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Radiocommunications Assignment and Licensing Instruction

DETERMINING THE APPLICABILITY OF LICENSING AND EMC REGIMES TO TRANSMITTERS

AUSTRALIAN COMMUNICATIONS AUTHORITY

SPECTRUM PLANNING AND ENGINEERING TEAM

CANBERRA

RADIOCOMMUNICATIONS ASSIGNMENT AND LICENSING INSTRUCTIONS

Suggestions for improvements to Radiocommunications Assignment and Licensing Instructions may be addressed to The Manager, Spectrum Planning and Engineering Team, ACA at PO Box 78, Belconnen, ACT, 2616. It would be appreciated if notification to the ACA of any inaccuracy or ambiguity found be made without delay in order that the matter may be investigated and appropriate action taken.

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Determining the Applicability of Licensing and EMC Regimes to Transmitters

1 Introduction

The *Radiocommunications Act 1992* (the Act) provides separate frameworks for the management of radiocommunications and non-radiocommunications transmitters in Australia.

The Act defines a transmitter as anything designed or intended for radio emission[1], or any other thing, irrespective of its use or function or the purpose of its design, that is capable of radio emission.

A radiocommunications transmitter (as defined in the Act) is subject to the Act's radiocommunications licensing regime. Under this regime the use of a radiocommunications transmitter must be authorised by a radiocommunications licence for it to be operated lawfully (except for certain circumstances specifically exempted by the Act). The licence that authorises the user to operate the radiocommunications transmitter could be a spectrum licence, an apparatus licence or a class licence.

A transmitter that is not a radiocommunications transmitter is not subject to the radiocommunications licensing regime. No authorisation (ie, radiocommunications licence) is required for its use. Instead, it is subject to the ACA's electromagnetic compatibility (EMC) requirements for non-radiocommunications devices. This regime provides minimum standards for radiated emissions from electronic and electrical devices, such that their potential for causing interference to other devices (including radiocommunications devices) is limited to an acceptable level.

From time to time, officers need to assess whether the radiocommunications licensing regime or the EMC framework should be applied to a transmitting device for which the answer is not necessarily self evident; this need might arise from a customer enquiry or regulatory investigation. Common examples of such devices are pipe and cable detectors, electronic key systems and certain electronic article surveillance (EAS) or radiofrequency identification (RFID) systems.

2 Purpose

The purpose of this RALI is to advise about the methodology to be applied in differentiating between radiocommunications transmitters and non-radiocommunications transmitters.

This RALI replaces RALI MS 27, dated 3 March 1998, sequence number 134.

3 Defining the Term 'Radiocommunications Transmitter'

A definition for radiocommunications transmitter can be determined from sections 6, 7 and 8 of

[1] For the purposes of the Act, a radio emission is any emission of electromagnetic energy of frequencies less than 420 terahertz without continuous artificial guide, whether or not any person intended the emission to occur.

the Act, and is paraphrased as follows:

> A radiocommunications transmitter is anything designed or intended for the emission of electromagnetic energy of frequencies less than 420 terahertz without continuous artificial guide...for use for the purpose of communicating information between persons and persons, persons and things or things and things.

From the above definition it can be seen that two conditions are essential for a device to be a radiocommunications transmitter:

1. the device must emit electromagnetic energy; and
2. the device must be using this electromagnetic energy to communicate information.

Sections 4 and 5 of this RALI elaborate on these two requirements.

4 Electromagnetic Energy

Generally speaking, electromagnetic waves arise as a consequence of the following two effects:

- a changing magnetic field produces an electric field; and
- a changing electric field produces a magnetic field.

The corollary of these effects is that neither stationary charges nor steady currents can produce electromagnetic waves, that is, the fundamental mechanism responsible for the radiation of electromagnetic energy is the acceleration of a charged particle[2] [Ref 1]. Consequently, whenever current through a conductor changes with time, that conductor emits electromagnetic energy.

4.1 Electromagnetic Field Regions

The space around a radiating element (which we will call the antenna) can be divided into three regions:

- the reactive near field;
- the radiating near field; and
- the radiating far field.

4.1.1 The Reactive Near Field

In the reactive near field, which is closest to the antenna, the electric (E) field lines do not exist in free space, but instead originate and terminate on the antenna conductors. As a consequence, the E-field and its companion magnetic (H) field facilitate the storage of electromagnetic energy in this region rather than its radiation. The field in this region is referred to as reactive because its behaviour is analogous to that of a reactive tuned circuit, where energy is stored by inductive and capacitive reactances.

[2] This RALI concerns itself with the generation of electromagnetic energy through time varying currents, as this is the relevant mechanism for the majority of devices that might be determined to be transmitters as defined by the Act. At terahertz frequencies certain materials generate electromagnetic energy through changes of energy states at the atomic level. Light emitting diodes and lasers are examples of devices that create electromagnetic energy this way. It is appropriate to use section 6 of this RALI for categorising these devices also.

