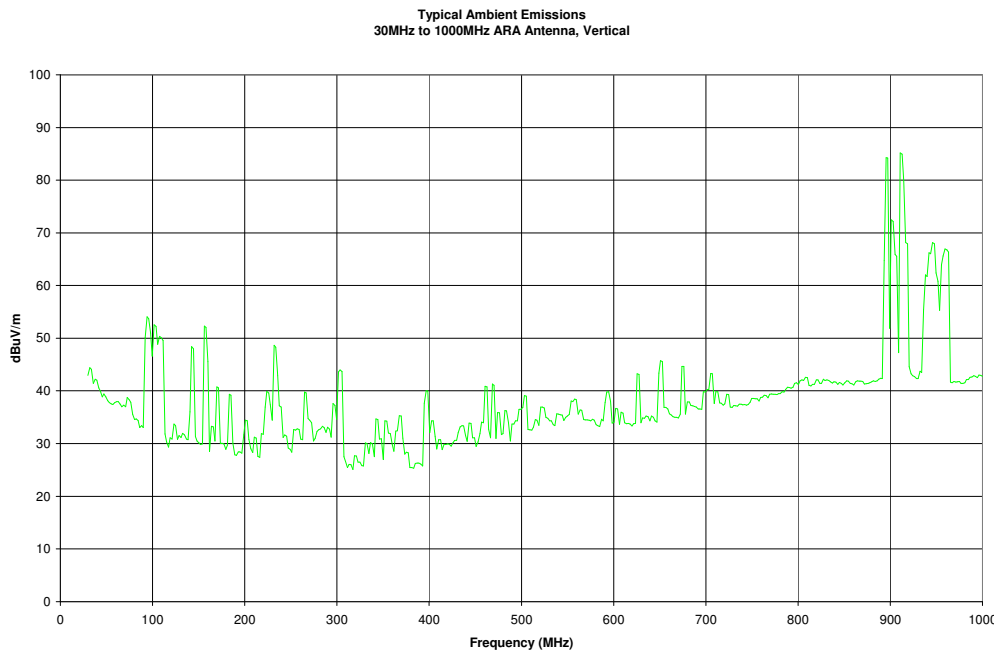


Figure 69 Typical RF Measurement 30MHz to 1000MHz, Vertical

The plots shown in Figure 94 and Figure 95 show emissions measured while the stunning system was in operation. This can be compared with Figure 96 below, showing typical levels of emissions normally seen.

In Figure 96, normal ambient transmissions are shown. For example;

| | |
|-------------------|-------------|
| FM radio | 88-108MHz |
| Mobile radios | 135-200MHz |
| Digital radio | 218-230MHz |
| Television | 400-750MHz |
| Mobile telephones | 900-1000MHz |

It can be seen from the plots that the stunning equipment produces high local levels of emissions.

9.5.5 Plots – Cattle stunning area

The plots presented are the levels of the 10 sweeps in each measurement range combined to show the maximum levels recorded.

See over.

9.5.5.1 9kHz to 30MHz – Loop Antenna

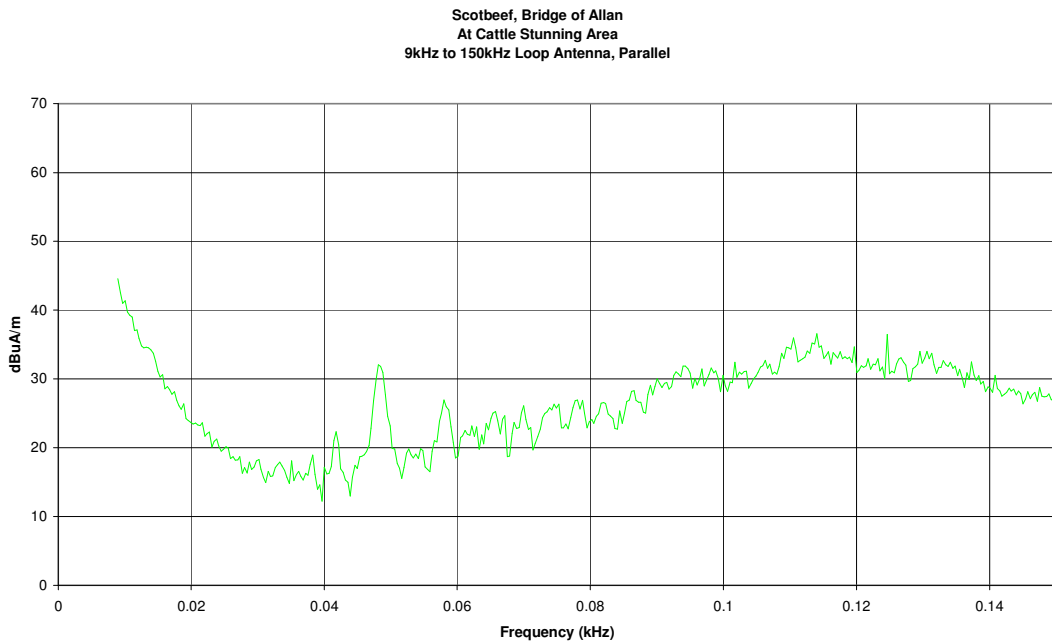


Figure 70 RF Measurement 9kHz to 150kHz, Parallel

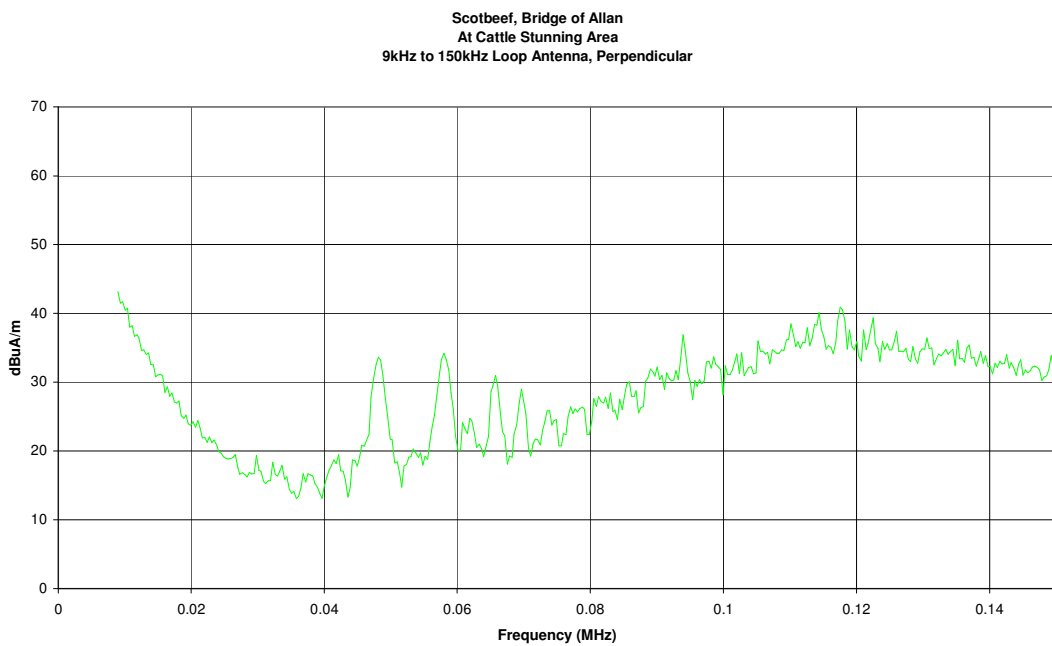


Figure 71 RF Measurement 9kHz to 150kHz, Perpendicular

The plots shown in Figure 97 and Figure 98 below show several peak emissions and an area of broadband emissions, likely being produced locally from equipment in use.

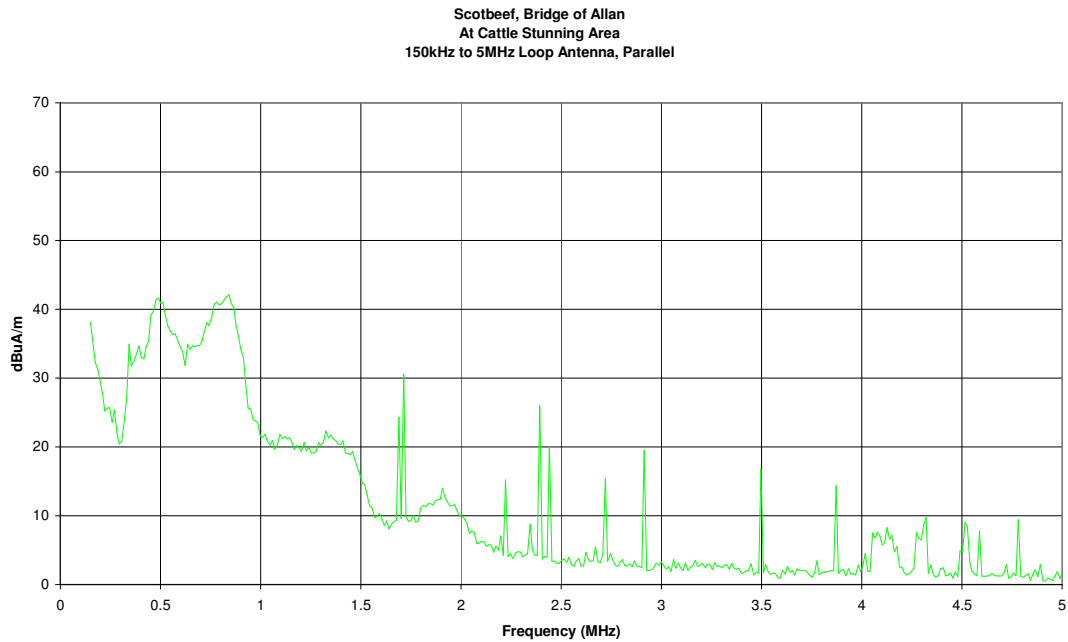


Figure 72 RF Measurement 150kHz to 5MHz, Parallel

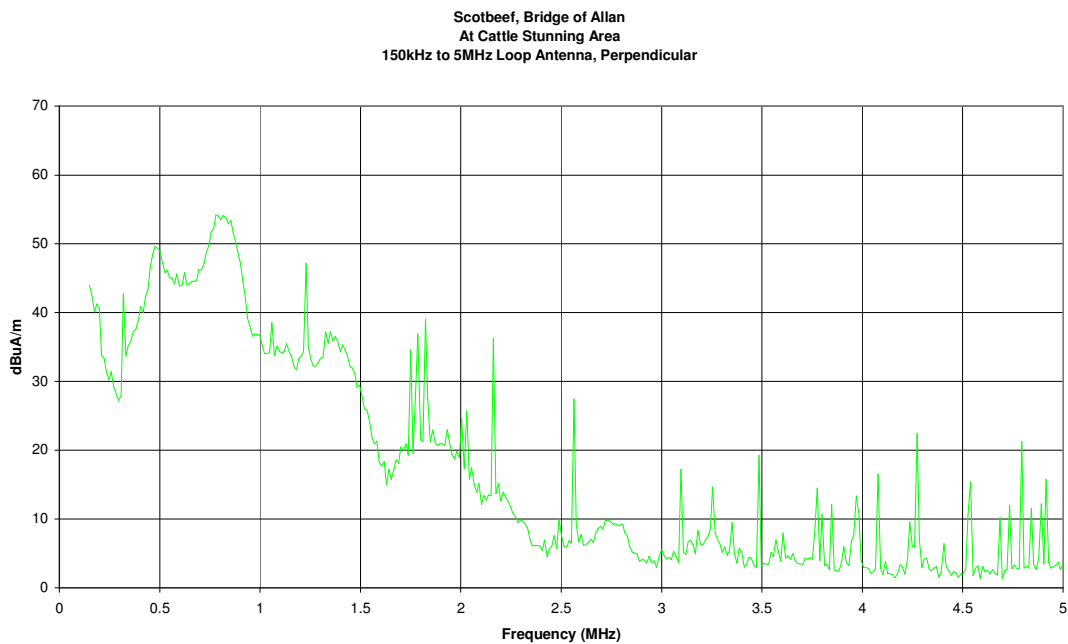


Figure 73 RF Measurement 150kHz to 5MHz, Perpendicular

The plots shown in Figure 99 and Figure 100 below show several peak emissions and an area of broadband emissions (500kHz to 1.5MHz). The broad emissions can be related to ambient radio broadcasts (AM radio allocation is 526.5kHz to 1.606MHz). Other peaks (1.5MHz to 2MHz) fall into the allocation frequencies for amateur services, land mobile radio (2.2MHz to 2.5MHz). Other peaks have frequencies related to similar services.

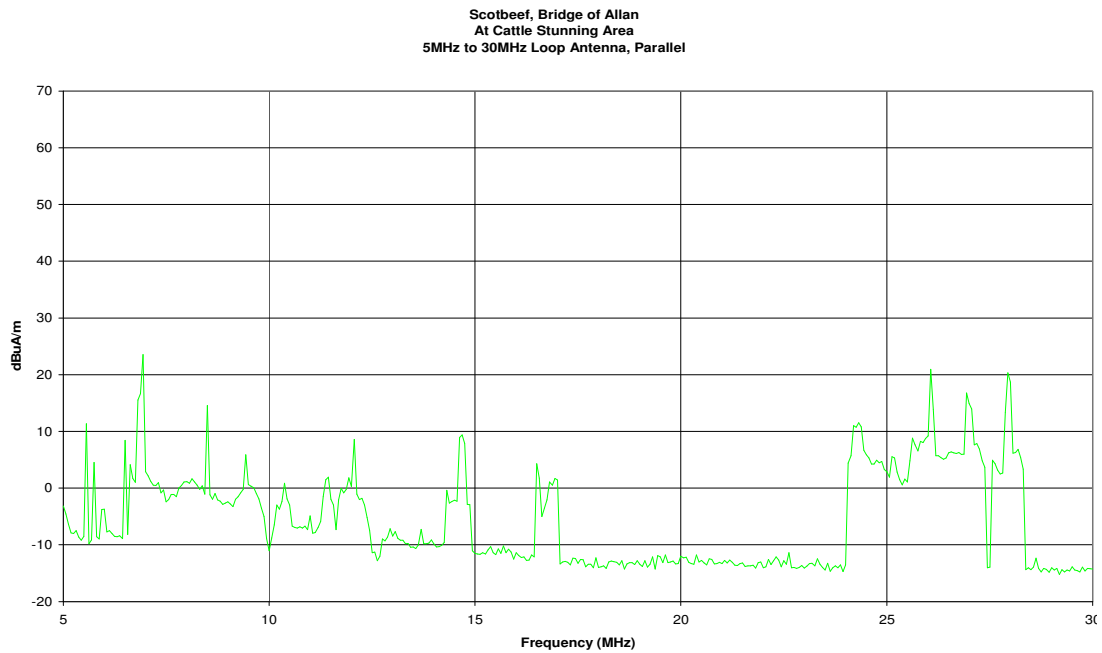


Figure 74 RF Measurement 5MHz to 30MHz, Parallel, measure 1

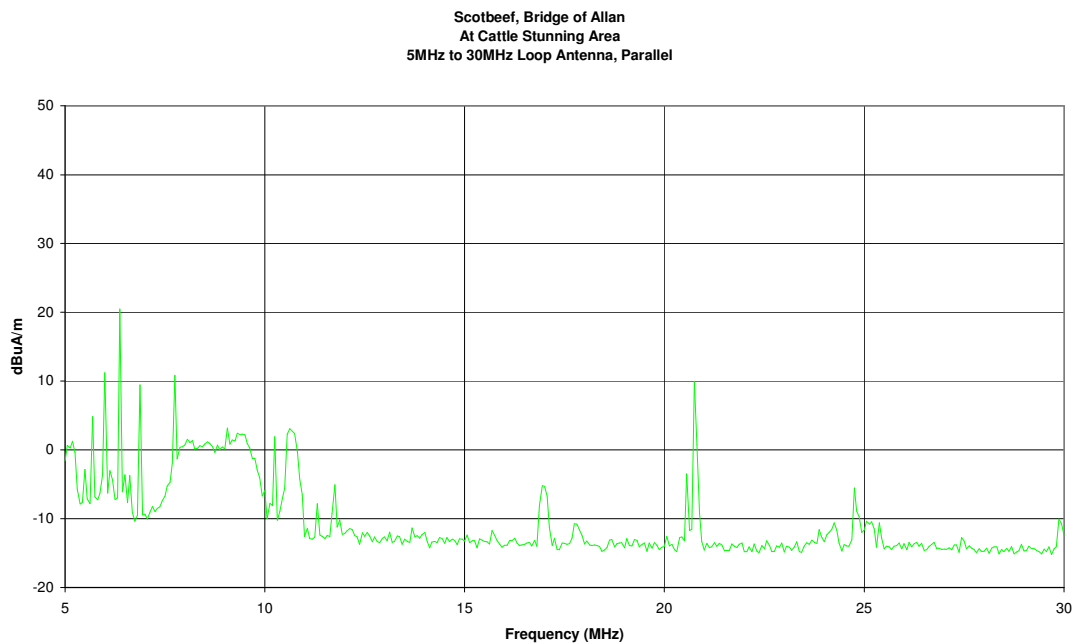


Figure 75 RF Measurement 5MHz to 30MHz, Parallel, measure 2

The plots shown in Figure 101 and Figure 102 below show emissions measured during operation, measurement 1, and during a break, measurement 2. Emissions caused by equipment operation can be seen in measurement 1 (24MHz to 28MHz).

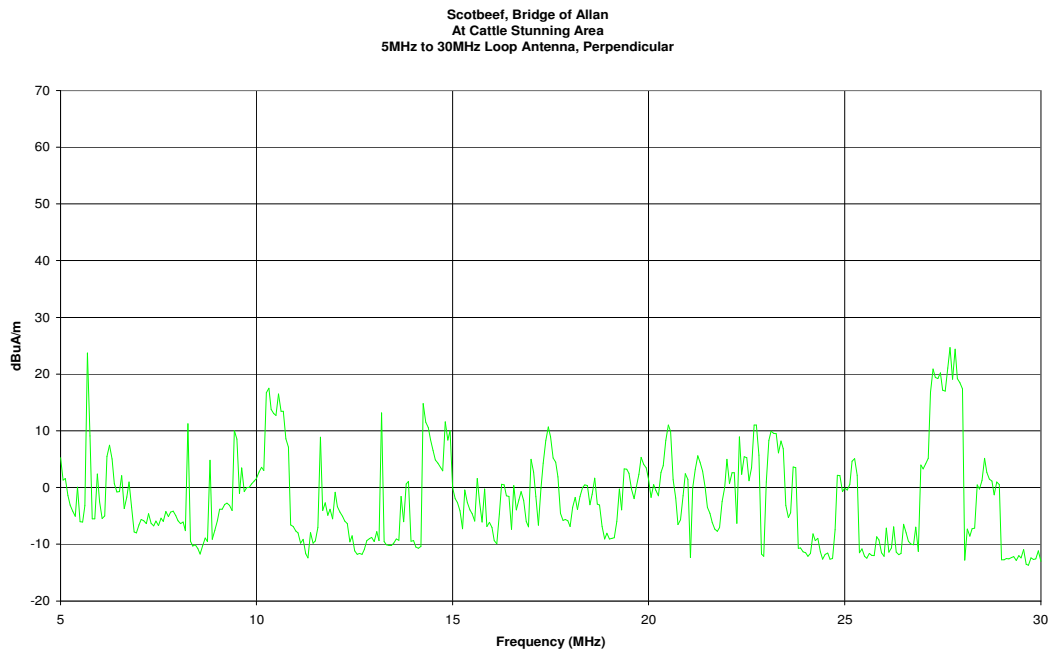


Figure 76 RF Measurement 5MHz to 30MHz, Perpendicular, measure 1

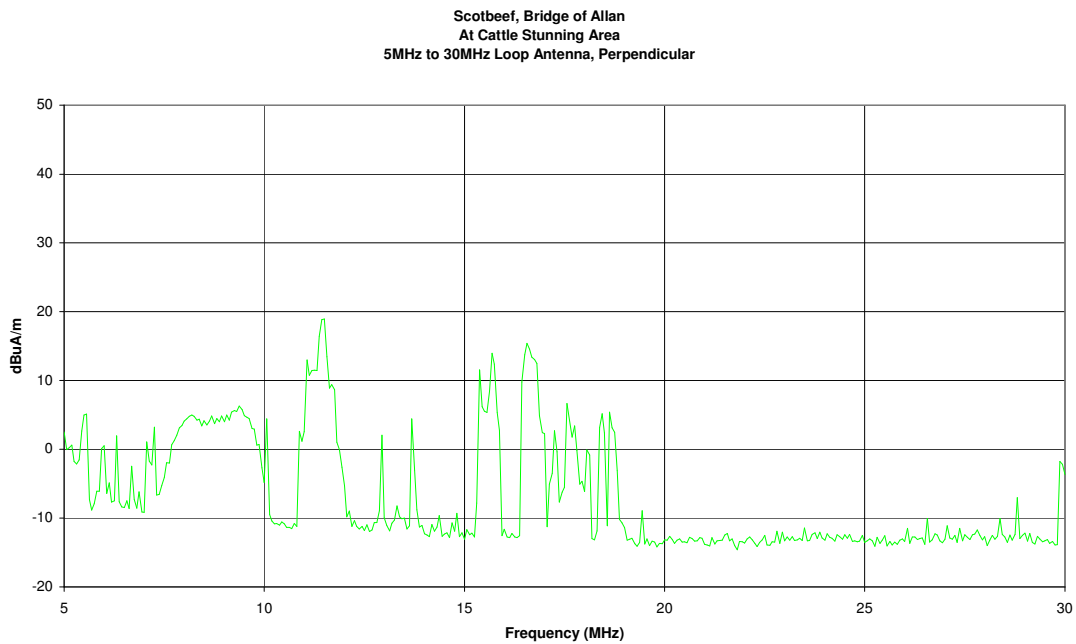


Figure 77 RF Measurement 5MHz to 30MHz, Perpendicular, measure 2

The plots shown in Figure 103 and Figure 104 below show emissions measured during operation, measurement 1, and during a break, measurement 2. Emissions caused by equipment operation can be seen in measurement 1 (27MHz to 28MHz), plus additional emissions across the range.

9.5.5.2 100kHz to 150kHz – Loop Antenna

The frequency range was narrowed down to cover the frequency of operation of the RFID system more closely.

