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Radiocommunications Assignment and Licensing Instruction

FREQUENCY ASSIGNMENT PROCEDURE FOR LAND MOBILE SERVICES ADJACENT TO TV CHANNELS 2, 3 AND 6

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Note: All reference to the Spectrum Management Agency, should be read as references to the Australian Communications and Media Authority. Similarly, all references to the SMA should be read as references to ACMA.

AUSTRALIAN COMMUNICATIONS AND MEDIA AUTHROITY

RADIOFREQUENCY PLANNING BRANCH

TABLE OF CONTENTS

Appendices

A Model 1: Frequency/Distance Separation Criteria for LMS Base Stations

B Model 1: Frequency/Distance Separation Criteria for an LMS RCS External to a TV Service Area

C Model 1: Frequency/Distance Separation Criteria for an LMS RCS within a TV Service Area

D Model 2: Inner Radius of Annulus vs. Frequency Offset from the Upper Edge of a TV Channel

E Model 2: Inner Radius of Annulus vs. Frequency Offset from the lower Edge of a TV Channel

F Model 2: Outer Radius of Annulus vs. Frequency Offset from a TV Channel

Frequency Assignment Procedures for Land Mobile Services Adjacent to TV Channels 2, 3 And 6

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1.0 Introduction

1.1 Purpose

This instruction provides improved frequency assignment procedures for the Land Mobile Service (LMS) in spectrum adjacent to television channels 2, 3 and 6.

1.2 Source Document

The information contained in this Radiocommunications Assignment and Licensing Instruction (RALI) is based on information contained in Spectrum Planning Policy Document SP7/91 'Frequency Assignment Criteria for Land Mobile Services Adjacent to Television Channels 2, 3 and 6'.

1.3 Background

Radiofrequency spectrum for TV channels 2, 3, and 6 abuts spectrum allocated for mobile services. In order to protect TV reception from adjacent channel interference from these services, simple guardband arrangements were put in place about a decade ago. These guardbands are located in spectrum allocated for mobile applications, and their existence has substantially reduced the number of channels available to the LMS near areas where these TV channels operate.

The result is that, in the case of the VHF Mid Band, the guardband for TV Channel 2 restricts the use of 141 two-frequency LMS channels and 19 Miscellaneous Service channels, and the guardband for TV Channel 3 inhibits the use of 145 two frequency LMS channels and 30 single frequency LMS channels. In the case of the VHF High Band, the TV Channel 6 guardband restricts the use of 319 channels, in particular 95 channels of the trunked two frequency LMS.

Detailed co-ordination procedures to replace the simple guardband arrangements have been developed in consultation with the Australian Broadcasting Authority. These procedures are to be applied in specified areas of Australia, as detailed subsequently in this RALI. The procedures provide for frequency assignment of VHF LMS channels in spectrum adjacent to horizontally polarised TV channels 2, 3 and 6, both inside and outside the relevant broadcast coverage areas. Application of these assignment procedures will provide additional opportunities for spectrum access in the highly congested VHF Mid and High Bands.

2.0 Development of the Frequency Assignment Procedures

2.1 The System Model

The frequency assignment procedures of this RALI were developed after first defining a system model based on relevant characteristics of both TV and land mobile services. The relevant service characteristics are detailed in the following paragraphs.

2.1.1 TV Service Characteristics

A TV transmit antenna is usually well sited to afford good coverage and is typically 200 m or higher above the TV receivers it is serving. Many TV transmitters operate at powers greater than 1 kW EIRP, and the polarisation of TV emissions may be horizontal or vertical. In particular, those stations which, due to their geographic location, currently impose the greatest limitation on use of LMS spectrum operate at 100 kW EIRP with a horizontal polarisation.

TV services to particular areas are classified as urban, suburban or rural, depending on the median value of field strength available to those areas. These median values are represented by field strength contours, the values of which decrease with increasing distance from the TV transmitter. For the VHF band the field strength contours for the above areas correspond to 75, 65 and 50 dB uV/m respectively. The 50 dB uV/m contour is considered as the effective limit of a TV coverage area. The shape of a TV coverage area depends very much on the surrounding terrain and the TV transmit antenna radiation pattern.

TV receiver antennas are typically fixed and mounted 10 m above the ground. Some TV receiver systems on the outskirts of a TV coverage area employ antennas on tall masts and use masthead amplifiers to improve TV signal reception. Typically, TV receivers have comparatively wide RF bandwidths and their adjacent channel rejection is not as effective as that of LMS receivers.

2.1.1.1 Antenna Discrimination

It was necessary during development of the assignment model to determine appropriate values for TV receive antenna discrimination. This parameter is a measure of a TV receive antenna's ability to discriminate against interfering signals in favour of the wanted signal, and is a function of the antenna's front to back ratio (directional discrimination) and its ability to reject signals of a polarisation different to those it is oriented to receive (polarisation discrimination). Typical values for antenna directional and polarisation discrimination were determined from CCIR reports and other reliable sources.