4.1.2 The Radiating Near Field

In the radiating near field, which in theory dominates in the region just beyond the reactive near field, the E-field and its companion H-field can exist as closed loops, independently of the source antenna. However because of the proximity of these field lines to the antenna and the tight curvature of the field loops, the energy in the E and H fields (and hence in the electromagnetic field as a whole) can vary significantly with relatively small changes in angular displacement around the antenna. The 'rule-of-thumb' transition point from the reactive region to the radiating near field region is set at $\lambda/2\pi$.

4.1.3 The Radiating Far Field

In the radiating far field, which exists beyond the radiating near field, the E and H fields exist as closed loops independently of the source antenna. In contrast to the radiating near field, energy in the far field varies relatively slowly with angular displacement around the antenna, because of the distance from the source of radiation. It is in this region that typical radiocommunications transmitters are designed to operate, and in which manufacturers' antenna characteristics (such as radiation pattern envelopes and antenna gain figures) can be considered valid. The 'rule-of-thumb' transition point to the radiating far field (from the radiating near field) is generally set at $2D^2/\lambda$, where D is the largest linear dimension of the aperture of the antenna[4].

Note: The radiating near field region may not exist when the length or diameter of the antenna is less than one wavelength (1λ). In this case the transition point between the reactive and radiating regions, which as a 'rule-of-thumb' is $\lambda/2\pi$, is between the reactive near field and the radiating far field.

4.2 General Observations

The boundaries of the above three field regions are not distinct; rather they are better described as transition zones, in which the dominance of one field type begins to give way to another. Actual distances to these transition zones from any given antenna often cannot be precisely determined by calculation, as there are many variables associated with antenna design and frequency of operation that influence the result. In particular, for antennas with very small dimensions operating at very low frequencies, or antennas with very large dimensions operating at very high frequencies, 'rule-of-thumb' calculations often produce inconclusive results regarding distances to the different field boundaries.

The main points to be drawn out of the above information on electromagnetic energy are as follows:

- in the region very close to an antenna (ie, typically within a distance of the order of a few wavelengths or less [Ref 2]), the reactive component of electromagnetic energy dominates (refer 4.1.1 above). The consequence of this is that systems in which devices operate in the reactive near field region are likely to be exploiting energy contained primarily in either the H-field or the E-field that is stored relatively close to the antenna (but is not radiated);
- in the region typically beyond several wavelengths from an antenna [Ref 2], energy exists in the form of a radiated electromagnetic field (refer 4.1.2 and 4.1.3 above). Systems in

[4] In the real world this would necessarily be the effective aperture of the antenna. The effective aperture is a statement of the real antenna's efficiency, which will be less than 100% and arises from design compromises and construction imperfections.

which devices operate in this region are therefore likely to be exploiting the characteristics of energy radiated in the form of E and H field components; and

- irrespective of the type of field energy (electric, magnetic or electromagnetic) used by a receiver in any given communications system, a time-varying current generated by a transmitter in that system will always produce electromagnetic energy (ie, energy comprised of electric and magnetic fields, be they 'near-field' or 'far-field'). In some cases, specific steps are taken in the design of such a transmitter to minimise the emission of one or the other field component (eg, electrostatic shielding around an antenna will attenuate the E-field).

5 Communicating Information

The nature of information that can be communicated by radiofrequency communications systems is quite diverse. For example, an RFID tag communicates identifying information about the object to which it is attached, a broadcast transmitter communicates program material to listeners, and a radar system communicates information to an operator on the range and bearing (and possibly other characteristics) of a distant object.

6 Method for Categorising Transmitters

Based on the previous information, the following method should be employed to ascertain whether a particular transmitter is a radiocommunications transmitter.

Step 1. Determine if the device's operation creates electromagnetic energy.

If the answer is yes, then the device is a transmitter for the purposes of the Act. Proceed to Step 2.

If the answer is no, then the device is not a transmitter for the purposes of the Act, and the Act does not apply to it.

Step 2. Determine whether the electromagnetic energy is used for communicating information.

If the electromagnetic energy is being used to communicate information, then the transmitter is a radiocommunications transmitter for the purposes of the Act, and its use requires licensing.

If the electromagnetic energy is not being used for the purpose of communicating information, then the transmitter is not a radiocommunications transmitter, and its use is not subject to licensing under the Act. The device must, however, meet the relevant requirements of the ACA's EMC framework for non-radiocommunications devices.

Note that in some cases the device will have been designed to minimise the radiated electromagnetic energy and that the communication will be via, for example, magnetic induction.