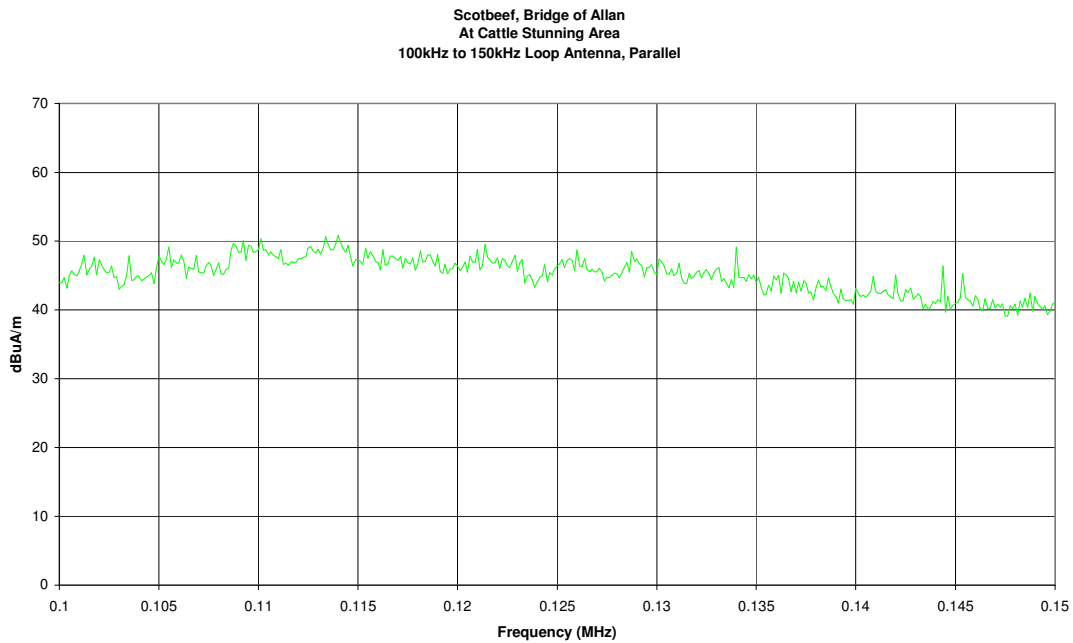


Figure 78 RF Measurement 100kHz to 150kHz, Parallel

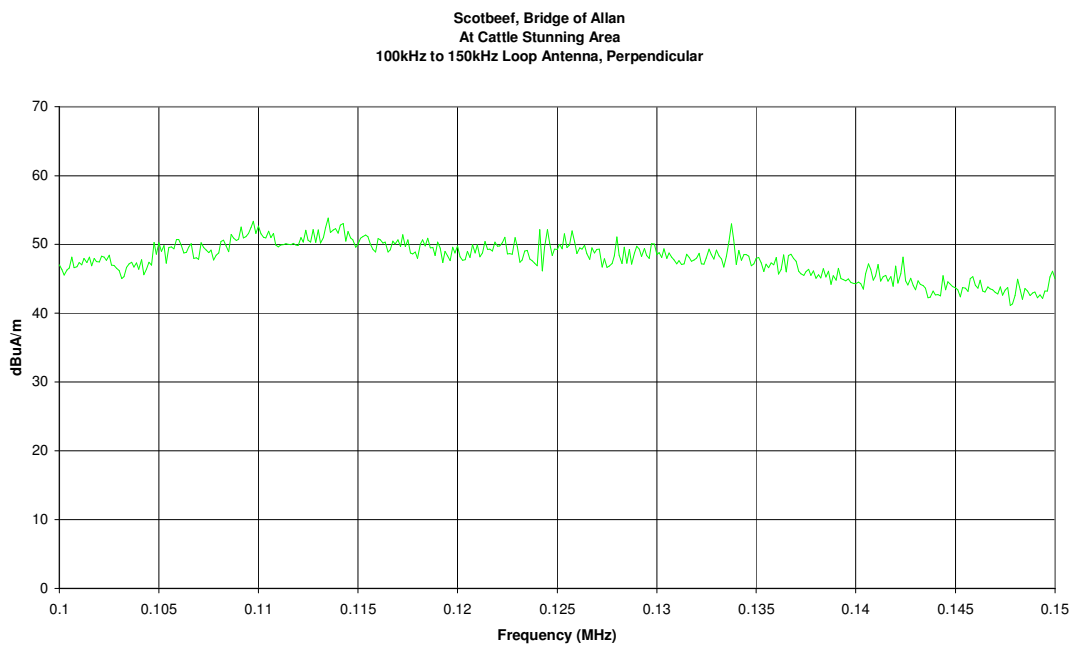


Figure 79 RF Measurement 100kHz to 150kHz, Perpendicular

The plots shown in Figure 105 and Figure 106 below show relatively high levels of broadband emissions noted around the typical frequency of operation of RFID equipment.

9.5.5.3 30MHz to 1000MHz – Active Receive Antenna

This range was chosen as the normal range used in typical EMC standards.

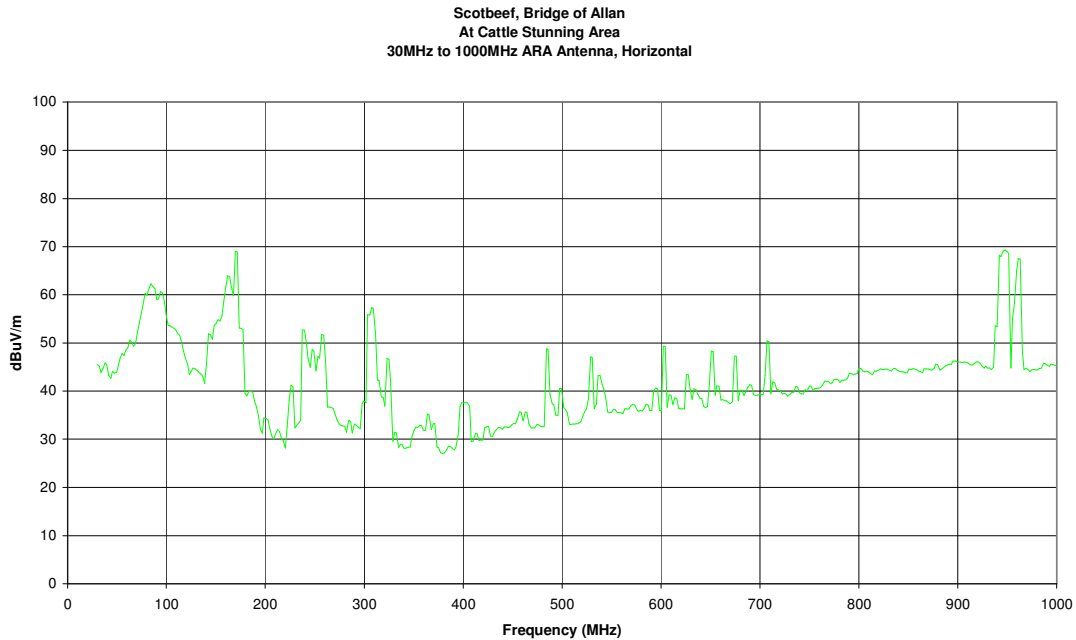


Figure 80 RF Measurement 30MHz to 1000MHz, Horizontal

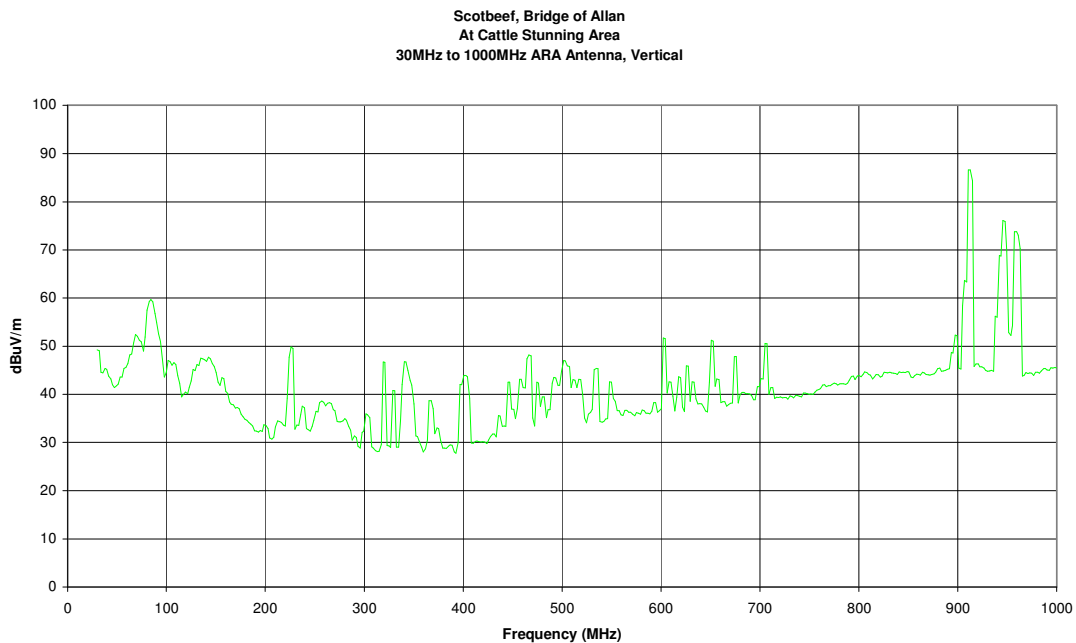


Figure 81 RF Measurement 30MHz to 1000MHz, Vertical

The plots shown in Figure 107 and Figure 108 below show, in general, typical levels of emissions expected in this frequency range related to normal radio (broadcasting and personal mobile radios), television, and mobile telephones.

10 Test Equipment Used

| Equipment | Manufacturer | Type |
|------------------------|-------------------|---------|
| Spectrum Analyser | Anritsu | MS2667C |
| Spectrum Analyser | Hewlett Packard | HP8594E |
| Current Clamp | Eaton | 93686-1 |
| Loop Antenna | ETS | 6511 |
| Loop Antenna | ETS | 6512 |
| Active Receive Antenna | York EMC Services | ARA 01 |

Table 15 List of Test Equipment Used

References

- ETSI EN 300 330-1 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 1 Technical characteristics and test methods
- ETSI EN 300 330-2 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 2 Harmonized EN under article 3.2 of the R&TTE Directive
- ETSI EN 301 489-1 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
- ETSI EN 301 489-3 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3 Specific conditions for short range radio devices (SRD) operating on frequencies between 9kHz and 40GHz.

Appendix C – Site Test Report, Scotbeef, Bridge of Allan

**Report on Radio Frequency Site
Measurements
at
Scotbeef, Longleys Plant
Bridge of Allan
Report (copy 1 of 3)
for
Scottish Executive Environment
and Rural Affairs Department
Contract FF/05/19**

Document number 2214TR1

Project number 7568

Author:

G. Whyte Senior Engineer

Checked:

B. Tait Principal Engineer, BSc, MIET

Approved:

B. Tait Principal Engineer, BSc, MIET

| Issue | Description | Issue by | Date |
|----------|--------------------|-----------|-------------------|
| 1 | First Issue | GW | 30/04/2006 |

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The results contained in this report are only applicable to the apparatus tested.

Executive Summary

This report details tests performed in support of the study commissioned by Scottish Executive Environment and Rural Affairs Department (SEERAD) to evaluate the effect of electromagnetic interference in transceivers (readers) used to identify animals electronically. The systems are normally known as Electronic Identification (EID) or RF Identification (RFID) systems.

As part of this project site testing was performed at typical locations where EID is intended be used in the tracking and recording of animal movements, for example auction sites and abattoirs, to identify typical local electromagnetic emissions and their possible threat to the correct operation of EID/RFID systems.

This report details the tests performed at a meat processing facility, Scotbeef Meat Packers at Longleys Farm, Bridge of Allan. Testing was carried out during a normal working day. Local RF emissions measurements were recorded over a range of frequencies (9kHz to 1000MHz) in various sub-ranges according to the antenna used. Measurements in each frequency sub-range were taken over a period of time (typically around 10 minutes) in order that any variations in the emissions due to operation of plant equipment could be recorded.

The tests show that some equipment used during the production process produce electromagnetic interference of significant amplitude. This may require that for the installation of fixed RFID systems (for example, panel readers), the manufacturers should ensure that sufficient mitigating measures be taken to reduce any effects due to EMI.

Mitigating measures can take the form of filtering, screening, or positioning of the equipment and cabling. Systems should also, as part of normal manufacture, meet the standards required by the EU for EMC.

This test report forms part of the overall report (2211CR1) that will contain a more in-depth analysis of the results and a draft Guidelines for Build and Installation that is intended to offer some methods used to minimise the effects of EMI on equipment and installations.

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Report Change History

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|--------------|-----------------------------|
| 1 | Original issue of report |
| 2 | |
| 3 | |
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Murray Hardy, Scotbeef, Longleys Plant, Bridge of Allan for allowing us access to the plant and to the plant staff.

Duncan Todd, Scottish Agricultural Organisation Society (SAOS) for assistance and introductions

List of Terms and Abbreviations

| | |
|--------|---|
| AC | Alternating Current |
| ARA | Active Receive Antenna |
| CISPR | Comité International Spécial des Perturbations Radioélectriques |
| DC | Direct Current |
| EID | Electronic Identification |
| EMC | ElectroMagnetic Compatibility |
| EMI | ElectroMagnetic Interference |
| EN | European Norm |
| ETSI | European Telecommunications Standards Institute |
| EU | European Union |
| IT | Information Technology |
| PC | Personal Computer |
| RF | Radio Frequency |
| RFID | Radio Frequency Identification |
| SAOS | Scottish Agricultural Organisation Society |
| SEERAD | Scottish Executive Environment and Rural Affairs Department |
| SRD | Short range Radio Device |
| YES | York EMC Services Ltd |

11 Introduction

11.1 Test Location

Testing was performed on site to investigate local electromagnetic signals present at the areas where RFID systems are likely to be used.

The tests were performed at;

Scotbeef Meat Packers

Longleys

Bridge of Allan

Stirlingshire

FK9 4NE

The tests were performed on 15 May 2006 during a normal operating day (06:00 to 17:00).

Tests were performed at both the sheep and cattle stunning areas. From discussions with the staff at the facility, these areas were identified as the most probable locations for fixed RFID systems and also the areas where plant equipment that may produce unwanted EMI is in use continuously.

These sites were chosen to represent the worst case measurements with respect to EMI.

At the request of Scotbeef, no photographs were taken at the facility.

11.2 Referenced Standards

EID/RFID equipment falls under the description of a short range radio device and therefore into the scope of the following standards.

| | |
|-------------------|--|
| ETSI EN 300 330-1 | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 1 Technical characteristics and test methods |
| ETSI EN 300 330-2 | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 2 Harmonized EN under article 3.2 of the R&TTE Directive |

These standards specify the characteristics and performance of the transmitter/receiver with respect to field strength, power, etc.

However, the relevant standards applicable to the EMC tests are referenced by;

ETSI EN 301 489-1 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements

This gives the general EMC tests applicable to all devices.

ETSI EN 301 489-3 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3 Specific conditions for short range radio devices (SRD) operating on frequencies between 9kHz and 40GHz.

This gives specific requirements and allowances for SRDs.

These standards refer to the specific requirements for equipment operation. During site investigations of ambient conditions, the ranges used in these standards will be referred to.

12 Testing

For emissions, the nominal CISPR bandwidth requirements are;

- 200Hz from 9kHz to 150kHz
- 9kHz from 150kHz to 30MHz
- 120kHz from 30MHz to 1000MHz

When performing compliance testing for emissions, measurements are performed using Quasi Peak and Average detectors for conducted emissions (RF interference present on power lines and other cabling) and Quasi Peak for radiated emissions. These detectors allow a differentiation between broadband and narrow band emissions by the 'smoothing out' of very short duration transient signals, for example those caused by switching of a load. A drawback of using these detectors is the time taken for the measurements, in particular the Quasi Peak measurement that requires 1 second at the frequency of measurement to obtain a reading. In order that a sequence of measurements could be taken over a period of time, spectrum analysers were used in peak detection mode. Although this does not exactly correspond to the CISPR compliance measurements, peak detection gives the worst possible case in that all emissions are noted, including short duration transients.

The spectrum analyser is also limited in its range of measurement bandwidths, being restricted to 1kHz, 10kHz, 100kHz, etc. The bandwidths that were the closest approximations to the CISPR bandwidths were used.

During the testing, results in each sub range of frequencies were recorded over a period of time (typically approximately 10 minutes per scan range). This allowed for variations in the local EM environment due to the local plant equipment operation to be recorded. The results presented are the maximum levels recorded during that time.

12.1 Current Clamp Tests

These tests are intended to measure the RF interference present on cabling (power and/or signal cables) used in the facility. This RF interference is typically generated by any electrical and electronic equipment connected to the power system or signal cabling, and if it is excessive, operation of sensitive equipment also connected can be affected.

This type of interference can be transferred either directly from the source to the victim by direct connection of cabling or induced from source cables to victim cables due to proximity, e.g., where cables are routed together in long runs.

Tests were performed in the frequency ranges 9kHz to 30MHz.

Current clamp measurements were performed at the sheep stunning area only; no access was available to any cabling in the cattle stunning area where the current clamp could be used.

12.2 Loop Antenna Tests

These tests are intended to measure local radiated H-Field (magnetic) emissions. This RF noise is typically generated by equipment using high currents, e.g. transformers, motors or generators, co-located in the area.

Tests were performed in the range 9kHz to 30MHz. Two loop antennae are used to cover the frequency range.

Radiated emissions can be polarised by the way in which the source of the emissions is constructed, for example by the orientation of cables. Measurements are therefore performed with the antenna positioned in two axes in order to pick up emissions polarised (mainly) in either direction. These are nominally called parallel and perpendicular, referring to the orientation of the antenna with respect to the equipment being tested.

In the case of these site measurements where no specific equipment is involved, therefore no specific direction that the antenna can be referenced to, the terms parallel and perpendicular are used simply to differentiate the two measurements.

12.3 Active Receive Antenna (ARA)

These tests are intended to measure local radiated E-Field (electric) emissions. This RF noise is typically generated by equipment using high frequency switching and digital circuits, e.g. IT equipment co-located in the area, and local radio transmissions. Tests were performed in the range 30MHz to 1000MHz.

For E-Field (electric) measurements are performed with the antenna positioned in two axes, horizontal and vertical, in order to pick up emissions that can be polarised by the way in which the source of the emissions is constructed or located.

12.4 Typical Emissions Normally Present

Throughout the whole frequency range there will be various emissions present originating from normal licensed broadcast equipment, e.g. mobile radios, emergency services radios, mobile telephones, AM/FM radio, digital radio, television, etc., as well as other data transmissions and beacons. These emissions may be continuous (e.g. AM/FM radio, television) or intermittent (e.g. mobile radio) and of varying levels depending on distance from the source.

12.5 Test Procedure

Testing was performed using PC controlled spectrum analysers with an antenna or clamp appropriate to the test type and frequency range.

12.5.1 Description of measurement parameters

The measurement frequency range of 9kHz to 1GHz was split into sub ranges applicable to each type of antenna (or current clamp) used. The ranges are as follows;

14. Clamp measurement 1

Measurements were performed on a local power cable accessible at the sheep stunning area.

| | |
|-----------------------|-----------------|
| Frequency range | 150kHz to 30MHz |
| Measurement bandwidth | 10kHz |
| Sweep time | 20s |
| No. of sweeps | 10 |

15. Clamp measurement 2

Measurements were performed on a local power cable accessible at the sheep stunning area.

| | |
|-----------------------|--|
| Frequency range | 100kHz to 150kHz (typical operating frequency of RFID equipment is likely to be 134kHz therefore this range was chosen to examine emissions more closely over the operating range) |
| Measurement bandwidth | 1kHz |
| Sweep time | 20s |
| No. of sweeps | 10 |

16. Magnetic Loop measurement

Measurements were performed at the sheep stunning and cattle stunning areas.

| | |
|-----------------------|----------------|
| Frequency range | 9kHz to 150kHz |
| Measurement bandwidth | 1kHz |
| Sweep time | 10s |
| No. of sweeps | 10 |

17. Magnetic Loop measurement

Measurements were performed at the sheep stunning and cattle stunning areas.

Frequency range 150kHz to 5MHz

Measurement bandwidth 10kHz

Sweep time 20s

No. of sweeps 10

18. Magnetic Loop measurement

Measurements were performed at the sheep stunning and cattle stunning areas.

Frequency range 5MHz to 30MHz

Measurement bandwidth 10kHz

Sweep time 20s

No. of sweeps 10

19. Magnetic Loop measurement

Measurements were performed at the sheep stunning and cattle stunning areas. Closer examination of typical RFID operating frequency range.

Frequency range 100kHz to 150kHz

Measurement bandwidth 1kHz

Sweep time 20s

No. of sweeps 10

20. ARA antenna measurement

Measurements were performed at the sheep stunning and cattle stunning areas.