TV receivers gain a benefit from directional discrimination when LMS stations are assigned external to the TV service area. However in the case of an LMS station located within a TV service area, antenna directivity discrimination against that station cannot be considered to be available. The additional benefit of polarisation discrimination has been considered, as LMS signals are vertically polarised, and these criteria are intended only for application within and adjacent to areas served by horizontally polarised TV services.

2.1.2 LMS Service characteristics

The fundamental components of a two frequency LMS system are a base station, associated mobile stations, and a remote control station (RCS) for control of the mobiles. The base station is often located on high ground away from built-up areas, and all transmissions between mobiles (including the RCS) are relayed through it, using one frequency to receive and another to transmit.

Single frequency LMS systems consist only of a base station and mobile stations. The base station is equivalent to the RCS in a two frequency system, and is therefore typically located in a built-up area, often having an antenna on a rooftop or on a tall mast. All mobiles (including the base station) communicate directly with one another.

In both single and two frequency LMS systems, the base station typically operates with an EIRP of 83 W and an antenna height of up to 200 m; and mobile stations have an EIRP of 25 W and an

antenna height of 1.5 m. These conditions provide a planned service radius of around 40 km. The RCS in a two frequency LMS system is assumed to operate with an EIRP of 1 W, using an antenna mounted 10 m above the ground.

2.2 Propagation Models

A number of propagation models were developed to describe how the interfering LMS signal is affected by transmission along the paths which are characteristic of the assignment models.

2.2.1 Propagation Model - for a Path Distance Less Than or Equal to 10 km

In the case of a path of 10 km or less from a wanted TV or unwanted LMS base station transmit antenna to a TV receive antenna, it was assumed that a receive antenna has 'line of sight' to a transmit antenna. The 'free space' propagation model was therefore used to calculate field strength at the TV receiver in this case.

For the case of a path of 10 km or less from an unwanted LMS mobile station or RCS transmit antenna to a TV receive antenna, the transmit antenna is not usually as well sited as an LMS base or TV transmit antenna. In this case, the field strength was calculated using the 'free space' model, with an additional attenuation factor of 10 dB to account for losses due to urban clutter.

2.2.2 Propagation Model - for a Path Distance Greater Than 10 km

In the case of a path greater than 10 km from a wanted TV or unwanted LMS base station transmit antenna to a TV receive antenna, the free space model was modified to take into account propagation effects detailed in CCIR Rec 370-5, as per the TV Broadcast Planning Guidelines. The CCIR (50,50) graphs were used for coverage calculations and the CCIR (50,10) graphs were used for interference calculations.

In the case of a path greater than 10 km from an unwanted LMS mobile station or RCS transmit antenna to a TV receive antenna, **t**he CCIR graphs do not have suitable transmit antenna height curves. While the Hata model is not ideal for distances greater than 20 km, it is the most suitable of those available and was used to determine the field strength received at the TV receive antenna from an LMS mobile or RCS.

2.3 Frequency Assignment Models

Report SP 7/91 develops two models for the assignment of LMS systems in spectrum adjacent to TV channels. These are described in the following paragraphs.

2.3.1 Frequency Assignment Model 1

Model 1 (see Figure 1) is used for assignment of LMS systems in areas geographically adjacent, and external, to TV coverage areas. Base stations must be situated external to the TV coverage area, but the LMS service area (including mobiles and RCSs) may overlap into the TV station coverage area. The model provides a set of three frequency/distance co-ordination graphs which are used to establish the required separation distance between Base Stations and RCSs, and TV receivers.

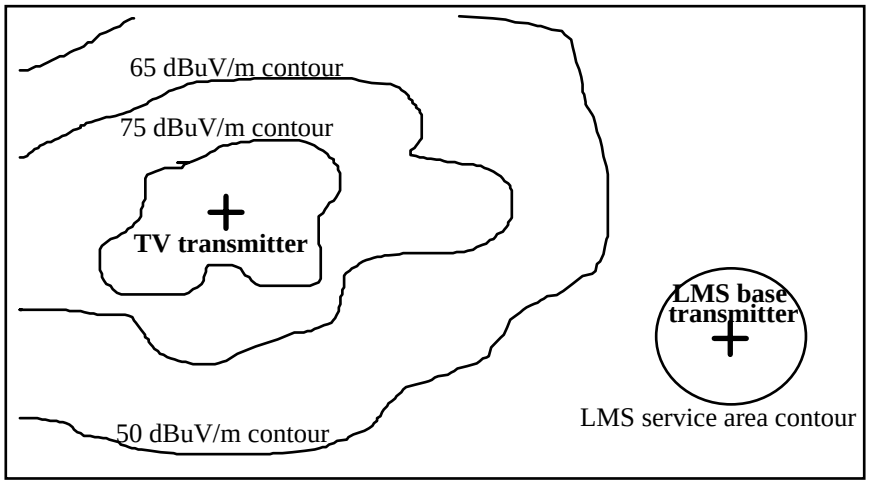


Figure 1: ***Model 1 - LMS External to the TV Coverage Area***

When developing this model it was necessary to :

- calculate the maximum value for LMS station field strength tolerable by a TV receiver, at particular frequency offsets from the TV channel;
- using an appropriate propagation model (from the previous section), calculate the separation distances required between a TV receiver and individual LMS base stations, RCSs and mobiles, at various frequency spacings from the edge of a TV channel, to satisfy the limit for field strength calculated above;
- consider the likelihood of TV interference from single and multiple mobile stations,
- develop graphical Frequency-Distance Criteria for multiple LMS base stations external to the TV coverage area; and
- develop graphical Frequency-Distance Criteria for multiple LMS RCSs both within and external to a TV coverage area.