The examples in the following section are intended to illustrate this categorisation process.

7 Examples of Transmitter Categorisation

7.1 Example 1 - Broadcasting Station

A typical AM broadcasting station operates at about 1 MHz. It is intended to communicate program material to listeners over distances up to around 50 km.

From our general knowledge of broadcast stations and the specific parameters provided above we can make the following assessment of the station:

Step 1

The station operates by producing a radiofrequency (ie, time-varying) current in an antenna. It must therefore emit electromagnetic energy, and it is a transmitter for the purposes of the Act.

Step 2

The wavelength of the operating frequency is 300 metres, and the distance over which reliable communications is intended is 50 km. The transmitter is therefore intended to operate over a distance equivalent to many wavelengths, which leads us to conclude that it is operating primarily in the radiating field region, that is, the region of radiated electromagnetic energy (unguided). The purpose of the broadcast transmitter is to communicate information to receivers tuned to its operating frequency using this energy. It is therefore a radiocommunications transmitter and its use requires licensing.

It is interesting to note in this example that the receivers for which emissions from the broadcast transmitter are intended employ either ferrite rod antennas (eg, household radios), which respond primarily to H-field energy, or monopole antennas (such as those installed on motor vehicles), which respond primarily to E-field energy. Although these receivers are responding to energy primarily in either E or H field form, this energy is acquired from an unguided radiated electromagnetic field (comprising E and H field components).

Conclusion

Because the primary means of communicating information between the broadcast transmitter and its target receivers is through the emission of electromagnetic energy, we conclude that the transmitter is a radiocommunications transmitter for the purposes of the Act, and its use requires licensing.

7.2 Example 2 - Pipe and Cable Detector

The pipe and cable detector is essentially a metal detector, typically used to locate pipes and cables buried to a depth of several metres below the ground. The device in this example operates with a centre frequency of 8 kHz, and works on the principle that a metallic object such as a pipe or cable, when entering the field produced by a radiofrequency current in a coil, will change the inductance of that coil. This change in inductance shifts the resonant frequency of a tuned circuit, which is subsequently detected by appropriate circuitry in the device.

From the above information we can make the following observations and conclusions:

Step 1

The device operates by producing a radiofrequency (ie, time-varying) current in a multi-turn coil. It must therefore emit electromagnetic energy, and it is a transmitter.

Step 2

From the theory of operation above, we note that the wavelength of the operating frequency is 37.5 km, and the maximum depth at which a pipe or cable can be reliably detected is only several metres. The device is therefore intended to operate over a distance equivalent to only a small fraction of a wavelength, and must consequently be operating in the reactive field region. Moreover, it is apparent from the device's theory of operation that it is relying on magnetic coupling (H-field) to sense the existence of a metallic object below it, because it is changes in magnetic coupling that lead to the indication of a pipe or cable being present. Therefore, it cannot be a radiocommunications transmitter.

Conclusion

Because the pipe and cable detector is intended to exploit characteristics of the reactive H-field, we conclude that the device does not rely on the emission of electromagnetic energy for its intended purpose, and that it cannot be a radiocommunications transmitter for the purposes of the Act. It would, however, need to comply with the EMC requirements for non-radiocommunications devices.

7.3 Example 3 - Electronic Article Surveillance (EAS) System

A particular EAS system operating at 3.5 MHz consists of two separate elements: an interrogator unit, and the electronic tag that is attached to the merchandise to be protected. The interrogator unit includes transmitting and receiving units that are each connected to a multi-turn coil antenna, these antennas being placed opposite one another on each side of a shop entrance and separated by around 1 - 1.5 metres. Each coil antenna is encased in an aluminium tube, which serves to minimise the amount of electrostatic interference that could otherwise be picked up by the receiving coil, and to minimise the amount of electric field energy emitted by the transmitting coil.

The transmitting coil is excited with radiofrequency current, the frequency of which is swept over a set range by a 'sawtooth' modulating signal. A portion of the radiofrequency (RF) energy produced by the transmitting coil is captured by a tuned circuit in the electronic tag when it comes between the transmitting and receiving coils. The tag momentarily stores the incident energy and subsequently emits energy across a narrow bandwidth centred on its resonant frequency. This RF energy is detected by the interrogator receiving unit at intervals determined by the transmitting unit sweep rate, and an alarm is triggered to indicate the presence of the tag.

The receiving unit is able to discriminate between the tag signal (which is of a very low level) and the signal transmitted by the coil (comparatively much larger) because the tag's signal is represented by an amplitude 'glitch' on the coil's signal, which is frequency modulated by the sawtooth waveform. By amplitude de-modulating the received signal, information is only extracted from the tag's emission - the frequency modulated signal from the coil is disregarded.