Frequency range 30MHz to 1000MHz

Measurement bandwidth 100kHz

Sweep time 20s

No. of sweeps 10

12.5.2 Test areas

In the absence of photographs, Figure 82 and Figure 83 below show an approximate plan view of the test areas

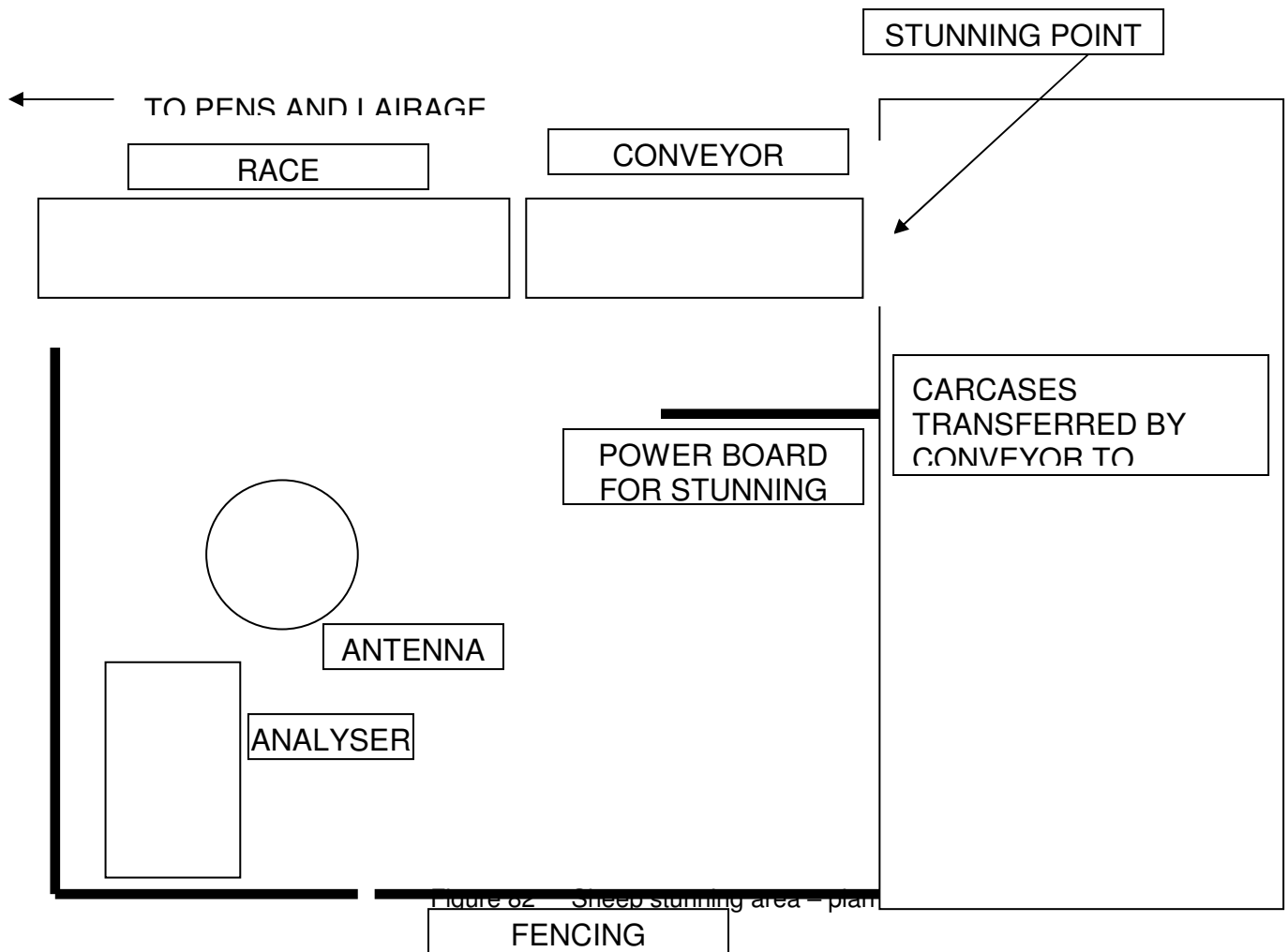
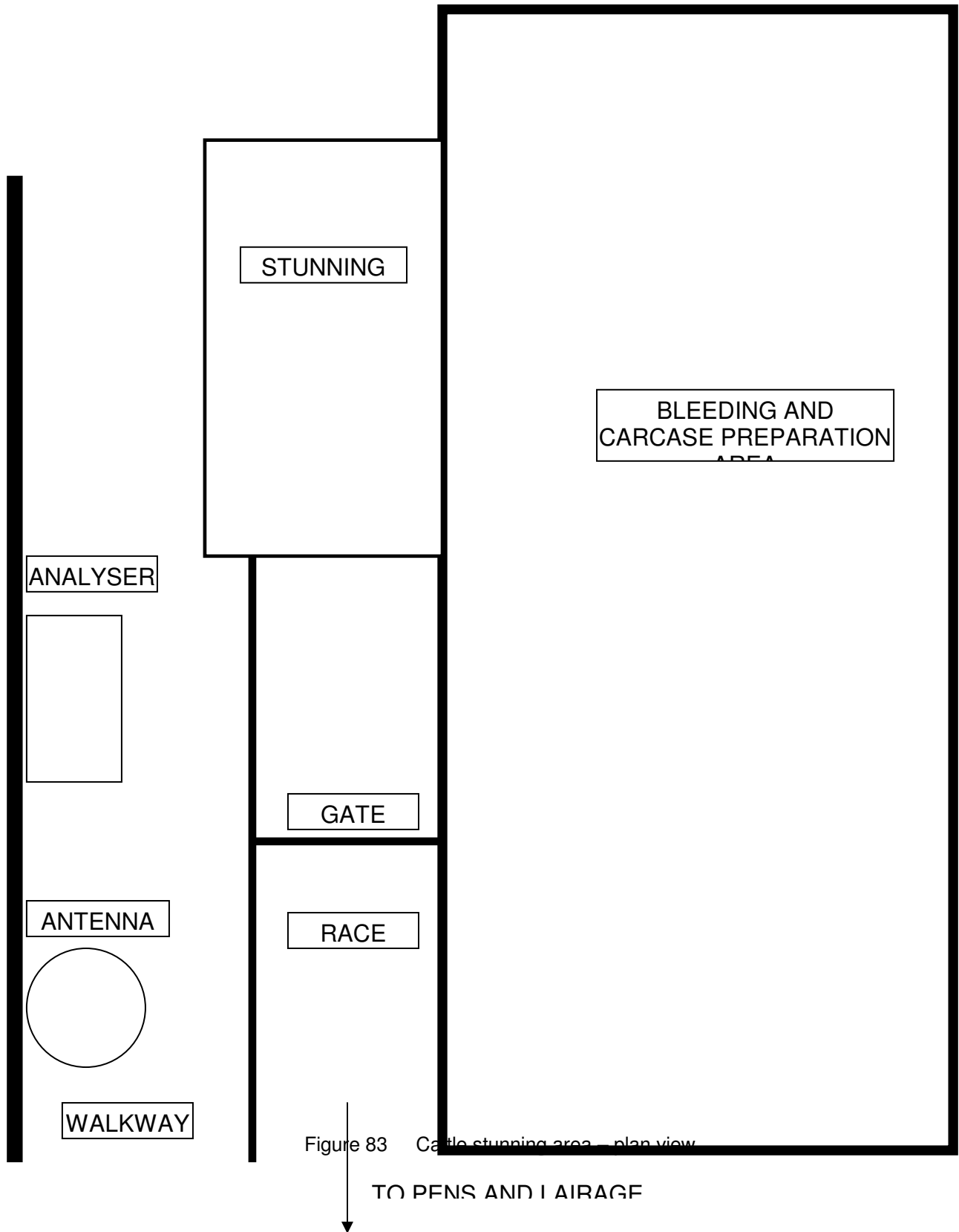


Figure 82 — Sheep stunning area — plan



12.5.3 Co-Located Equipment

From observation, other electrical/electronic equipment in use at this site included;

- i) Electrical stunning equipment, sheep stunning area.
The charging and discharge of this equipment during use produces EMI.
- ii) Motors and conveyor systems, both sheep and cattle stunning areas
Motors, particularly if using a brush and commutator system, are a known source of EMI.
- iii) Electrical pneumatic systems. cattle stunning areas
The electrical switching of valves may produce transient EMI.
- iv) Carcass processing equipment, cattle stunning areas.
Electro-stimulation of carcasses, powered cutting equipment

12.5.4 Plots – Sheep stunning area

The plots presented are the levels of the 10 sweeps in each measurement range combined to show the maximum levels recorded.

12.5.4.1 150kHz to 30MHz – Clamp

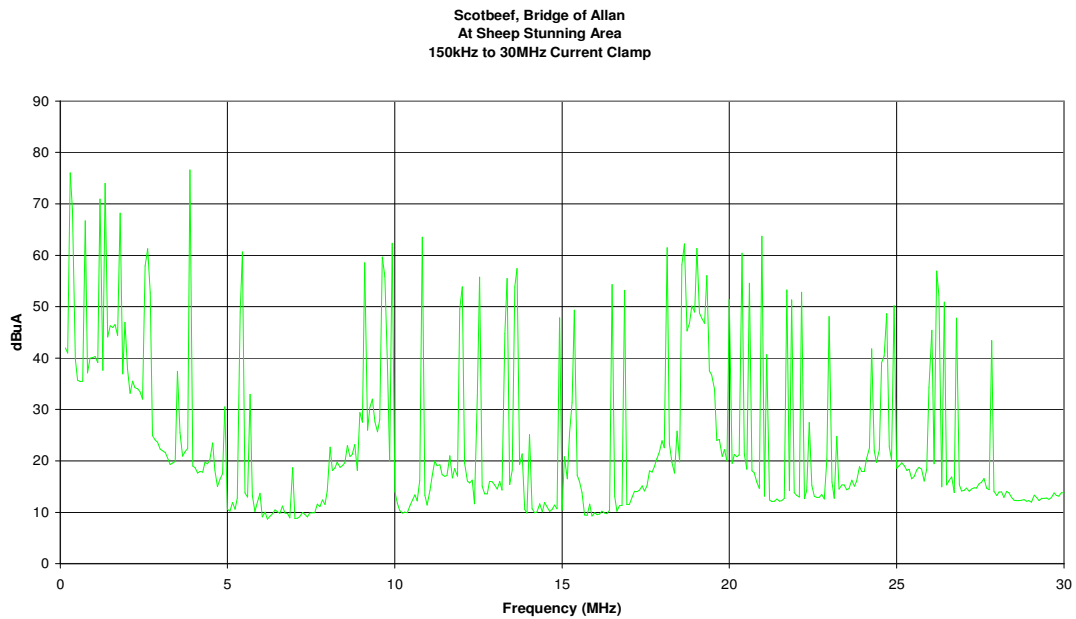


Figure 84 RF Measurement 150kHz to 30MHz, clamp

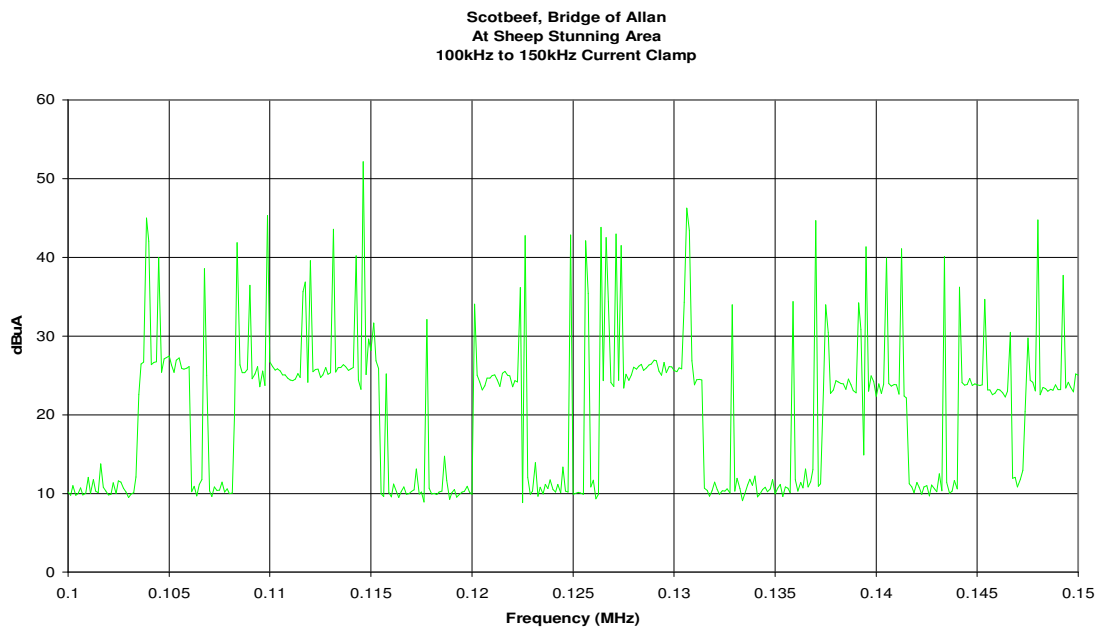


Figure 85 RF Measurement 100kHz to 150kHz, clamp

Figure 84 and Figure 85 above show emissions on the local power cables related to the stunning equipment. In Figure 85, which shows the measurement around the typical frequency of operation of RFID equipment (134kHz), the emissions can be seen to consist of high, short duration peaks combined with longer periods of constant level emissions lasting approximately 1 second and were repeated while the stunning equipment was in use. The longer constant levels will be combined emissions over the 10 sweeps performed.

12.5.4.2 9kHz to 30MHz – Loop Antenna

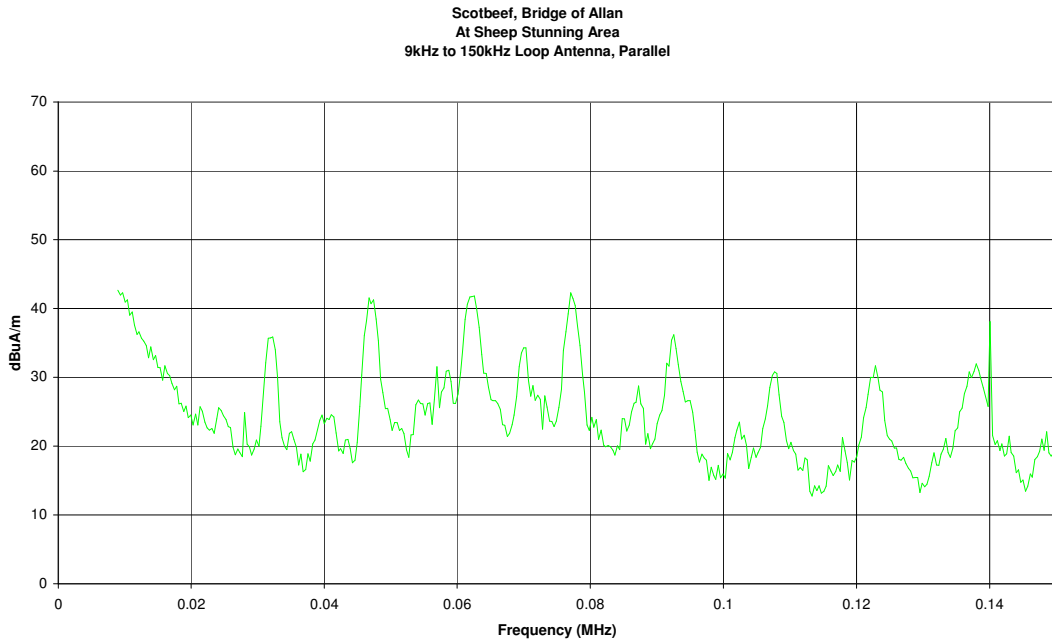


Figure 86 RF Measurement 9kHz to 150kHz, Parallel

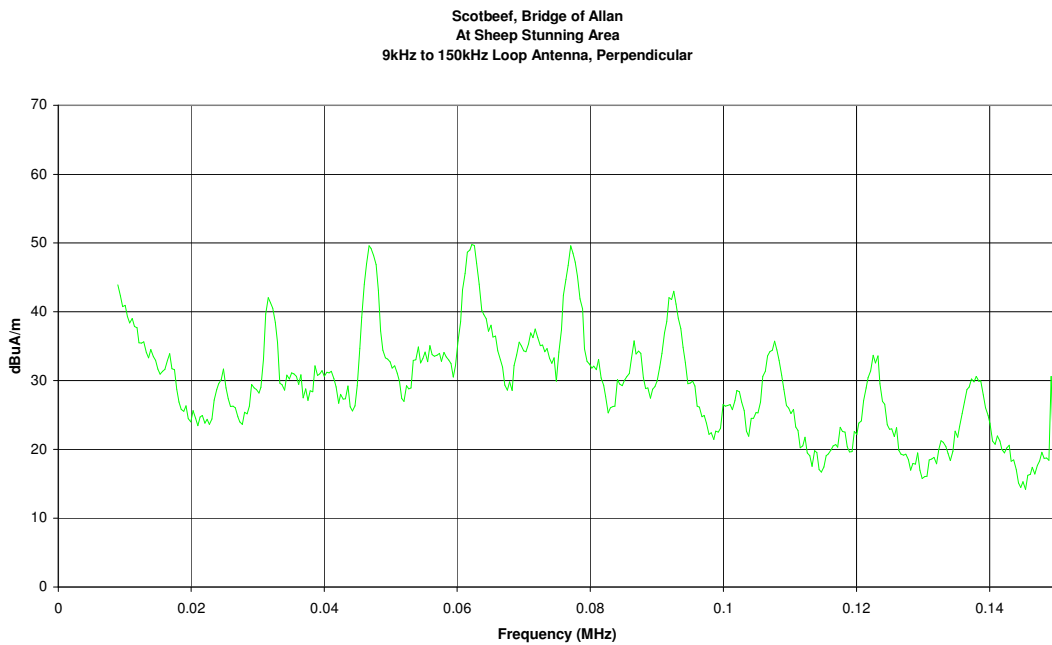


Figure 87 RF Measurement 9kHz to 150kHz, Perpendicular

The plots in Figure 86 and Figure 87 above show a series of harmonically related peaks (between 14 and 16kHz separation) likely to be related to the sheep stunning equipment.

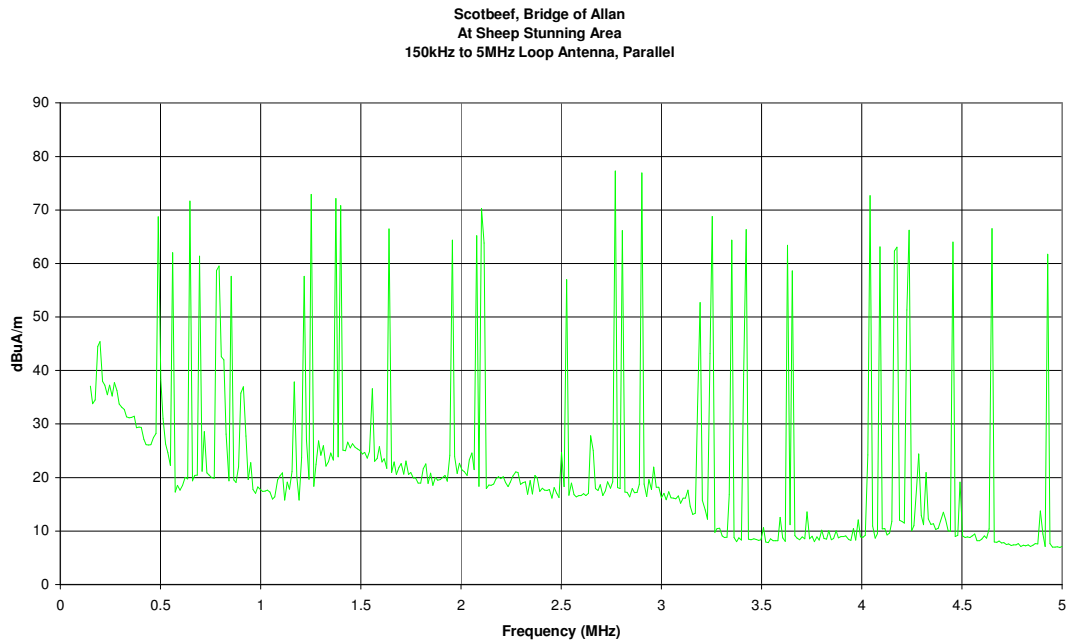


Figure 88 RF Measurement 150kHz to 5MHz, Parallel

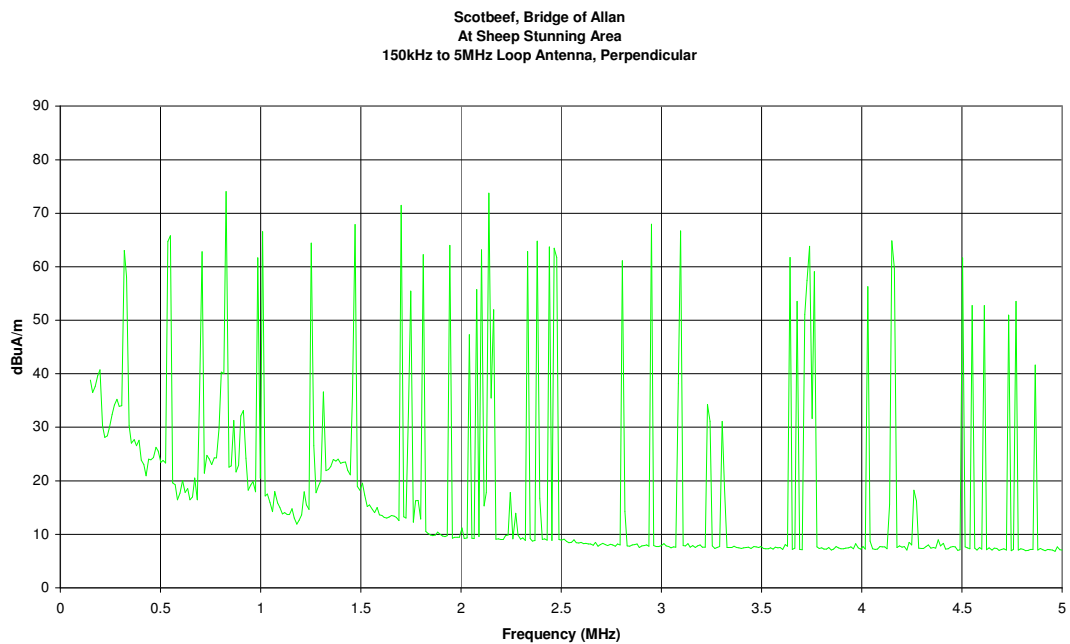


Figure 89 RF Measurement 150kHz to 5MHz, Perpendicular

The plots in Figure 88 and Figure 89 above show RF emissions that occurred during the operation of the stunning equipment, seen as the high peaks on the plots.

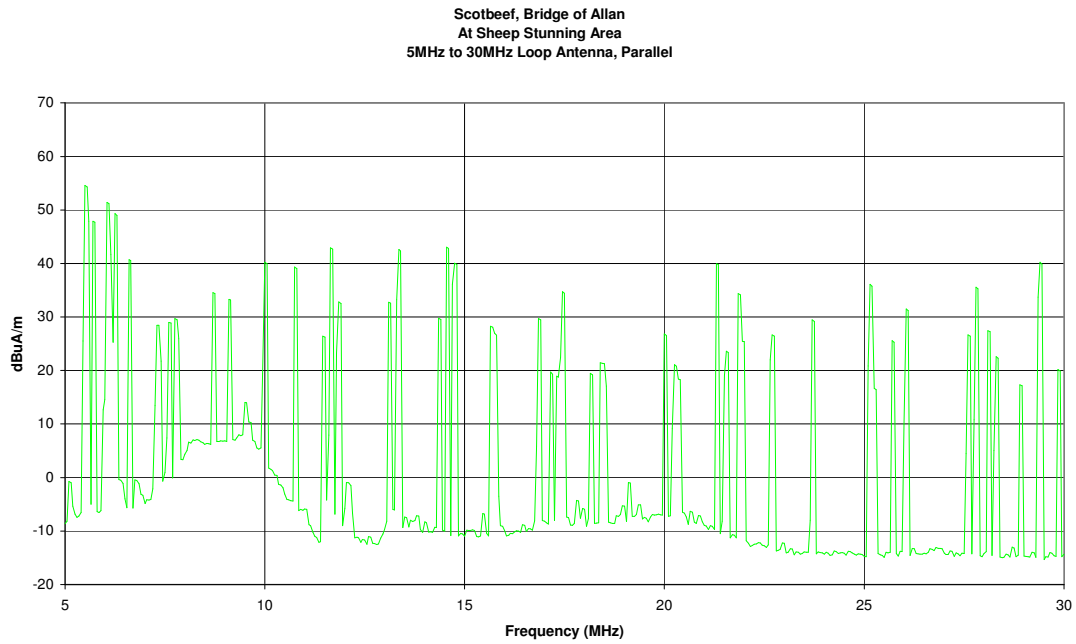


Figure 90 RF Measurement 5MHz to 30MHz, Parallel

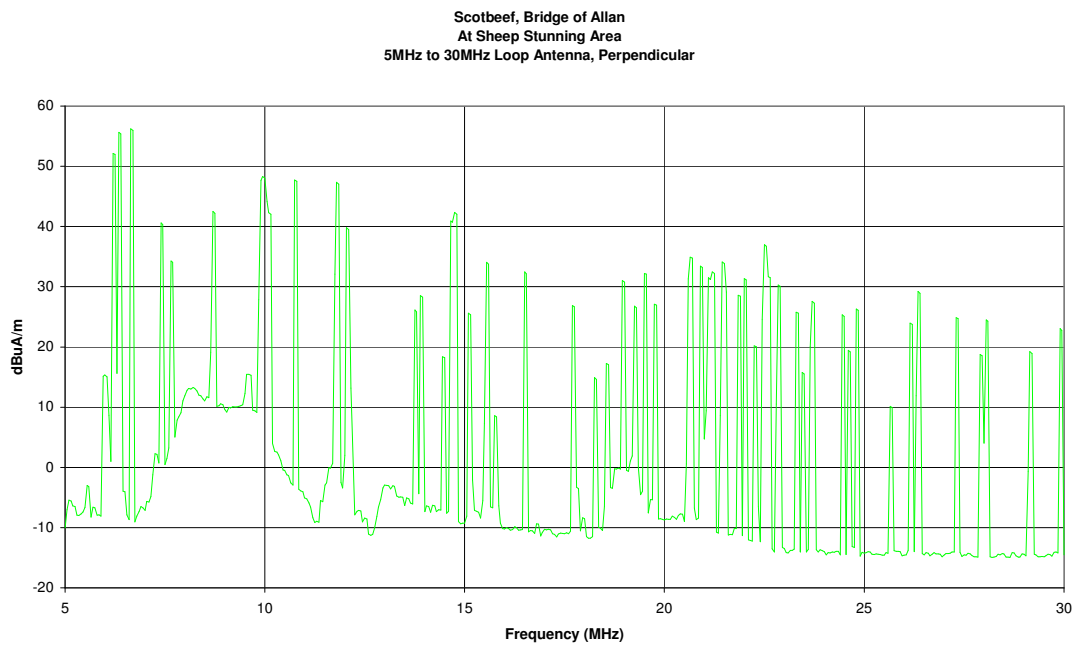


Figure 91 RF Measurement 5MHz to 30MHz, Perpendicular

The plots in Figure 90 and Figure 91 above show RF emissions that occurred during the operation of the stunning equipment, seen as the high peaks on the plots.

12.5.4.3 100kHz to 150kHz – Loop Antenna

Typical RFID systems intended for use in animal identification operate at 134kHz. The measurement frequency range was reduced to investigate local emissions around this frequency in greater detail.

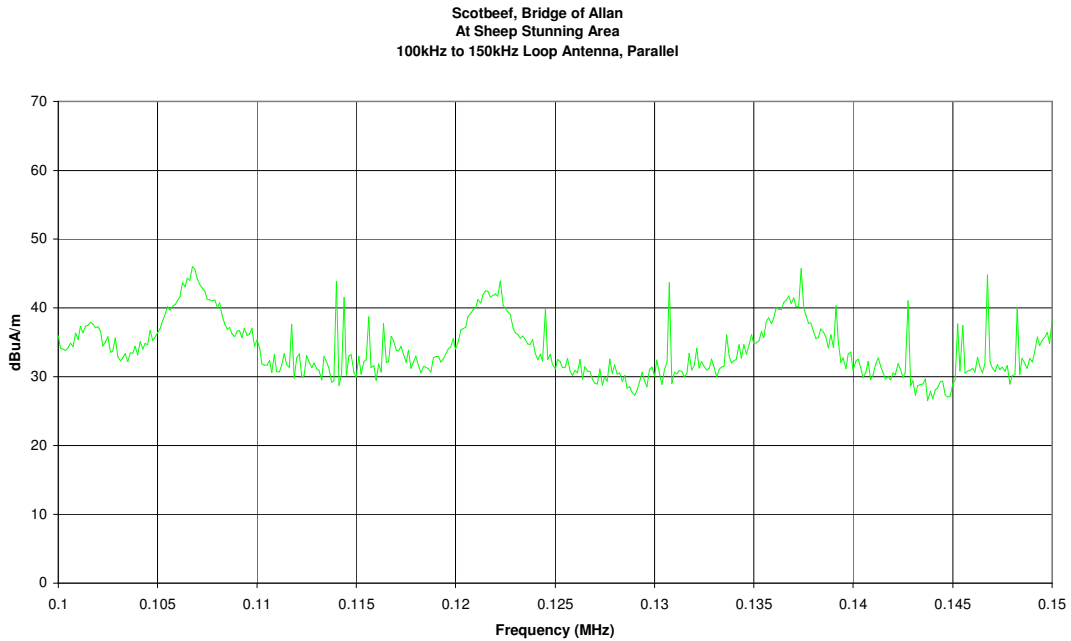


Figure 92 RF Measurement 100kHz to 150kHz, Parallel

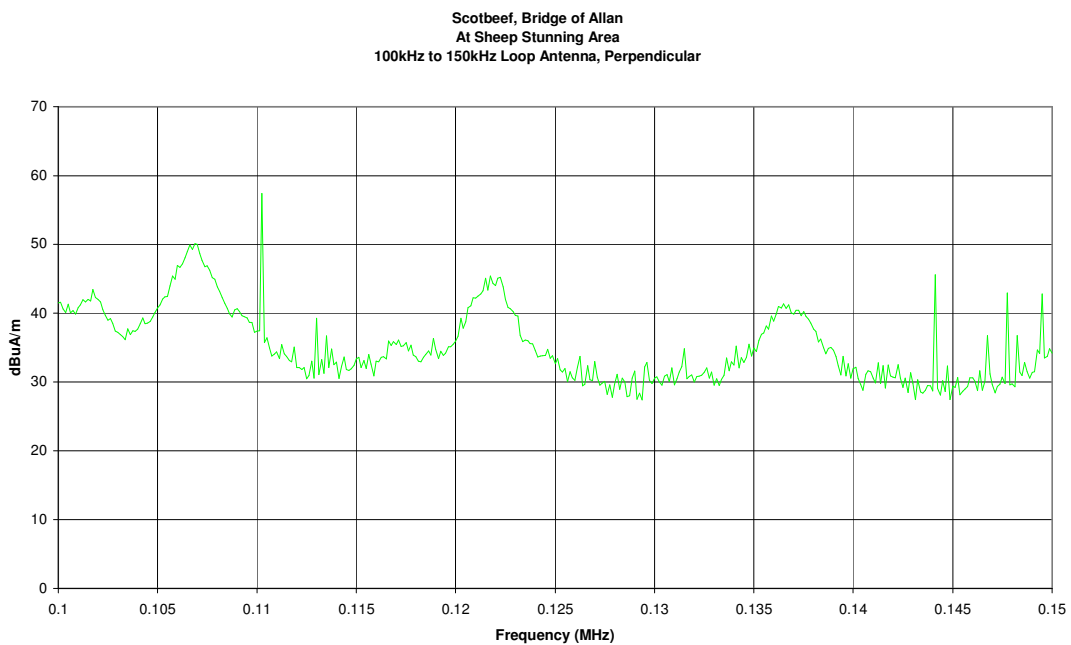


Figure 93 RF Measurement 100kHz to 150kHz, Perpendicular

The plots in Figure 92 and Figure 93 above show the harmonically related peaks related to the stunning equipment, with higher, short duration emissions during operation of the stunning.

12.5.4.4 30MHz to 1000MHz – Active Receive Antenna

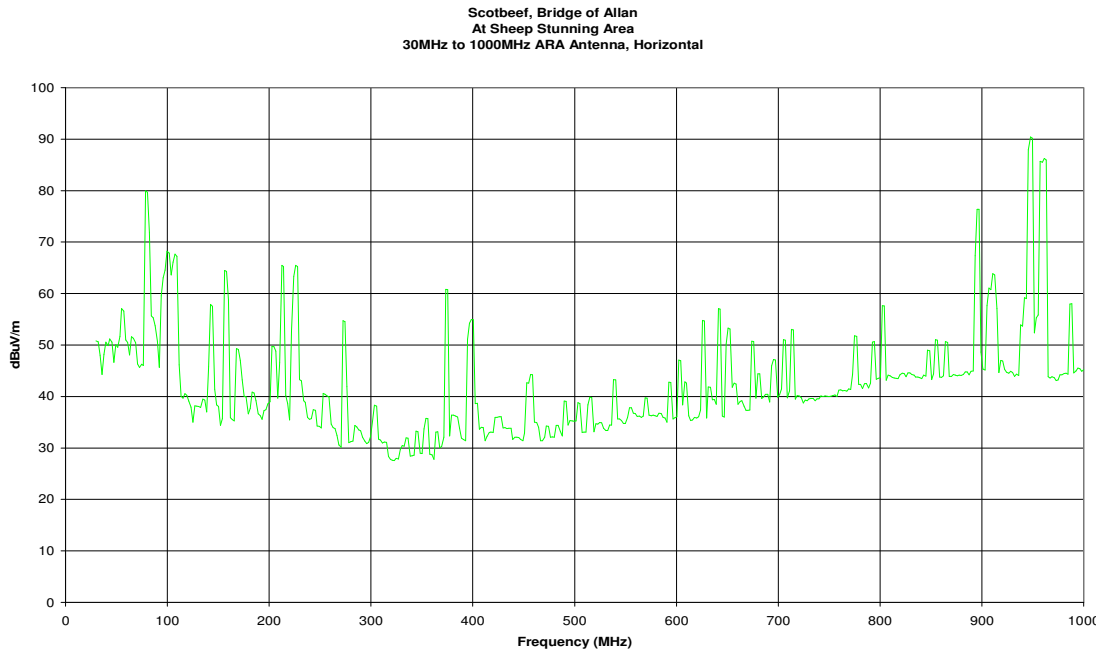


Figure 94 RF Measurement 30MHz to 1000MHz, Horizontal

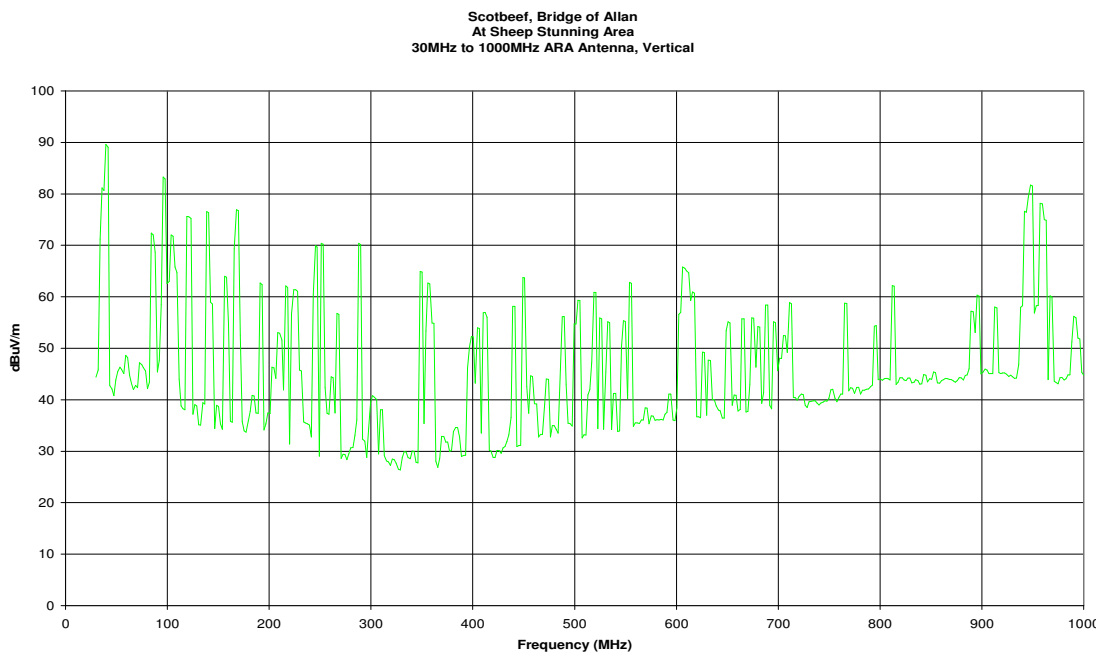


Figure 95 RF Measurement 30MHz to 1000MHz, Vertical

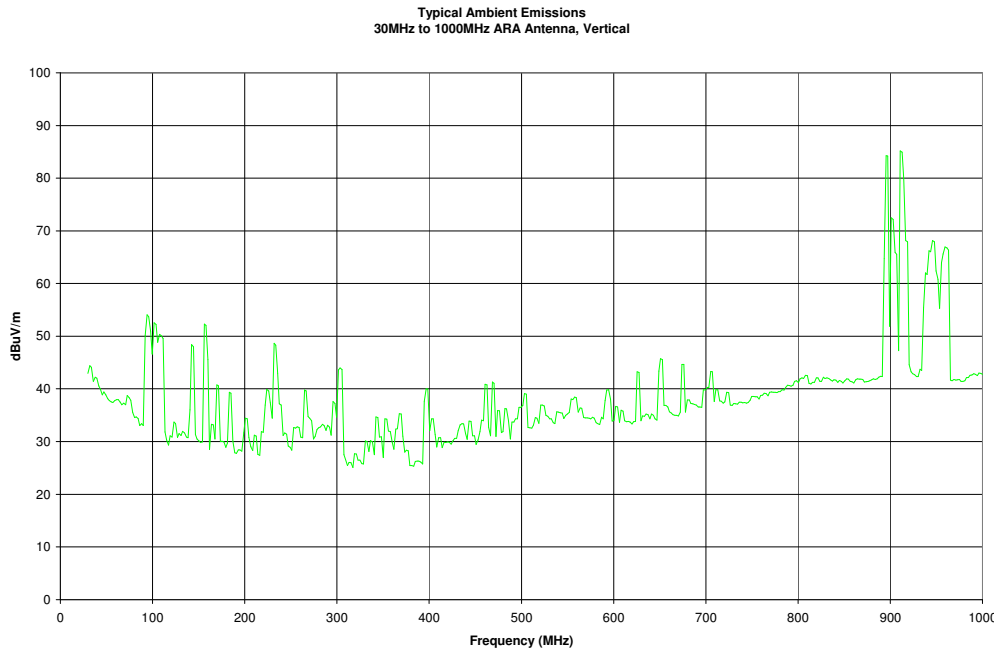


Figure 96 Typical RF Measurement 30MHz to 1000MHz, Vertical

The plots shown in Figure 94 and Figure 95 show emissions measured while the stunning system was in operation. This can be compared with Figure 96 above, showing typical levels of emissions normally seen.

In Figure 96, normal ambient transmissions are shown. For example;

| | |
|-------------------|-------------|
| FM radio | 88-108MHz |
| Mobile radios | 135-200MHz |
| Digital radio | 218-230MHz |
| Television | 400-750MHz |
| Mobile telephones | 900-1000MHz |

It can be seen from the plots that the stunning equipment produces high local levels of emissions.

12.5.5 Plots – Cattle stunning area

The plots presented are the levels of the 10 sweeps in each measurement range combined to show the maximum levels recorded.

See over.

12.5.5.1 9kHz to 30MHz – Loop Antenna

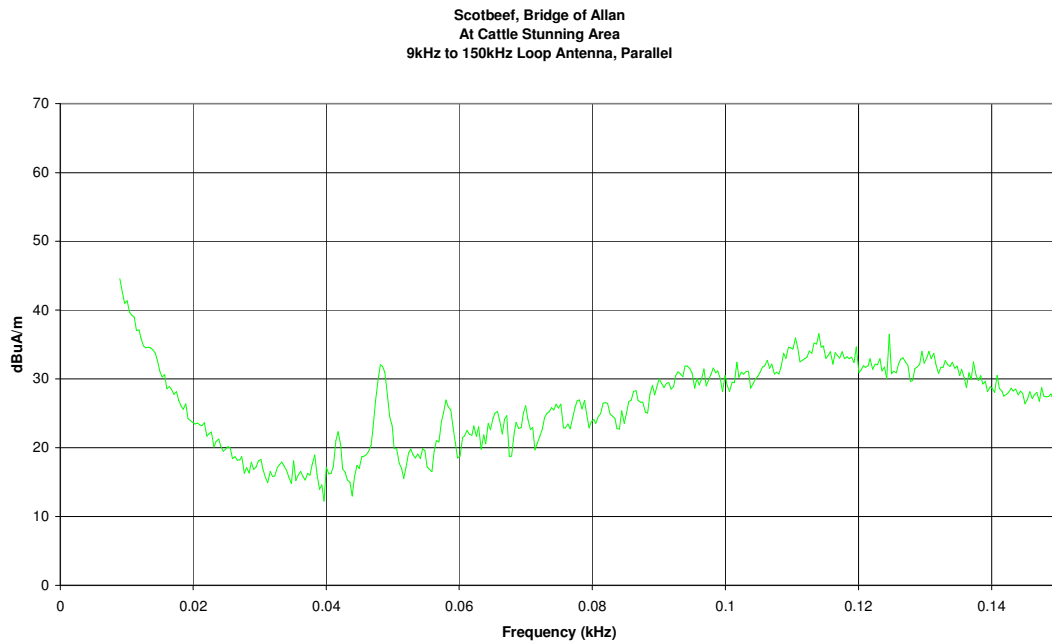


Figure 97 RF Measurement 9kHz to 150kHz, Parallel

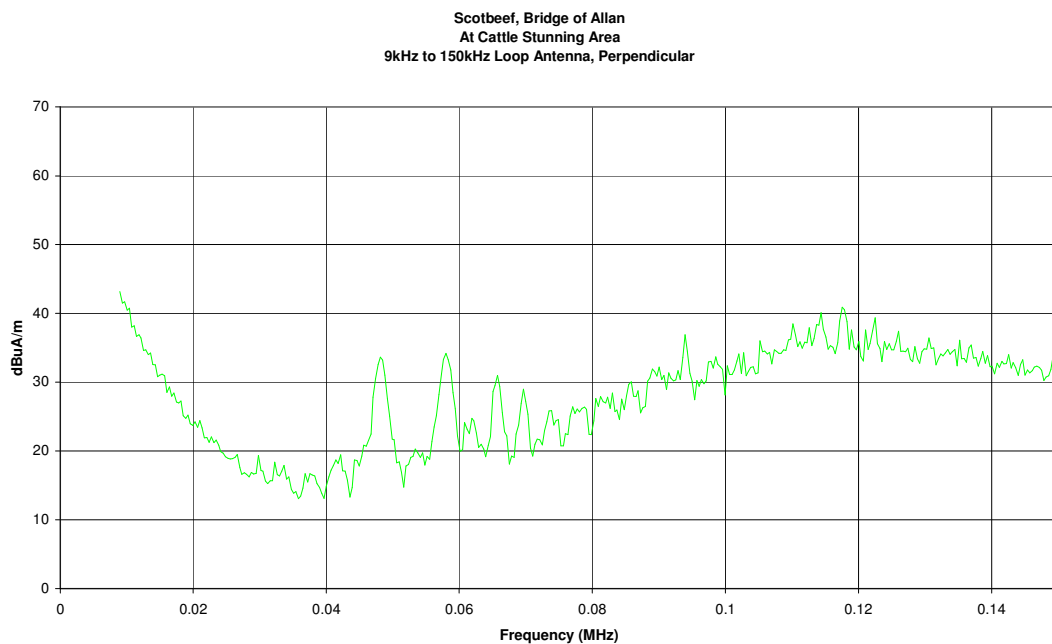


Figure 98 RF Measurement 9kHz to 150kHz, Perpendicular

The plots shown in Figure 97 and Figure 98 above show several peak emissions and an area of broadband emissions, likely being produced locally from equipment in use.