From the description of the EAS system given above, and using the categorisation process above, we can make the following observations and conclusions:

Step 1

The EAS interrogator produces a radiofrequency (ie, time-varying) current in a multi-turn coil. It must therefore emit electromagnetic energy, and it is a transmitter.

The electronic tag captures radiofrequency energy emitted by the EAS interrogator. This energy produces a time varying current in the tag's tuned circuit, which is then re-radiated. The tag produces electromagnetic energy, and it is a transmitter.

Step 2

The wavelength of the operating frequency is around 83 metres, so it can be concluded the EAS system is intended to operate in the reactive near field region where magnetic and electric fields exist separately.

The EAS interrogator transmitting coil emits electromagnetic energy, and it is encased in an aluminium tube (or a similar electrically conducting, non-magnetic, material). It is clear that the purpose of this design is to exploit magnetic field coupling to a tag in close proximity. From this we conclude that the EAS interrogator transmitting unit is not a radiocommunications transmitter for the purposes of the Act. Note that the aluminium tube, by minimising the electric field component, reduces significantly the strength of the electromagnetic energy that ultimately forms and radiates away from the coil. This reduces the likelihood of false alarms from tags elsewhere in the shop, and the risk of interference to radiocommunications.

The tag emits electromagnetic energy. The proximity of the tag to the interrogator receiving coil (of the order of 1 metre) means that operation is in the reactive field region of the tag; the receiving coil's design means the signal detection is intended to occur via magnetic coupling. The tag does not rely on the emission of electromagnetic energy for its intended operation, even though it clearly must create some. We therefore conclude that the tag is not a radiocommunications transmitter for the purposes of the Act.

Conclusion

We conclude that the EAS interrogator and the tag are not radiocommunications transmitters for the purposes of the Act. Use of this EAS system would not require licensing, but it would need to comply with the EMC requirements for non-radiocommunications devices.

7.4 Example 4 – RFID (RadioFrequency IDentification) System

A particular RFID system operates at 920 MHz over a distance of several metres. The general operation of these systems requires an exciter at a given frequency, an ID tag device and a system receiver. Typically the exciter and system receiver are contained in the same mechanical casing and the tag is generally a flat style label that can be affixed to packaging or containers. The tags come in two variants, active and passive. Active tags contain there own power source while passive tags rely on the exciter emission to power them for transmission. As a tag comes into proximity of the exciter the tag responds by sending its identification number, which is then in turn logged by the receiver.

From our general knowledge of RFID systems and the specific parameters provided above we can make the following assessment of the exciter and the RFID tags:

Step 1

Both the exciter and the tag operate by producing a radiofrequency (ie, time-varying) current in an antenna. They therefore emit electromagnetic energy, and they are both transmitters.

Step 2

The wavelength of the operating frequency is around 33 centimetres, and the distances over which reliable operation is intended is several metres for both the exciter and the ID tag. The exciter and ID tags are therefore both intended to operate over a distance equivalent to a number of wavelengths, which leads us to conclude that they are operating primarily in the radiating field region and hence are using electromagnetic energy for communication.

The purpose of the exciter is to elicit information from the tag, which is a basic telecommand action. The tag is responding to the elicitation by transmitting a unique serial number to the system receiver. Both therefore communicate information.

Conclusion

Because the primary means of communicating information from the exciter to the tag, and from the tag to the system receiver is through the emission of electromagnetic energy, we conclude that both the exciter and the ID tag are radiocommunications transmitters for the purposes of the Act, and their use requires licensing.

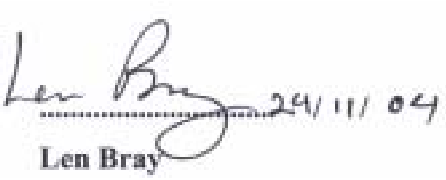
8 Summary

This RALI provided the methodology for differentiating between radiocommunications and non-radiocommunications devices in a manner consistent with the provisions of the Act. It enables ACA officers to determine whether the use of particular transmitters requires licensing under the Act, or if they are instead subject to the EMC framework. The methodology is based on the principle, drawn directly from the Act, that any given transmitter is a radiocommunications transmitter for the purpose of the Act if it is used for the purpose of communicating information and if it communicates that information by the emission of electromagnetic energy. A radiocommunications licence is required to use such a transmitter.

If a transmitter does not meet these necessary conditions for classification as a radiocommunications transmitter, it must meet the relevant requirements of the EMC framework for non-radiocommunications devices.

Through an understanding of the principles underlying the methodology (explained at sections 3, 4 and 5 of this RALI), ACA officers should be able to successfully apply the procedure at section 6 of this RALI to the categorisation of transmitters. The examples at section 7 of this RALI are intended to assist with this process.

RALI Authorisation



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