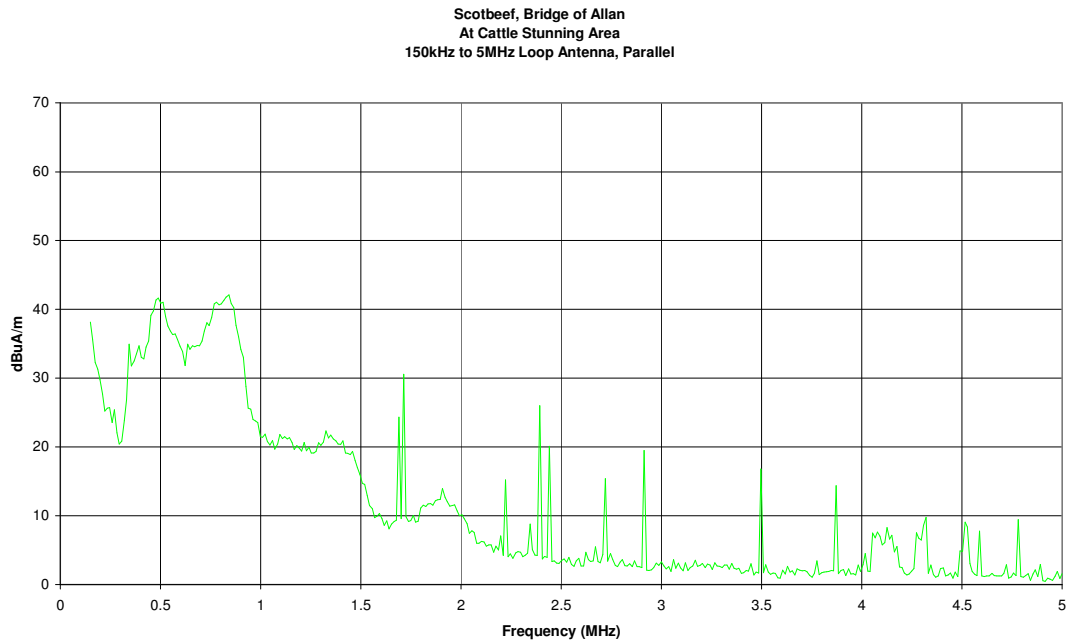


Figure 99 RF Measurement 150kHz to 5MHz, Parallel

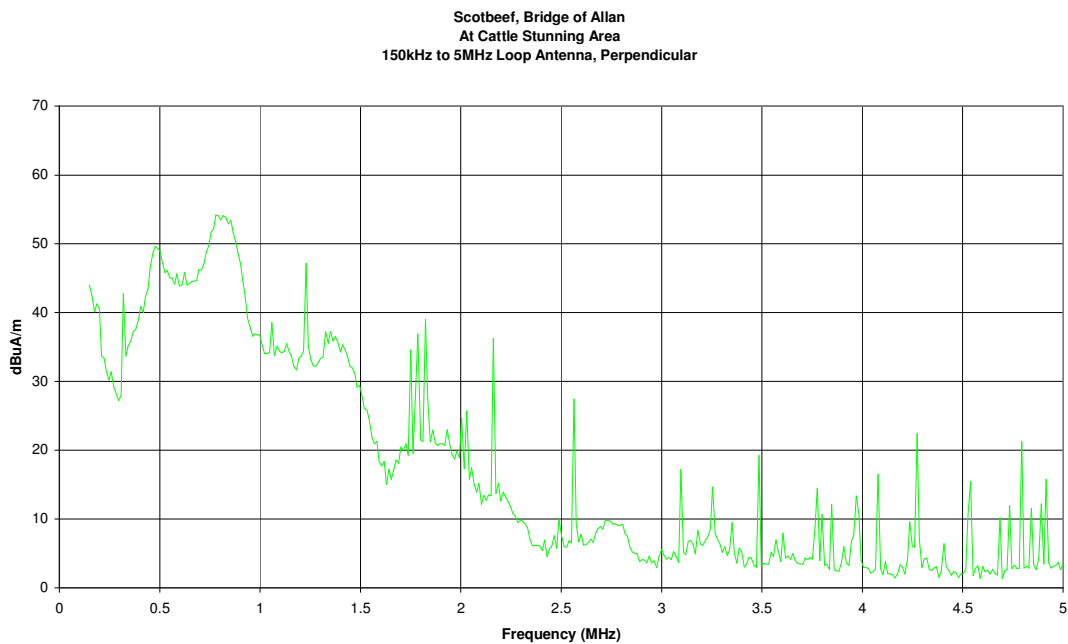


Figure 100 RF Measurement 150kHz to 5MHz, Perpendicular

The plots shown in Figure 99 and Figure 100 above show several peak emissions and an area of broadband emissions (500kHz to 1.5MHz). The broad emissions can be related to ambient radio broadcasts (AM radio allocation is 526.5kHz to 1.606MHz). Other peaks (1.5MHz to 2MHz) fall into the allocation frequencies for amateur services, land mobile radio (2.2MHz to 2.5MHz). Other peaks have frequencies related to similar services.

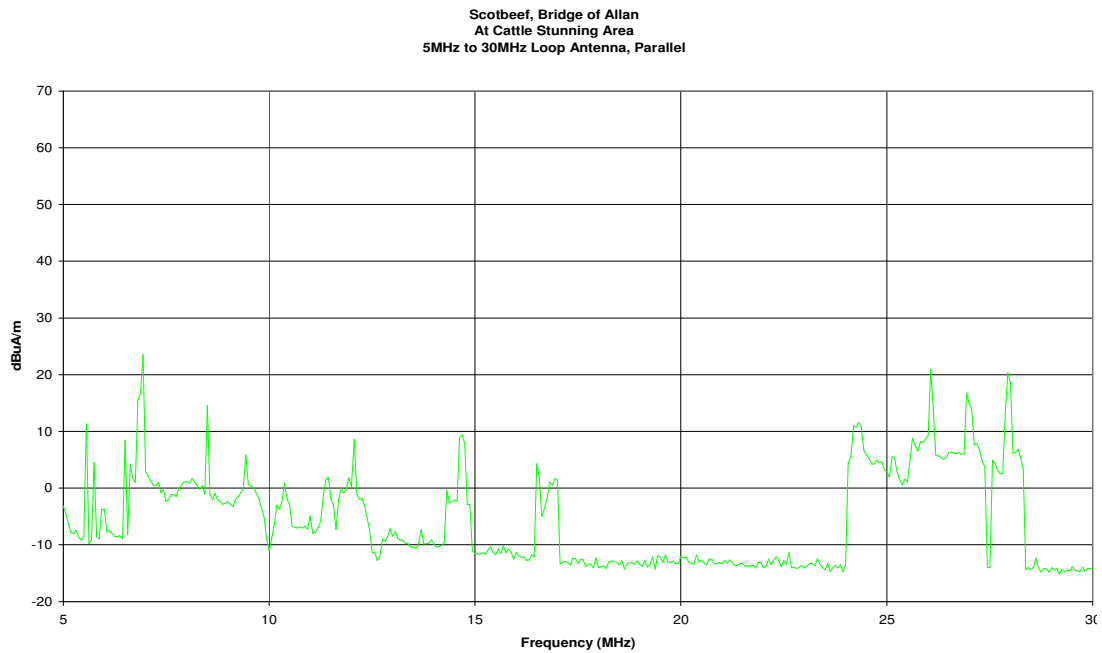


Figure 101 RF Measurement 5MHz to 30MHz, Parallel, measure 1

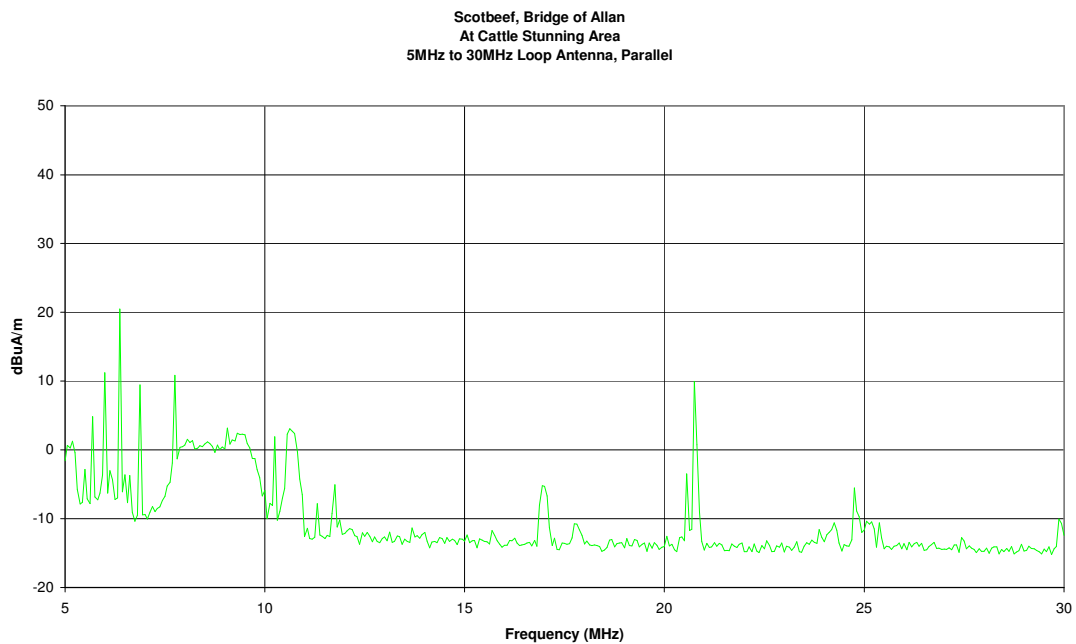


Figure 102 RF Measurement 5MHz to 30MHz, Parallel, measure 2

The plots shown in Figure 101 and Figure 102 above show emissions measured during operation, measurement 1, and during a break, measurement 2. Emissions caused by equipment operation can be seen in measurement 1 (24MHz to 28MHz).

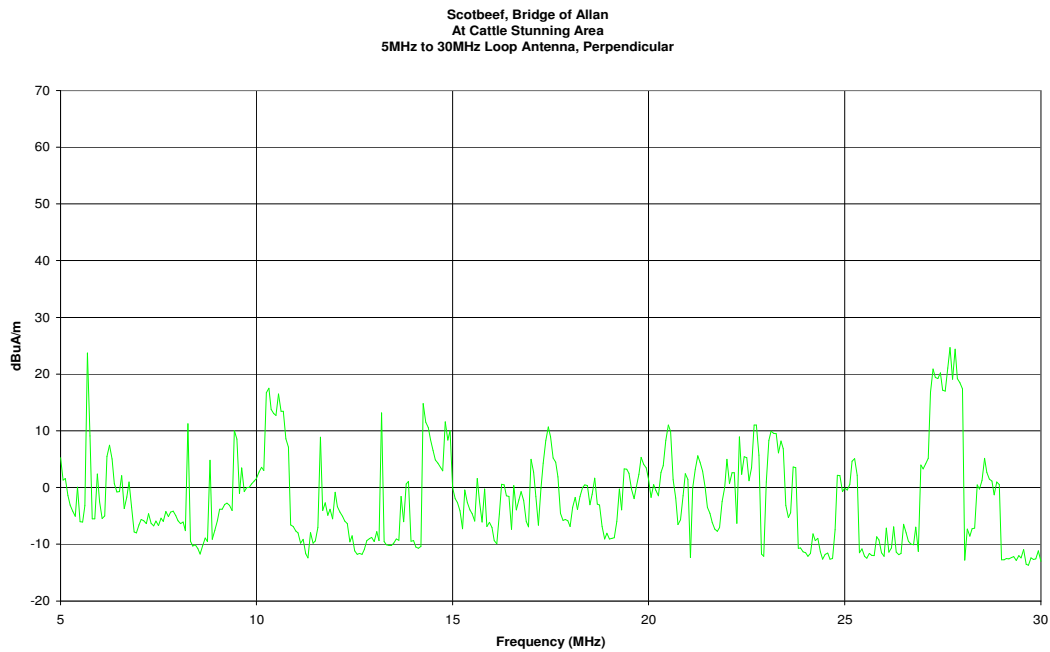


Figure 103 RF Measurement 5MHz to 30MHz, Perpendicular, measure 1

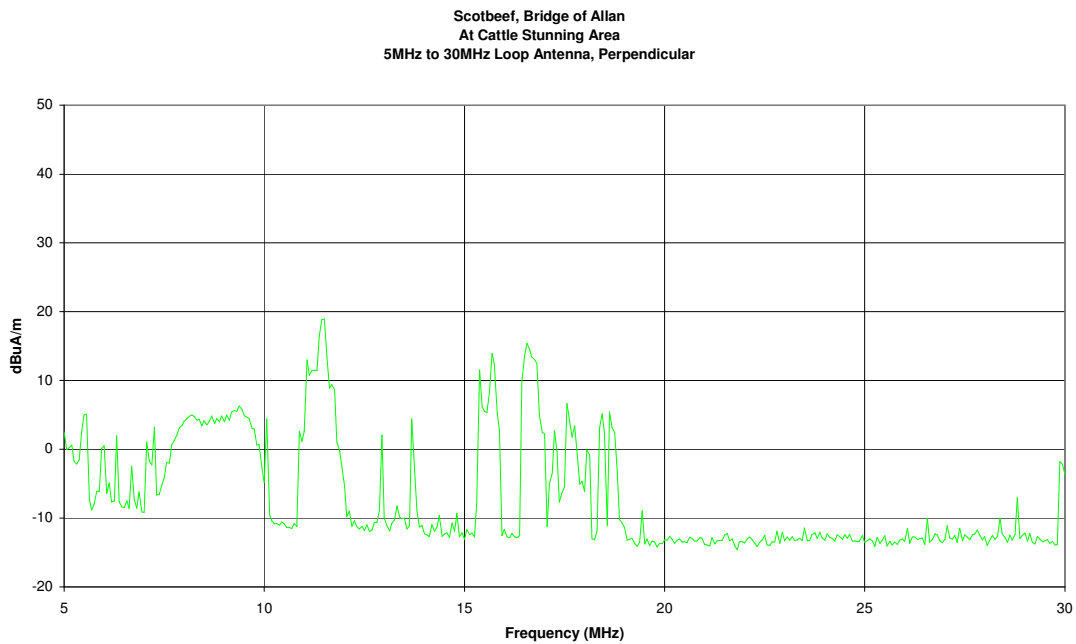


Figure 104 RF Measurement 5MHz to 30MHz, Perpendicular, measure 2

The plots shown in Figure 103 and Figure 104 above show emissions measured during operation, measurement 1, and during a break, measurement 2. Emissions caused by equipment operation can be seen in measurement 1 (27MHz to 28MHz), plus additional emissions across the range.

12.5.5.2 100kHz to 150kHz – Loop Antenna

The frequency range was narrowed down to cover the frequency of operation of the RFID system more closely.

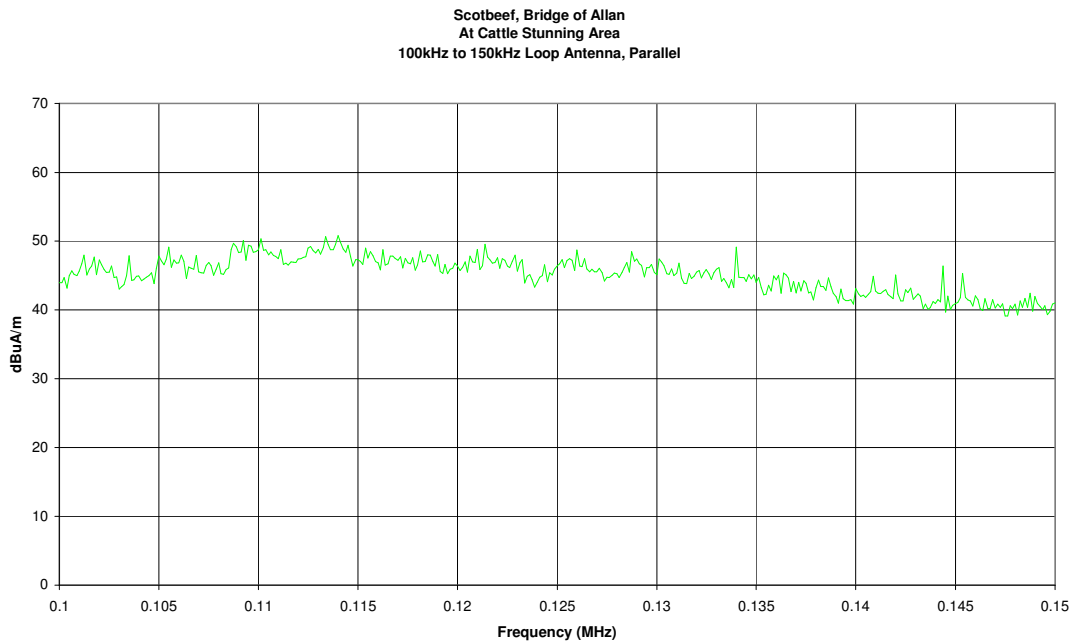


Figure 105 RF Measurement 100kHz to 150kHz, Parallel

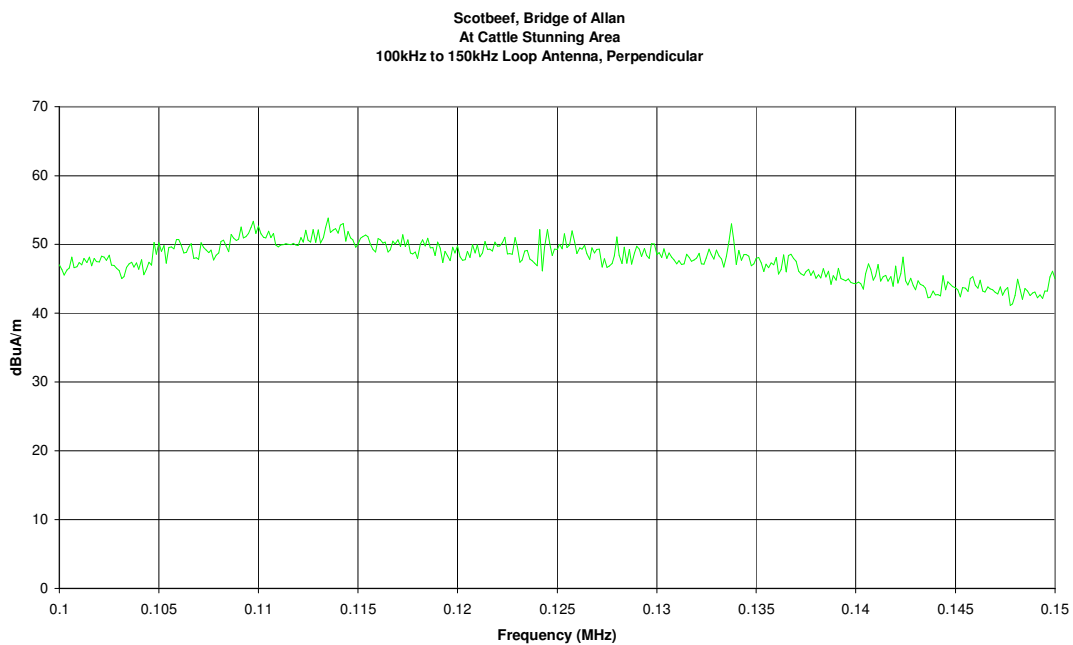


Figure 106 RF Measurement 100kHz to 150kHz, Perpendicular

The plots shown in Figure 105 and Figure 106 above show relatively high levels of broadband emissions noted around the typical frequency of operation of RFID equipment.

12.5.5.3 30MHz to 1000MHz – Active Receive Antenna

This range was chosen as the normal range used in typical EMC standards.

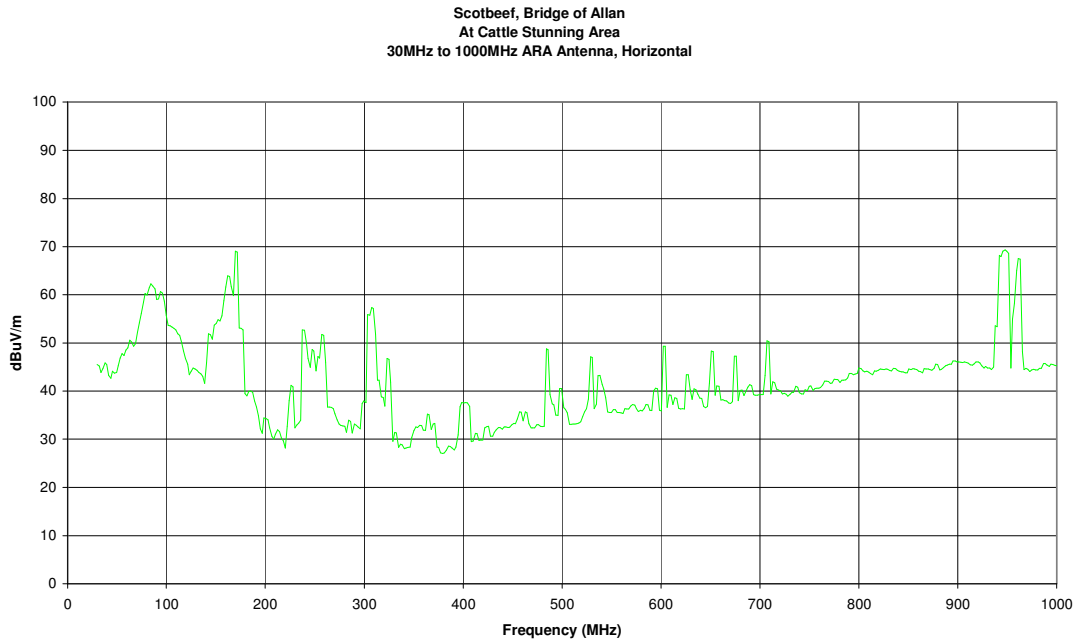


Figure 107 RF Measurement 30MHz to 1000MHz, Horizontal

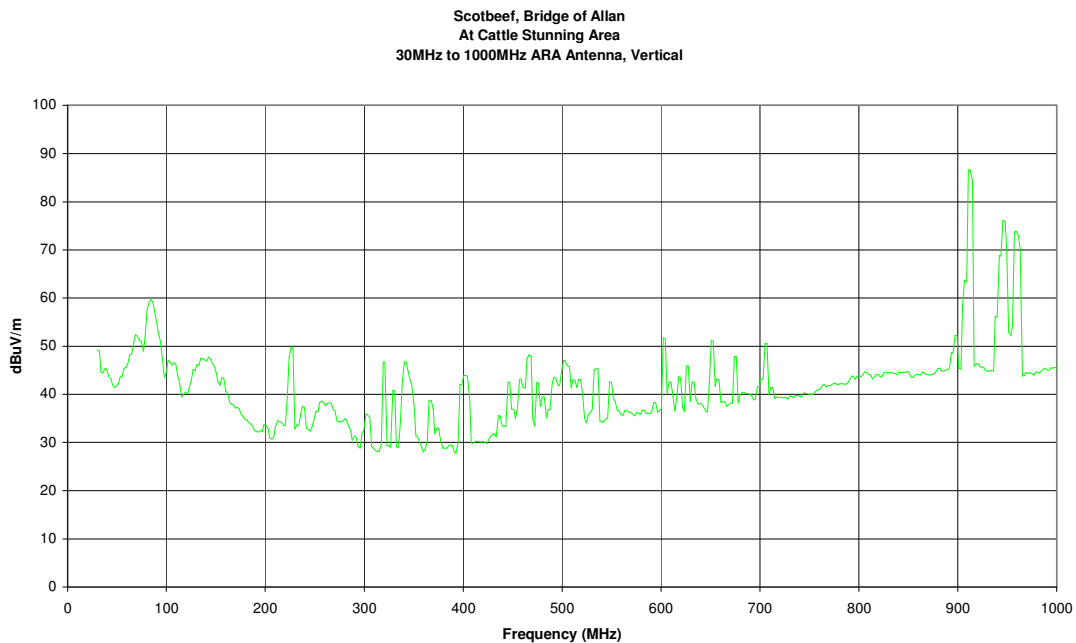


Figure 108 RF Measurement 30MHz to 1000MHz, Vertical

The plots shown in Figure 107 and Figure 108 above show, in general, typical levels of emissions expected in this frequency range related to normal radio (broadcasting and personal mobile radios), television, and mobile telephones.

13 Test Equipment Used

| Equipment | Manufacturer | Type |
|------------------------|-------------------|---------|
| Spectrum Analyser | Anritsu | MS2667C |
| Spectrum Analyser | Hewlett Packard | HP8594E |
| Current Clamp | Eaton | 93686-1 |
| Loop Antenna | ETS | 6511 |
| Loop Antenna | ETS | 6512 |
| Active Receive Antenna | York EMC Services | ARA 01 |

Table 16 List of Test Equipment Used

References

- ETSI EN 300 330-1 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 1 Technical characteristics and test methods
- ETSI EN 300 330-2 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 2 Harmonized EN under article 3.2 of the R&TTE Directive
- ETSI EN 301 489-1 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
- ETSI EN 301 489-3 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3 Specific conditions for short range radio devices (SRD) operating on frequencies between 9kHz and 40GHz.

Appendix D – Laboratory Test Report, EMC Test Centre

**Report on Laboratory
Measurements of RFID Equipment
at
York EMC Services Ltd
EMC Test Centre, Donibristle
Report (copy 1 of 3)
for
Scottish Executive Environment
and Rural Affairs Department
Contract FF/05/19**

Document number 2215TR1

Project number 7568

Author:

G. Whyte Senior Engineer

Checked:

B. Tait Principal Engineer, BSc, MIET

Approved:

B. Tait Principal Engineer, BSc, MIET

| Issue | Description | Issue by | Date |
|-------|-------------|----------|------------|
| 1 | First Issue | GW | 30/08/2006 |

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The results contained in this report are only applicable to the apparatus tested.

Executive Summary

This report details tests performed in support of the study commissioned by Scottish Executive Environment and Rural Affairs Department (SEERAD) to evaluate the effect of electromagnetic interference in transceivers (readers) used to identify animals electronically. The systems are normally known as Electronic Identification (EID) or RF Identification (RFID) systems.

As part of this project laboratory testing was performed on samples of RFID equipment designed for the purpose of tracking farm animals. The equipment was designed to meet the ISO 11784 and 11785 standards for tag reading. A sample of a fixed reader (panel antenna type) and a hand reader were tested. In the interests of commercial confidentiality the manufacturer is not identified.

This report details the tests performed at York EMC Services, EMC Test Centre, Donibristle. The equipment was tested with reference to the immunity requirements specified by ETSI EN 301 489-1 and ETSI EN 301 489-3. In addition, further radiated and conducted RF immunity tests were performed with the level and/or frequency ranges extended to examine the effects of RF interference outside of the normal requirements. The fixed panel reader was powered from the normal AC mains via an AC-DC power supply. No special filtering arrangements were made. The hand held reader was battery powered with either a serial or wireless connection to a PC.

The tests show that the fixed panel type reader can be particularly susceptible to conducted RF interference at frequencies below 200kHz and to radiated RF interference at higher levels between 80-200MHz. It must be expected that the equipment will be susceptible at frequencies close to the operating frequency (134kHz) since it is designed to operate at very low signal levels in this frequency range. At the radiated RF frequencies, system cabling is a primary mode of coupling RF interference into a system, and the panel antenna and cables provide a route for the interference.

The hand held reader does not require conducted RF immunity testing since it has no external power or cabling other than the serial link, if used. Since this is less than 3m in length, the standards do not require it to be tested. It did not show susceptibilities under radiated RF testing.

For use in an environment where there are significant EMI threats, the fixed panel readers are likely to require careful installation and possibly mitigating measures to ensure correct operation. Mitigating measures can take the form of filtering, screening, or positioning of the equipment and cabling. Systems should also, as part of normal manufacture, meet the standards required by the EU for EMC.

This test report forms part of the overall report (2211CR1) that will contain a more in-depth analysis of the results and a draft Guidelines for Build and Installation that is intended to give some guidelines on installations to minimise the effects of EMI.

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Report Change History

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| 1 | Original issue of report |
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Acknowledgements

York EMC Services Ltd would like to thank the following people for their help and assistance during this study

The manufacturers of the RFID equipment who kindly let us borrow it for the duration of the test. Since this report may contain data that is commercially sensitive, they wished to remain anonymous.

List of Terms and Abbreviations

| | |
|--------|---|
| AC | Alternating Current |
| ARA | Active Receive Antenna |
| CDN | Coupling/Decoupling Network |
| CISPR | Comité International Spécial des Perturbations Radioélectriques |
| DC | Direct Current |
| EFT/B | Electrical Fast Transient/Bursts |
| EID | Electronic Identification |
| EMC | ElectroMagnetic Compatibility |
| EMI | ElectroMagnetic Interference |
| EN | European Norm |
| ESD | Electro Static Discharge |
| ETSI | European Telecommunications Standards Institute |
| EU | European Union |
| EUT | Equipment Under Test |
| FDX | Full Duplex |
| HCP | Horizontal Coupling Plane |
| HDX | Half Duplex |
| IT | Information Technology |
| PC | Personal Computer |
| RAM | Radio Absorbent Material |
| RF | Radio Frequency |
| RFID | Radio Frequency Identification |
| SAOS | Scottish Agricultural Organisation Society |
| SEERAD | Scottish Executive Environment and Rural Affairs Department |
| SRD | Short range Radio Device |
| VCP | Vertical Coupling Plane |
| YES | York EMC Services Ltd |

14 Introduction

14.1 Test Location

The tests were performed at;

York EMC Services Ltd
EMC Test Centre
Fleming Building
Donibristle Industrial Park
Dunfermline
Fife
KY11 9HZ

14.2 Referenced Standards

EID/RFID equipment falls under the description of a short range radio device and therefore into the scope of the following standards.

- | | |
|-------------------|--|
| ETSI EN 300 330-1 | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 1 Technical characteristics and test methods |
| ETSI EN 300 330-2 | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 2 Harmonized EN under article 3.2 of the R&TTE Directive |

These standards specify the characteristics and performance of the transmitter/receiver with respect to field strength, power, etc.

However, the relevant standards applicable to the EMC tests are referenced by;

- | | |
|-------------------|---|
| ETSI EN 301 489-1 | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements This gives the general EMC tests applicable to all devices. |
| ETSI EN 301 489-3 | Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3 Specific conditions for short range radio devices (SRD) operating on frequencies between 9kHz and 40GHz. This gives specific requirements and allowances for SRDs. |

These standards refer to the specific requirements for equipment operation. During site investigations of ambient conditions, the ranges used in these standards will be referred to.

15 Testing

15.1 Equipment tested

Testing was performed on 2 different types of reader.

- Type 1 Fixed panel antenna reader, powered from 230V AC mains via an AC-DC supply. It can also be powered directly from 12V DC. Data would be transferred directly to a PC. For radiated immunity testing, two sizes of panel antenna were tested: large panel, 125cm x 70cm loop, and small panel, 70cm x 70cm (sizes are approximate). The other parts of the system are identical.
- These readers are designed for detecting tags as the animals, guided through a race, pass the antenna panel. They have a typical read range of around 1m.
- The panel readers continuously read the tag and an LED flashes and 'beeper' sounds for a good read. Other LEDs indicate power on and that the antenna was being powered, producing the magnetic field used to interrogate the tag.
- Both types of tag specified by ISO 1784 and 11785, half duplex and full duplex (HDX and FDX) can be read.
- Type 2 Hand held 'stick' reader. Internal battery powered, a built in display shows the tag information that is read. This data can be stored in the reader for transfer later, or transferred directly to a PC. Data can be transferred either via a wireless link or a serial cable.
- These readers are typically used for checking tags in fields or pens where it is impractical to use a panel reader.
- An LED shows when the antenna magnetic field is powered; the display shows tag number and type (HDX or FDX).

15.2 Test procedures and results

Immunity testing is specified in EN 301 489-1 and refers to the EN61000-4 –X series of standards which form the basis of most immunity testing.

15.2.1 Radiated RF immunity

The standard referenced in EN 301 489-1 is EN61000-4-3 with levels;

| | |
|--------------------|--|
| Level: | 3V/m, antenna in both horizontal and vertical orientations |
| Frequency range: | 80-1000MHz and 1400-2000MHz |
| Signal modulation: | Amplitude modulation, sinusoidal, 80% depth, 1kHz |
| Sweep rate: | Stepped at 1% of the used frequency |
| Dwell time: | The dwell time at each frequency is typically 3 seconds to allow the equipment under test (EUT) to react to the disturbance. |

15.2.1.1 Test setup

At the Donibristle laboratory, the test is performed in a semi-anechoic chamber lined with a combination of ferrite tiles and Radio Absorbent Material (RAM) to minimise any reflection within the chamber allowing a plane field to be produced. The field is produced by an antenna within the chamber; an X-Wing type for frequencies between 80-1000MHz and Double Ridged Horn type for frequencies between 1400-2000MHz. Adjoining the main chamber is a control room where the control and RF amplification equipment is situated.

For tests in accordance with EN61000-4-3, the power required to produce the field is pre-calibrated in order to maintain a uniform field. For the chamber at the EMC Test Centre this is;

| | |
|--------------|--|
| 80-1000MHz | The uniform field is at a distance of 3m from the antenna (X-Wing) across the frequency range. |
| 1400-2000MHz | The uniform field is at a distance of 1.5m from the antenna (Double ridged horn) across the frequency range. |

As an indication that a field is present during the tests, a field probe is placed close to the EUT to monitor the field intensity at that point.

A plan diagram of the chamber layout is shown in Figure 109 and a photograph of the chamber (showing the antennae and RAM) is shown in Photo 5.

Note in the plan view that the orientation of the antennae with the EUT is offset from the centre line of the room. This is to reduce the possibility of reflections within the room causing resonances at certain frequencies.

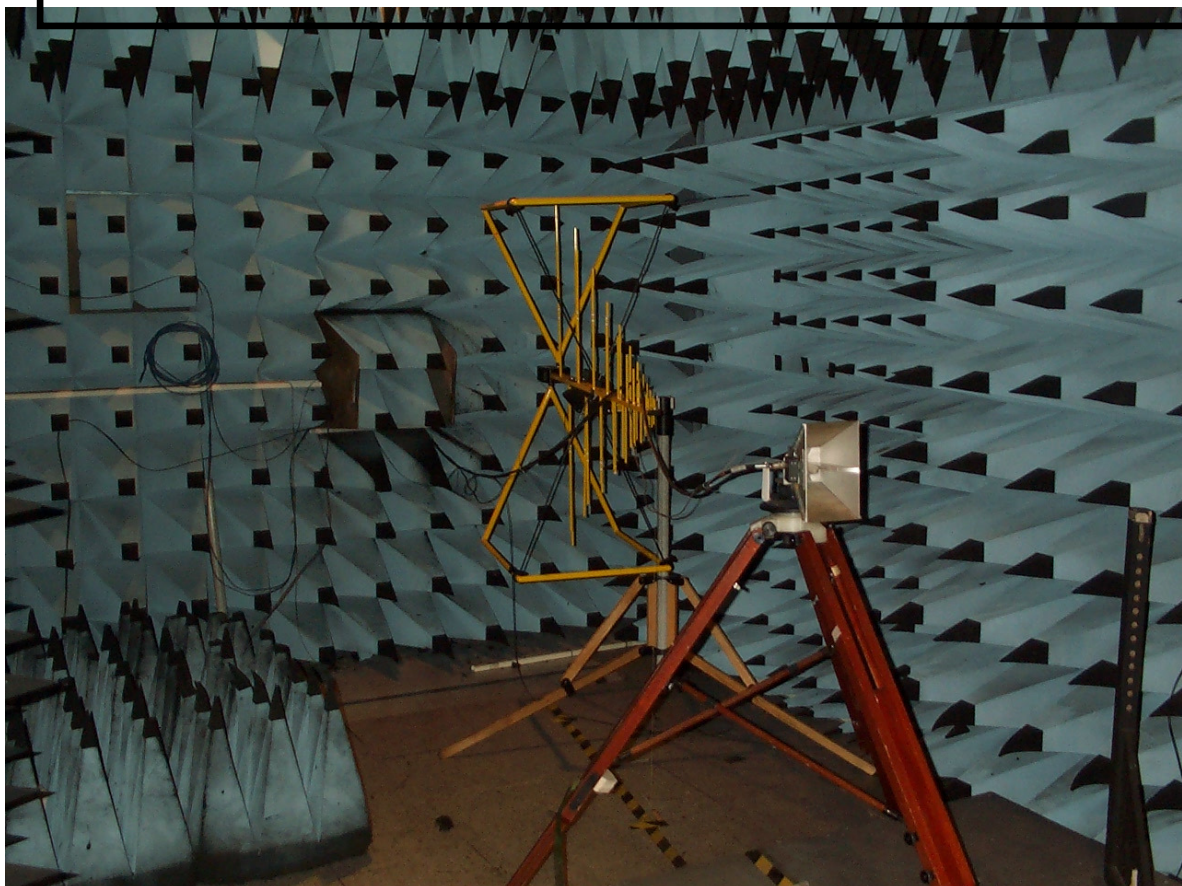
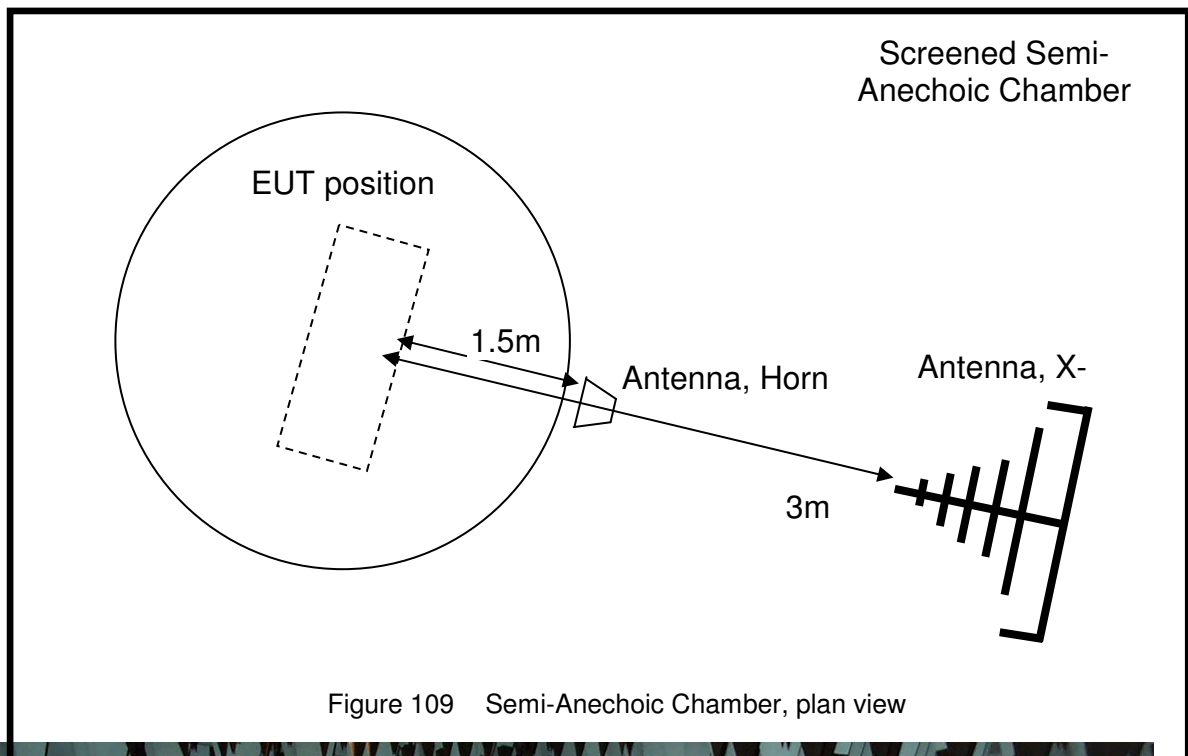


Photo 5. Semi anechoic chamber

15.2.1.2 EUT setup – panel reader

15.2.1.2.1 Large panel with HDX tag

The panel reader was set up in the chamber at a distance of 3m from the antenna in the range 80-1000MHz or 1.5m for the range 1400-2000MHz. A tag (half duplex, HDX, type) set at a position 1m from the mid point of the panel and orientated to give maximum coupling. From the visits to the marts and abattoir, this was estimated as a typical maximum distance requirement. It was within the maximum range of the reader which ranged up to approximately 1.5m depending on orientation and position with respect to the panel.

15.2.1.2.2 Large panel with FDX tag

The HDX tag was replaced with a full duplex, FDX, type. The maximum read distance for this type of tag seemed less than that of the HDX tag (approximately 0.8-1m depending on position and orientation), and it was set at a position 0.4m from the mid point of the panel and orientated to give maximum coupling.

15.2.1.2.3 Small panel with HDX tag

The panel reader was set up in the chamber at a distance of 3m from the antenna in the range 80-1000MHz or 1.5m for the range 1400-2000MHz. A tag (half duplex, HDX, type) set at a position 1m from the mid point of the panel and orientated to give maximum coupling. From the visits to the marts and abattoir, this was estimated as a typical maximum distance requirement. It was within the maximum range of the reader which ranged up to approximately 1.5m depending on orientation and position with respect to the panel.

This test was only performed with the HDX type tag.

15.2.1.2.4 Stick reader with HDX tag

The reader was placed on a wooden table at a distance of 3m from the antenna in the range 80-1000MHz or 1.5m for the range 1400-2000MHz. The stick reader requires that the tag is in close proximity to the antenna part and an HDX tag was used at distance of 1-2cm from the end of the antenna part of the stick reader.

15.2.1.2.5 Stick reader with FDX tag

The reader was placed on a wooden table at a distance of 3m from the antenna in the range 80-1000MHz or 1m for the range 1400-2000MHz. The stick reader requires that the tag is in close proximity to the antenna part and an FDX tag was used at distance of 1-2cm from the end of the antenna part of the stick reader.

15.2.1.3 Results

The results for the standard levels of test 80-1000MHz, 1400-2000MHz, 3V/m are presented in Table 17 below;

| Frequency MHz | Field Strength V/m | Antenna Polarity Horiz/Vert | Effect Witnessed |
|----------------------------------|-----------------------------------|--|---|
| Large panel with HDX tag | | | |
| 80-1000 | 3 | Horiz | No effects noted |
| | | Vert | No effects noted |
| 1400-2000 | 3 | Horiz | No effects noted |
| | | Vert | No effects noted |
| Large panel with FDX tag | | | |
| 80-1000 | 3 | Horiz | Tag read was slightly intermittent 80-115MHz |
| | | Vert | Tag read was slightly intermittent 80-115MHz |
| 1400-2000 | 3 | Horiz | No effects noted |
| | | Vert | No effects noted |
| Small panel with HDX tag | | | |
| 80-1000 | 3 | Horiz | Tag read was slightly intermittent 113-128MHz |
| | | Vert | No tag read was indicated 80-101MHz |
| 1400-2000 | 3 | Horiz | No effects noted |
| | | Vert | No effects noted |
| Stick reader with HDX tag | | | |
| 80-1000 | 3 | Horiz | No effects noted |
| | | Vert | No effects noted |
| 1400-2000 | 3 | Horiz | No effects noted |
| | | Vert | No effects noted |
| Stick reader with FDX tag | | | |
| 80-1000 | 3 | Horiz | No effects noted |
| | | Vert | No effects noted |
| 1400-2000 | 3 | Horiz | No effects noted |
| | | Vert | No effects noted |

Table 17 Radiated RF immunity results, 3V/m

15.2.1.4 Extended tests

The applied level of field was then increased to 10V/m. EN61000-4-3 specifies levels in the order 1V/m, 3V/m, 10V/m, other.

The EUT setup was the same as the 3V/m tests. The results are shown in Table 18

| Frequency MHz | Field V/m | Antenna Pol Horiz/Vert | Effect Witnessed |
|----------------------------------|--------------|------------------------------|--|
| Large panel with HDX tag | | | |
| 80-1000 | 10 | Horiz | Tag read intermittent between 80-95MHz No tag read between 200-220MHz Threshold of effect was approximately 7V/m |
| | | Vert | No tag read between 80-95MHz, effect starts to decrease until normal operation resumes at 135MHz No tag read between 400-420MHz Threshold of effect was approximately 4.5V/m |
| 1400-2000 | 10 | Horiz | No effects noted |
| | | Vert | No effects noted |
| Large panel with FDX tag | | | |
| 80-1000 | 10 | Horiz | No tag read between 80-148MHz No tag read between 200-230MHz Threshold of effect was approximately 3.5V/m |
| | | Vert | No tag read between 80-170MHz, Between 170-190MHz intermittent tag read No tag read between 190-210MHz Threshold of effect was approximately 3.5V/m |
| 1400-2000 | 10 | Horiz | No effects noted |
| | | Vert | No effects noted |
| Small panel with HDX tag | | | |
| 80-1000 | 10 | Horiz | Intermittent tag read 80-130MHz and 150-160MHz Threshold of effect was approximately 3.5V/m |
| | | Vert | No tag read between 80-130MHz Threshold of effect was approximately 3.5V/m |
| 1400-2000 | 10 | Horiz | No effects noted |
| | | Vert | No effects noted |
| Stick reader with HDX tag | | | |
| 80-1000 | 10 | Horiz | No effects noted |
| | | Vert | No effects noted |
| 1400-2000 | 10 | Horiz | No effects noted |
| | | Vert | No effects noted |
| Stick reader with FDX tag | | | |
| 80-1000 | 10 | Horiz | No effects noted |

| | | | |
|-----------|----|-------|------------------|
| | | Vert | No effects noted |
| 1400-2000 | 10 | Horiz | No effects noted |
| | | Vert | No effects noted |

Table 18 Radiated RF immunity results, 10V/m

15.2.1.5 Comment on results

At the level required by the standard, 3V/m, the panel reader EUTs did show some effects;

- i) Large panel reading FDX tag, intermittent tag read 80-115MHz
- ii) Small panel reading HDX tag, no tag read 80-101MHz

These effects would need to be rectified for full compliance to the requirements of the standard.

There was a slight difference in construction between the large panel reader and the small panel reader in that the large panel had the exciter/control module attached to the panel itself and connected via a short cable, while on the small panel reader it was separate and attached via a long cable. This extra length of cable is the most likely cause of the reduction in immunity of the reader.

Increasing the field showed marked effects on the panel readers with tag reading being inhibited totally over some frequency ranges.

The threshold of the effect was measured at a minimum of 3.5V/m, which is only slightly above the level of compliance. This could be of some concern where the equipment is installed in areas of significant RF interference.

No effects were noted for the stick reader.

15.2.2 Conducted RF immunity

The standard referenced in EN 301 489-1 is EN61000-4-6 with levels;

| | |
|--------------------|--|
| Level: | 3Vrms |
| Frequency range: | 0.15-80MHz |
| Signal modulation: | Amplitude modulation, sinusoidal, 80% depth, 1kHz |
| Sweep rate: | Stepped at 1% of the used frequency |
| Dwell time: | The dwell time at each frequency is typically 3 seconds to allow the equipment under test (EUT) to react to the disturbance. If the EUT's reaction time is slower than this, the dwell time should be increased. |

15.2.2.1 Test setup

The test is performed in a screened chamber. The disturbance can be applied in three ways;

1. Via a coupling/decoupling network (CDN). Preferred method, and normally used for injection onto power cables, AC or DC.
2. Via an Electromagnetic clamp. Used on cables (typically signal cables) where there is no specific CDN or a CDN cannot be fitted. Preferred over the current clamp.
3. Via a current injection clamp. Used on cables (typically signal cables) where there is no specific CDN or a CDN cannot be fitted.

For tests in accordance with EN61000-4-6, the power required to produce the disturbance is pre-calibrated in order to maintain a constant level for the standard impedance of 150Ω. For injection using either the electromagnetic or current clamps, the impedance of the equipment can change dependant on the frequency of injection and this can affect the disturbance level. Changes in this impedance over the frequency range can cause higher than specified disturbance levels to be injected onto the cables. For clamp injection therefore, a monitoring clamp is used to between the injection clamp and the EUT to measure the injection level applied. This level is fed back to the application software which adjusts the level of signal applied to reduce the disturbance, ensuring that the level does not exceed that specified.

Tests are performed on a copper ground plane with the EUT separated from it by 10cm wooden spacers and cables by 5cm (or less) wooden spacers.

Examples of various setups are shown in Photo 6 to Photo 8.

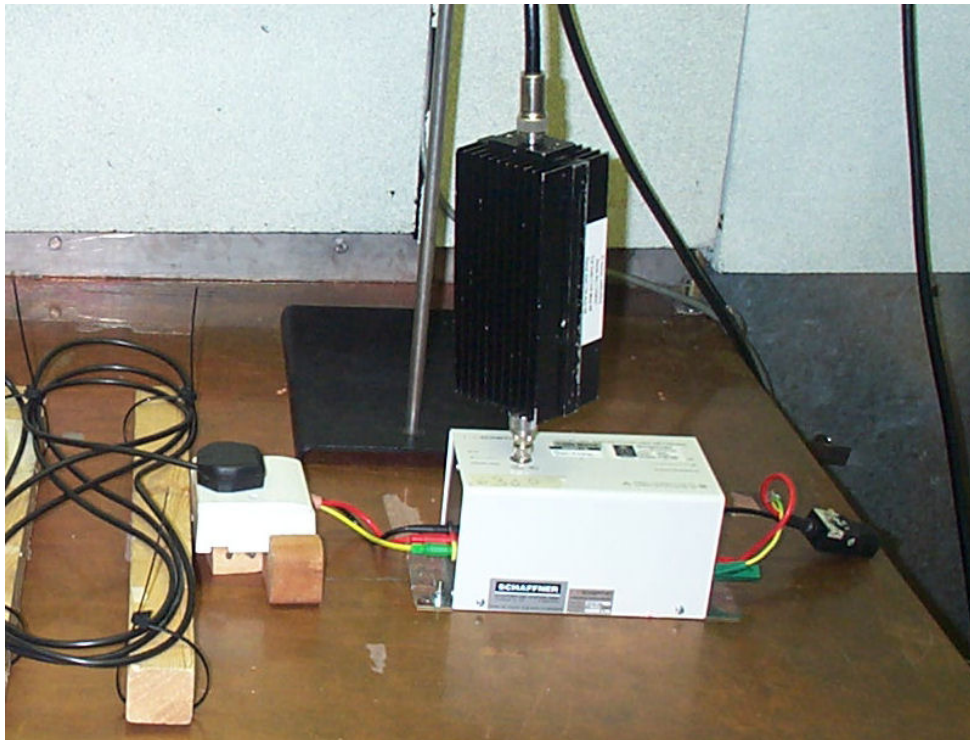


Photo 6. Disturbance injection via CDN



Photo 7. Disturbance injection via electromagnetic clamp

Note the monitoring clamp at the left hand end

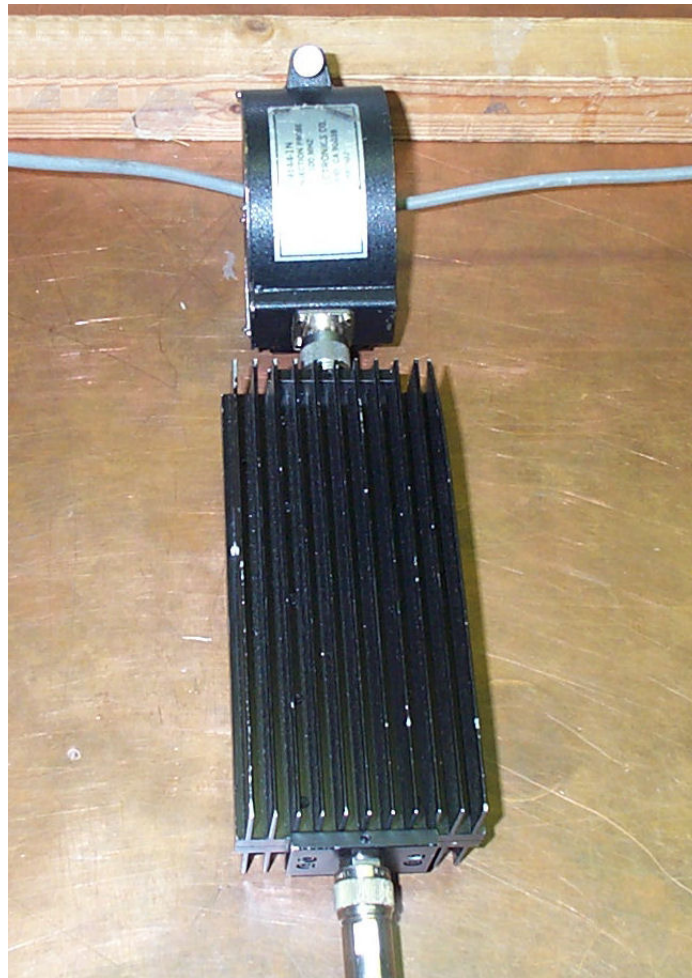


Photo 8. Disturbance injection via current clamp

Note that in all cases the RF signal is passed through a 6dB attenuator. This improves the impedance matching of the RF amplifier and the injection devices giving a more stable level across the frequency range.

15.2.2.2 EUT setup

This test only applies to the fixed panel readers. The stick reader has no power cables and the serial cable (if used) is less than the 3m minimum required for test.

Since the component parts of the panel antenna system are the same only the small panel reader was tested. This also allowed access to the cable between the exciter unit and the panel antenna for injection of the RF disturbance. This can be considered a worst case set up.

An HDX tag mounted at 0.2m from the panel antenna was used to initiate the read.

15.2.2.2.1 RF injection to the AC mains

The panel reader was set up in accordance with the standard requirements. The RF disturbance was applied to the mains power lines via a CDN (M3 type) over the frequency range 0.15-80MHz.

The test was also repeated using the current clamp to compare results.

15.2.2.2.2 RF injection to the DC line

The disturbance was applied to the DC line via a CDN (M2 type) over the frequency range 0.15-80MHz.
 The test was also repeated using the electromagnetic and current clamps to compare results.

15.2.2.2.3 RF injection to the exciter to panel cable

The disturbance was applied to the panel cable via an electromagnetic clamp over the frequency range 0.15-80MHz.
 The test was also repeated using the current clamp to compare results.

15.2.2.3 Results

The results for the standard levels of test 0.15-80MHz, 3Vrms are presented in Table 19.

| Frequency MHz | Field Strength Vrms | Line tested | Coupling method | Effect Witnessed |
|---------------|---------------------|-------------|-----------------|-----------------------------------|
| 0.15-80 | 3 | AC mains | CDN | No tag read between 0.15-0.195MHz |
| | 3 | AC mains | Current clamp | No tag read between 0.15-0.18MHz |
| 0.15-80 | 3 | DC input | CDN | No tag read between 0.15-0.23MHz |
| | 3 | DC input | EM clamp | No tag read between 0.15-0.23MHz |
| | 3 | DC input | Current clamp | No tag read between 0.15-0.19MHz |
| 0.15-80 | 3 | Panel cable | EM clamp | No effects noted |
| | 3 | Panel cable | Current clamp | No effects noted |

Table 19 Conducted RF immunity results, 3V rms

15.2.2.4 Extended tests

For conducted RF immunity the applied disturbance was varied in two ways;

- i) Frequency range
 This was increased to the limits of the CDN or clamp used;
 CDN: 50kHz to 100MHz
 EM Clamp: 100kHz to 100MHz
 Current clamp: 10kHz to 100MHz

ii) Level

The applied level of field was increased to 10V rms. EN61000-4-6 specifies levels in the order 1V, 3V, 10V, other (where 'other' can be specified by the manufacturer if higher levels are required).

The results for extended frequency ranges are shown in Table 20.

| Frequency MHz | Field Strength Vrms | Line tested | Coupling method | Effect Witnessed |
|---------------|---------------------|-------------|-----------------|---|
| 0.05-100 | 3 | AC mains | CDN | No tag read between 0.05-0.195MHz |
| 0.01-100 | 3 | AC mains | Current clamp | No tag read between 0.01-0.18MHz |
| | | | | |
| 0.1-100 | 3 | DC input | CDN | No tag read between 0.1-0.23MHz |
| 0.1-100 | 3 | DC input | EM clamp | No tag read between 0.1-0.23MHz |
| 0.01-100 | 3 | DC input | Current clamp | No tag read between 0.01-0.19MHz |
| | | | | |
| 0.05-100 | 3 | Panel cable | EM clamp | No tag read between 0.1-0.145MHz |
| 0.01-100 | 3 | Panel cable | Current clamp | No tag read between 0.01-0.132MHz Intermittent tag read to 0.15MHz |

Table 20 Results for extended frequency tests

| Frequency MHz | Field Strength Vrms | Line tested | Coupling method | Effect Witnessed |
|---------------|---------------------|-------------|-----------------|-----------------------------------|
| 0.05-100 | 10 | AC mains | CDN | No tag read between 0.05-0.288MHz |
| 0.01-100 | 7 | AC mains | Current clamp | No tag read between 0.01-0.230MHz |
| | | | | |
| 0.01-100 | 7 | DC input | Current clamp | No tag read between 0.01-0.245MHz |
| | | | | |
| 0.05-100 | 10 | Panel cable | EM clamp | No tag read between 0.1-0.15MHz |

| | | | | |
|----------|---|-------------|---------------|----------------------------------|
| 0.01-100 | 7 | Panel cable | Current clamp | No tag read between 0.01-0.19MHz |
|----------|---|-------------|---------------|----------------------------------|

Table 21 Results for extended level tests

Note: The current clamp efficiency drops at the lower frequencies and the maximum level attainable across the whole range was 7V rms.

15.2.2.5 Comment on results

At the level required by the standard, 3V rms, the panel reader did show some effects;

- i) AC input: susceptible to disturbance 150kHz to 195kHz
- ii) DC input: susceptible to disturbance 150kHz to 230kHz

These effects would need to be rectified for full compliance to the requirements of the standard.

For the extended frequency range, it was noted that the EUT was susceptible to any disturbance below 150kHz. The threshold of susceptibility was below 1V.

This is understandable since the EUT operates the tag read at a nominal frequency of 134kHz and it is likely that any disturbance of the field, especially by the 1kHz modulated RF applied, will interfere with the operation of the equipment which relies on detection of very low power signals.

The antenna panel cable is less susceptible to the RF disturbance since it is a screened cable and it meets the requirements of the standard. However, it still shows susceptibilities when frequencies below the 150kHz standard limit are applied.

If the disturbance level is raised to 10V (7V applied when using the current clamp), all cables/inputs show susceptibilities. Again the panel cable is less susceptible than the others due to its screening.

15.2.3 Electrostatic discharge immunity

The standard referenced in EN 301 489-1 is EN61000-4-2 with levels;

- Level: 4kV contact discharge (applied to conductive parts)
- 8kV air discharge (applied to non-conductive parts)

Tests are applied directly to the EUT and indirectly via a vertical and horizontal coupling plane (VCP and HCP)

15.2.3.1 Test setup

The test is performed with the EUT on a copper plane, grounded to the room earth via 940Ω (470Ω at each end of the bonding cable), and separated from it by a 0.5mm insulating sheet. The electrostatic discharge, ESD, is applied using a specialised ESD Gun fitted with the appropriate head for either contact or air discharge.

Discharges are applied to selected points on the EUT appropriate for air or contact discharge and at both positive and negative polarities.

There is a possibility that lower levels of ESD can have an effect on the EUT when the higher levels show no susceptibility. This can be due to a flashover to ground dissipating the ESD charge before it can interfere with the circuits. Because of this, ESD is applied at the levels below and up to the maximum required, therefore the test sequence is as shown in Table 22. The appropriate discharges are applied to each selected point.

| Contact Discharge (EUT and VCP/HCP) | | | Air Discharge | | |
|--|-----------------|--------------------------|----------------------|-----------------|--------------------------|
| Level | Polarity | No. of Discharges | Level | Polarity | No. of Discharges |
| 2 | + | 10 | 2 | + | 10 |
| 2 | - | 10 | 2 | - | 10 |
| 4 | + | 10 | 4 | + | 10 |
| 4 | - | 10 | 4 | - | 10 |
| | | | 6 | + | 10 |
| | | | 6 | - | 10 |
| | | | 8 | + | 10 |
| | | | 8 | - | 10 |

Table 22 ESD test sequence

An example of the test equipment is shown in Photo 9.



Photo 9. ESD test table showing gun and VCP

15.2.3.2 EUT setup

This test applies to both the panel type reader and the hand held reader.

15.2.3.2.1 *Small panel reader*

The panel reader system was set up on the ground plane as required by the standard. A tag (half duplex, HDX, type) was used to check operation after each discharge was applied.

15.2.3.2.2 *Stick reader*

The stick reader was set up on the ground plane as required by the standard. A tag (half duplex, HDX, type) was used to check operation after each discharge was applied.

15.2.3.3 Results

The results for the standard levels of test are presented in Table 23 and Table 24.

| Point | Type of Discharge | Voltage kV | Polarity +/- | Number of discharges | Comment |
|-----------------------------------|-------------------|------------|--------------|----------------------|------------------|
| Panel Antenna reader | | | | | |
| Control box | | | | | |
| Enclosure | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| Connector 1 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| Connector 2 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| Display | Air | 2, 4, 6, 8 | +/- | 10 at each setting | No effects noted |
| AC-DC supply (plastic box) | | | | | |
| Latch | Air | 2, 4, 6, 8 | +/- | 10 at each setting | No effects noted |
| LED | Air | 2, 4, 6, 8 | +/- | 10 at each setting | No effects noted |
| AC in | Air | 2, 4, 6, 8 | +/- | 10 at each setting | No effects noted |
| DC out | Air | 2, 4, 6, 8 | +/- | 10 at each setting | No effects noted |
| Antenna panel | | | | | |
| Connector in | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| Panel | Air | 2, 4, 6, 8 | +/- | 10 at each setting | No effects noted |
| | | | | | |
| VCP 1 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| VCP 2 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| VCP 3 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| VCP 4 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |

| | | | | | |
|-------|---------|------|-----|--------------------|------------------|
| HCP 1 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| HCP 2 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| HCP 3 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| HCP 4 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |

Table 23 ESD results, panel reader

| Point | Type of Discharge | Voltage kV | Polarity +/- | Number of discharges | Comment |
|---------|-------------------|------------|--------------|----------------------|------------------|
| Probe | Air | 2, 4, 6, 8 | +/- | 10 at each setting | No effects noted |
| Display | Air | 2, 4, 6, 8 | +/- | 10 at each setting | No effects noted |
| LEDs | Air | 2, 4, 6, 8 | +/- | 10 at each setting | No effects noted |
| End cap | Air | 2, 4, 6, 8 | +/- | 10 at each setting | No effects noted |
| | | | | | |
| VCP 1 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| VCP 2 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| VCP 3 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| VCP 4 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| HCP 1 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| HCP 2 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| HCP 3 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |
| HCP 4 | Contact | 2, 4 | +/- | 10 at each setting | No effects noted |

Table 24 ESD results, stick reader

15.2.3.4 Comment on results

At the level required by the standard, 4kV contact and 8kV air discharge, the EUTs showed no susceptibilities to ESD.

ESD is unlikely to be a problem at the intended sites for use, therefore extended testing was not applied.

15.2.4 Electric fast transient/burst immunity

The standard referenced in EN 301 489-1 is EN61000-4-4 with levels;

- Level: 1kV AC power input
- 0.5kV DC power
- 0.5kV signal ports

Transients are applied in both positive and negative polarities.

Tests are applied directly to the power lines via a coupling network and indirectly to signal/other cables via a capacitive coupling clamp.

It is only applicable to mains powered (or DC powered if connected to a remote DC supply) equipment and to cables in excess of 3m. Only the panel reader was therefore tested.

15.2.4.1 Test setup

The test is performed with the EUT on a ground plane and separated from it by 10cm insulating spacers.

Electrical Fast Transients/Bursts (EFT/B) are applied to the required power and signal lines of the EUT.

There is a possibility that lower levels of EFT/B can have an effect on the EUT when the higher levels show no susceptibility. This can be due to protection (breakdown) devices operating and removing the transient before it can interfere with the circuits. Because of this, EFT/B is applied at the levels below and up to the maximum required.

An example of the test equipment is shown in Photo 10.

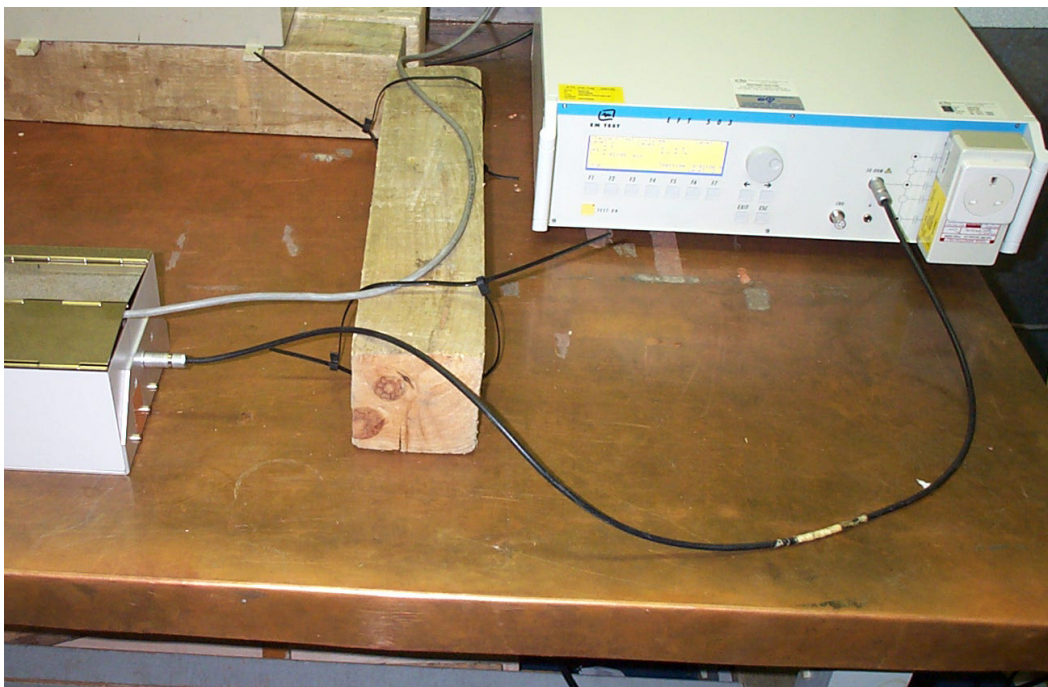


Photo 10. EFT/B applied to signal cable via capacitive clamp

15.2.4.2 EUT setup

This test only applies to the fixed panel readers. The stick reader has no power cables and the serial cable (if used) is less than the 3m minimum required for test.

Since the parts of the panel meter system are the same only the small panel reader was tested. This also allowed access to the cable between the exciter unit and the panel antenna for application of the transients. This can be considered a worst case set up.

An HDX tag mounted at 0.2m from the panel antenna was used to initiate the read.

15.2.4.3 Extended testing

The applied transient voltage was raised to the next severity level, i.e., 2kV AC power, 1kV other.

The test was applied to the lines as detailed in Table 25.

| Line | Voltage kV | Polarity +/- | Application time | Comment |
|-------|---------------|-----------------|-----------------------|---|
| L | 0.5, 1, 2 | +/- | 1 min at each setting | Some slight interruption of reading, indicated by a 'stutter' in the audible signal and LEDs, but no continuous failure |
| N | 0.5, 1, 2 | +/- | 1 min at each setting | |
| E | 0.5, 1, 2 | +/- | 1 min at each setting | |
| L/N/E | 0.5, 1, 2 | +/- | 1 min at each setting | |
| DC | 0.5, 1 | +/- | 1 min at each setting | As above |
| Panel | 0.5, 1 | +/- | 1 min at each setting | As above |

Table 25 EFT/B results

15.2.4.4 Comment on results

At the levels required by the standard, and to the next level above, the EUT met the standard criteria for susceptibility for EFT/B.

15.2.5 Surge immunity

The standard referenced in EN 301 489-1 is EN61000-4-5 with levels;

- Level: 2kV AC power input, line to earth
- 1kV AC power input, line to line
- 1kV DC power
- 1kV signal ports

Surges are applied in both positive and negative polarities at 0°, 90°, 180° and 270° position on the mains waveform.

Tests are only applicable to mains powered (or DC powered if connected to a remote DC supply) equipment and to cables in excess of 10m.

15.2.5.1 Test setup

Surges are applied to the required power lines of the EUT.

Only one mains powered sample was available. Since surge testing can damage the EUT, it was decided only to test to half the required level to avoid any risk of losing the EUT due to equipment failure.

15.2.5.2 EUT setup

This test only applies to the fixed panel readers. The stick reader has no power cables and the serial cable (if used) is less than the 10m minimum required for test.

Since the parts of the panel meter system are the same only the small panel reader was tested.

An HDX tag mounted at 0.2m from the panel antenna was used to initiate the read.

The test was applied to the lines as detailed in Table 26.

| Line | Voltage kV | Polarity +/- | Application time | Comment |
|--------------|---------------|-----------------|--|------------------|
| L to Earth | 0.5, 1 | +/- | 5 at each setting and position on mains waveform | No effects noted |
| N to Earth | 0.5, 1 | +/- | 5 at each setting and position on mains waveform | No effects noted |
| Panel L to N | 0.5 | +/- | 5 at each setting and position on mains waveform | No effects noted |

Table 26 Surge results

15.2.5.3 Comment on results

At the levels tested the EUT showed no susceptibilities.

15.2.6 Voltage Dips and Interruptions immunity

The standard referenced in EN 301 489-1 is EN61000-4-11 with levels;

- Level: 30% reduction for 10ms (one half cycle, positive and negative going)
- 60% reduction for 100ms (5 cycles)
- >95% reduction for 5s (250 cycles)

Tests are only applicable to mains powered equipment.

15.2.6.1 Test setup

Voltage Dips and Interruptions are applied to the required power lines of the EUT.

15.2.6.2 EUT setup

This test only applies to the fixed panel readers. The stick reader has no power cables. Since the parts of the panel meter system are the same only the small panel reader was tested. An HDX tag mounted at 0.2m from the panel antenna was used to initiate the read. The test was applied to the lines as detailed in Table 27.

| Line | Voltage reduction | Length of variation | Applications | Comment |
|-------------------------|-------------------|---------------------|--------------------------|--|
| AC power (nominal 230V) | 30% | 0.5 cycles | 3 positive 3 negative | No effects noted |
| | 60% | 5 cycles | 3 | No effects noted |
| | >95% | 250 cycles | 3 | No effects noted (equipment switches off during the interruption but function returns on re-application of the power). |

Table 27 Voltage Dips and Interrupts results

15.2.6.3 Extended testing

Long term variations were also tested. The EUT operated satisfactorily at 264V AC (240V +10%, worst case) and down to 90V AC.

15.2.6.4 Comment on results

At the required levels, the EUT showed no susceptibilities.

References

- ETSI EN 300 330-1 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 1 Technical characteristics and test methods
- ETSI EN 300 330-2 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Radio Devices (SRD); Radio Equipment in the Frequency Range 9kHz to 25MHz and Inductive Loop Systems in the frequency range 9kHz to 25MHz. Part 2 Harmonized EN under article 3.2 of the R&TTE Directive
- ETSI EN 301 489-1 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
- ETSI EN 301 489-3 Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3 Specific conditions for short range radio devices (SRD) operating on frequencies between 9kHz and 40GHz.
- EN 61000-4-2: Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test.
- EN 61000-4-3 Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test.
- EN 61000-4-4 Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test.
- EN 61000-4-5 Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test.
- EN 61000-4-6 Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields.
- EN 61000-4-11 Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests".

Appendix E – Guidelines for Build and Installation

Guidelines for Build and Installation

1 Introduction

There is the possibility that the use of RFID tagging is likely to become widespread in the very near future. A centralised database of livestock requires timely and accurate data, and the use of RFID tag systems could almost keep the database updated in real time.

The key point here is accuracy of data, and to this end manufacturers have a responsibility to ensure that their equipment meets the required standards for EMC. As a minimum, they should meet the requirements of the relevant ETSI standards, (see this report section 2.4.2 ETSI Standards), or higher if the equipment is to be used in areas where EMI is a known or suspected problem.

Many of the problems associated with interference can be reduced by simple means at no (or little) cost to the manufacturer or installer, and further improvements can be made by careful design and incorporation of EMC components at the initial build. EMC considerations are often addressed at the production stage instead of design stage. Retro-fitting of components or design changes at this stage is far more costly than including them in the original build, and trial and error re-design and re-test is costly and can delay the release of the product onto the market.

This guide is not meant as information for EMC specialists, rather it intends to give general guidelines and rules of thumb for the product designer/manufacturer in improving EMC in the product.

2 Incorporation of EMC measures

For RF conducted and radiated effects, the methods outlined are beneficial for both immunity and emission considerations on the equipment.

2.1 Segregation, filtering and shielding

In the case of RFID systems we have the cabling possibilities of –
230V mains power supply

Auxiliary power cabling, for example the ac-dc converter output to the detector/exciter unit

Antenna cable from the detector/exciter unit

Data output to a PC

The effects of EMI on these can be dealt with by various methods.

2.1.1 Segregation

Segregation is a very powerful EMC design tool. It costs nothing if done early in the design process, but can be expensive if left until later. This includes segregation within the equipment itself as well as during installation to separate any sensitive parts of the system from noisy equipment already installed at the location.

The aim is to segregate sensitive circuits and equipment from 'noisy' circuits and equipment, by as much distance as is possible.

The sensitive circuits in this case are the detection of the tag data and the processing of this for transfer to a computer.

'Noisy' equipment includes relays, contactors, switches, variable-speed motor drives, radio transmitters, and heavy power equipment, all of which can be found in meat processing areas.

Cables are often the most likely to pick up interference leading to susceptibility problems. Cables in parallel with each other 'crosstalk', that is they couple electromagnetic energy from one to another. This must be controlled, to control EMC, therefore during installation of the equipment, these cables should not be installed in the same cable runs as any high powered equipment already in place. The equipment used at the sheep stunning area is a case in point. Where cables have to cross each other this should be ideally at right angles, where this is not possible the greatest angle achievable should be used.

Within equipment enclosures, the amount of space available for segregation is continually reducing, so techniques such as shielding and filtering for segregated circuit areas are increasingly necessary. In addition, within an enclosure, it is generally best to locate the higher-speed circuits towards the centre, if possible, to achieve the best segregation achievable from the enclosure.

2.1.2 Filtering

At such an installation it is likely that any local mains power will be shared by the RFID system and other equipment. To ensure isolation from noisy equipment, filtering at the input of the AC-DC converter is likely to be necessary. This also has the added advantage of minimising any emissions.

Filter manufacturers have a wide range of off-the-shelf filters available and careful consideration of the requirements must be taken to ensure that the correct filter is selected. Particular attention must be made to the frequency characteristics. The site tests performed for this report and the laboratory tests on the equipment suggest that low frequency noise may be a problem and the filter characteristics need to take this into account, ideally having sufficient attenuation of noise below the 134kHz frequency of operation.

In addition, the installation of the filter must be correct, in the EMC sense. Mains power filters normally rely on a low impedance earth bond to shunt noise away, and the best way to achieve this is via a metal enclosure securely bonded to earth. The metal body of the filter and its earth connection provide the low impedance path. An earth wire alone should not be relied on to provide adequate grounding. Cables must also be carefully routed to get the most effectiveness from the filter. Good filters can be severely compromised by bad cable routing, see Figure 110.

Filters are easily compromised by RF coupling from the conductors on their unfiltered side to the conductors on their filtered side. In unshielded enclosures, filters should be positioned as near to the point of entry of the cable as possible. If it is not possible to put the filter at the point of entry then the cable should not be run across the circuit but should be routed around the box, tied as closely to the earthed chassis as is possible.

Maximum separation distances should be maintained between the filters external and internal cables, and between the external cable and the rest of the product's internal circuits and wiring.

Where the enclosure is shielded, it is *essential* to mount the filter in the wall of the enclosure, with the filter body electrically bonded directly to the shielding surface of the wall, otherwise shielding *will* be compromised by leakage through the cable. This type of filter is often called a bulkhead-mounting filter, because it fits in a metal wall.

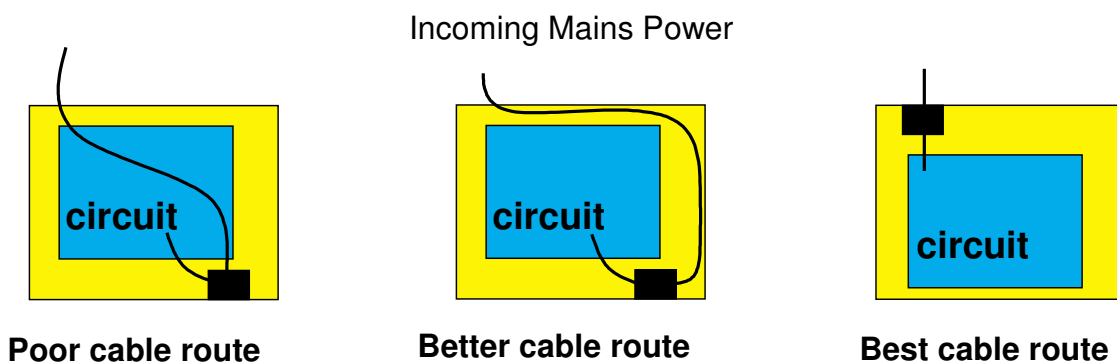


Figure 110 Appendix E: Filter and cable routing

Auxiliary power connections, e.g., the DC from the power supply can also be filtered in the same way.

At its simplest, cable filtering can be achieved through the use of ferrite rings or split cores which are placed around susceptible cables (see Figure 111).

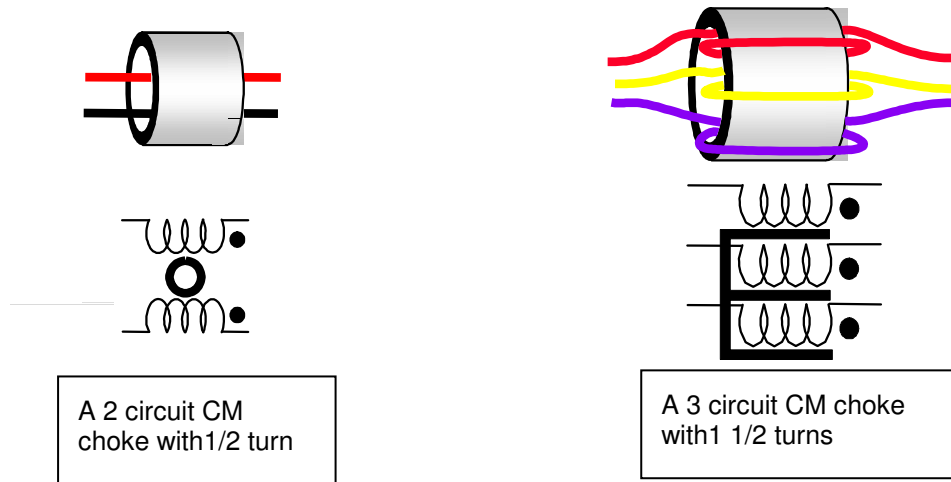


Figure 111 Appendix E: Use of ferrite chokes on cables

This can be effective in some cases but the benefits of using ferrite chokes cannot be guaranteed. They are, however useful as a retrofit item since they are easy to incorporate. Ferrite manufacture has advanced considerably, and ferrite material is made that is absorbent to RF down to low MHz frequencies. At lower frequencies, though, their effects are limited.

In-line signal filtering is more complex, and if it is necessary, careful consideration of the signal attenuation characteristics of the filter must be taken so that filtering does not compromise data transfer.

2.1.3 Shielding

For enclosures, almost any thickness of conductive material will make a good electric-field shield, but below 100kHz, achieving good shielding performance can require significant thicknesses of metal. This is especially important for shielding from low-frequency magnetic fields. Ferromagnetic materials such as steel or nickel give better shielding of magnetic fields at low frequencies, while at higher frequencies, metals with high conductivity (such as aluminium and copper) tend to give better shielding for both magnetic and electric fields. A problem with aluminium is oxidation, either accidental or deliberate as an anodised coating. The oxide has high impedance that makes it almost impossible to achieve electrical contact between mating parts, creating large apertures and reducing the shielding effectiveness.

Enclosure shielding is of limited use, however, if gaps are left in it. A common mistake is all over painting of an enclosure. This inhibits the metal to metal contact required for efficient shielding. Where panels join or overlap, the paint must be masked to leave a bare metal contact along the full length of the join. Similarly, environmental gaskets sealing enclosure doors from moisture or dust are usually not EMC gaskets. The material that they are made from effectively insulates the door or panel from the rest of the enclosure leaving RF gaps all round and therefore access to external interference.

To ensure high quality RF seals around doors and panels, there is a wide variety of gasketing available, for example, wire mesh covered foam or copper fingers. Some combination environmental and EMC gaskets are also available. See Figure 112 for an example of a double row of spring fingers in flanged shielding panel and Figure 113 and Figure 114 for examples of finger stock and gasket.

Plastic enclosures are cheap and can be coated internally with conductive paint that can offer reasonable shielding at high frequencies. Their efficiency at low frequencies however, is unlikely to be sufficient for purpose in this case, so their use for RFID systems would not be advised.



Figure 112 Appendix E: Example of a double row of spring fingers

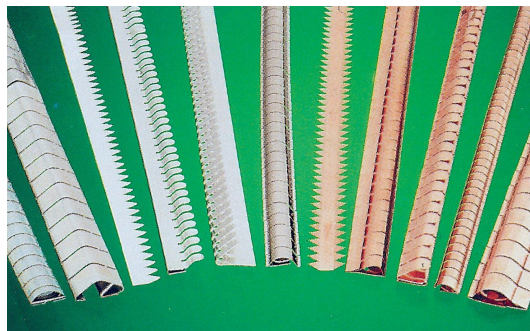


Figure 113 Appendix E: Examples of fingerstock (Chomerics)

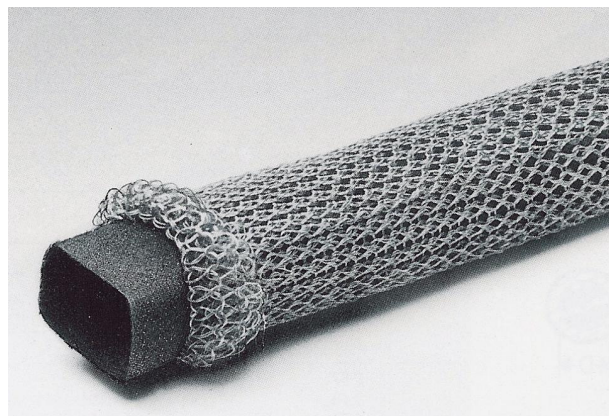


Figure 114 Appendix E: Example of knitted wire over foam core gasket (Feuerherdt GmbH)

Cable shielding should also be an option for use in high EMI areas, especially if it is required that long runs must be made. From the results obtained during the site and laboratory tests, both magnetic and electric field shielding should be considered. To achieve this, a combination of twisted pair cores within a screened cable would be advised. Grounding the screen at both ends using 360° terminations (see Figure 115) should provide suitable screening at higher frequencies and running the cable against a suitable grounded plane, e.g. cable tray, would reduce any earth loop current. The use of 'pigtail' screen termination at connectors should be discouraged since they act like antennae in both receiving and transmitting RF interference.

If, because of the design of a system, cable screening can only be terminated at a single end, then the cable must be kept as short as possible. Less than 1/10 of a wavelength of the frequency of concern is a general rule of thumb. (For example, the wavelength at 100MHz is 3m, therefore a length of 30cm max).

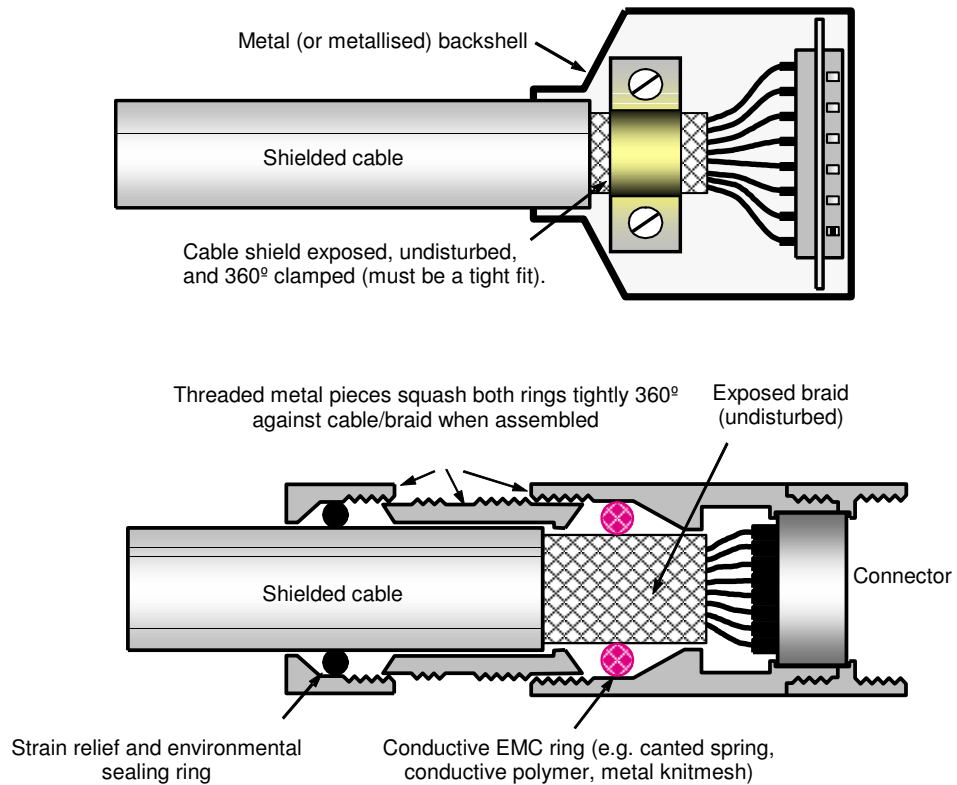


Figure 115 Appendix E: Examples of 360° Terminations

2.2 Other considerations

2.2.1 Electro Static Discharge (ESD)

Although ESD is not likely to be of significant concern in the areas where the RFID will be used, the equipment should still comply with the requirements of the EMC Directive.

The best way to guard against ESD effects is non-conductive enclosures, a 0.5mm thickness of any common plastic is usually more than adequate to protect from more than 8kV of ESD. This however does not offer any immunity protection from radiated RF interference that, in this case, is more of a concern.

Assuming a metal enclosure for the equipment, to ensure protection against possible ESD events, the enclosure must be solidly grounded otherwise the 'earth lift' effect due to inductances in the earth connection caused by the very fast pulse during a discharge can indirectly transfer the ESD pulse to the internal circuits. Earth bonding should be made using direct metal to metal contact.

2.2.2 Electrical Fast Transients/Bursts (EFT/B)

Transients occur during high power switching events or sparking (e.g. at motor brushes, welding etc.).

Typically filtering, if already applied to mains inputs, can offer some protection against mains borne transients. Where this is found to be ineffective, transient effects can be reduced by the use of transient voltage suppressors in the lines.

Segregation of cables also reduces the transfer of transients via cross coupling.

2.2.3 Surges

Surges on the power lines can damage the equipment therefore reasonable measures should be taken to ensure that the equipment can withstand them. Again, mains input filtering can offer some protection against this, and if further protection is required filters are available which include surge suppression. Alternatively, surge suppressors, e.g. metal oxide varistors (MOVs), gas discharge tubes, can be used in the lines.

2.2.4 Voltage Dips and Interrupts

Caused by reduction in the mains voltage or short term drop outs, these can interrupt operation of equipment. Sufficient capacitance in a DC system powered from an AC-DC converter will allow equipment to remain operational during short term interruptions or reduction in voltage. Immunity to longer term interruptions would require the use of battery backup or uninterruptible power supply to allow continuous operation.

2.3 Checklist

2.3.1 Equipment Build

1. Enclosure material, steel is preferred because of its shielding properties to both electric and magnetic field. Enclosures should be either continuous with a lid or door, or if constructed from panels the seams should overlap and form a tight fit.
2. Any painting of the enclosure should be masked to leave bare metal at contact points of the enclosure.
3. Gasketing should be used if required to ensure gap free seams in an enclosure. Doors or removable panels should also be gasketed if a tight fit can not be guaranteed.
4. Mains power should be filtered at the entry point of the mains cable, and the filtered earth bonded securely to the enclosure with a metal to metal contact.
5. Long cables should be screened with 360° screen terminations at the connectors. Twisted pair cabling should be used if possible.

2.3.2 Installation

1. Prior to a permanent installation, a survey would be advisable to determine what other equipment was operating in the area, where cable runs were fitted, if there were any suitable earth bonds and where the equipment power would come from.
2. The unit should be fitted at a distance from any machinery that may be operating.
3. Cable lengths should be kept to a minimum where possible.
4. If long cables are unavoidable, they should be screened and routed separately from any existing cables. Where cables cross they should do so as near to right angles as possible.
5. Long cables should be screened with 360° screen terminations at the connectors. Twisted pair cabling should be used if possible.

References

1 Allflex Group

2 Shearwell Data Ltd

3 <http://www.rfid-handbook.de/rfid/frequencies.html>