In relation to the above, consideration was given to TV antenna characteristics, field strength of the wanted TV signal, and the frequency dependent adjacent channel protection ratios specified for a TV receiver in Australian Standard AS 2839.

2.3.2 Frequency Assignment Model 2

Model 2 was developed to facilitate assignment of LMS systems within a TV coverage area, and allows the siting of base stations within the TV service area. The concepts behind this model are explained in the following paragraphs.

Those TV transmitters which, due to their geographic location, currently impose the greatest limitation on use of LMS spectrum are operating at an EIRP of 100 kW; 31 dB above the transmitted power of a typical LMS base station (83 W EIRP). As the maximum required TV receiver protection ratio is 30 dB1 at the lower edge of TV Channels 3 and 6, and only 12 dB1 at the upper edge of TV Channel 2, then if the LMS and TV transmit antennas were co-sited, the wanted (TV) to unwanted (LMS) ratio of signal field strengths at all TV receivers within the TV coverage area would always be greater than the TV receiver protection ratio required, for any frequency offset from the TV channel edge. Hence, a TV receiver would not be subject to

1 As specified in AS 2839-1988.

interference from the LMS base transmitter, and all of the LMS channels in the spectrum adjacent to the TV channel would be available at that site.

However, the high radiated power of a TV transmit antenna will desensitise a co-sited LMS base receiver; therefore some distance separation is required between a TV transmit antenna and an LMS base receive antenna. This distance is a function of the frequency separation between the TV transmit frequency and the base receive frequency. This frequency-distance relationship has been developed from measurement of transmitted TV signals made by the Department of Communications Laboratory .

If the TV transmit and LMS base receive antennas must be separated in order to protect LMS base receivers, then some difference in propagation loss may be introduced between the wanted and unwanted signal paths (i.e. between the wanted TV transmit antenna to TV receive antenna path, and the unwanted LMS base transmit antenna to TV receive antenna path). Any path loss differences must be accounted for by affording additional protection to TV receivers, and this will limit the maximum separation distance between a TV transmit antenna and an LMS base transmit antenna.

The combination of factors described in the preceding paragraphs means that an annulus exists around a TV transmit antenna whose inside and outside radii specify the area within which an LMS base station may operate without interference being caused to either TV receivers or the base station (see Figure 2). Model 2 thus provides a set of frequency/distance co-ordination graphs which are used to establish the required dimensions for the inner and outer radii of the annulus within which an LMS base station may in principle be sited.

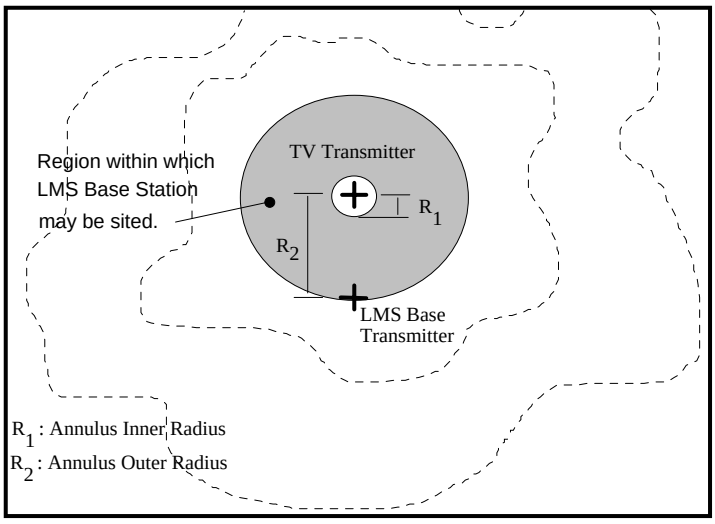


Figure 2 : Model 2 - LMS System Near a TV Transmit Antenna

When developing Model 2 it was necessary to :

- calculate the minimum value for the inner radius of the annulus required to avoid harmful interference to the LMS base receiver from the TV transmitter,
- calculate the value of the outer radius of the annulus that will result in a wanted (TV) to unwanted (LMS) ratio that is greater than or equal to the required TV receiver protection ratio for all TV receivers within the TV coverage area, and
- establish the relationship between annulus size and TV transmitter power.

Additionally, it was necessary to make certain assumptions regarding separation distances between LMS base stations and TV receivers, and LMS RCS and TV receivers. These assumptions are reflected in the Assignment Criteria at Section 3.4.

3.0 The Frequency Assignment Procedures

3.1 General

The frequency assignment procedures are to be applied only in the areas specified in Section 3.2; all other areas must retain the existing simple guardband arrangements. Additionally, the following general points in relation to the frequency assignment procedures should be noted:

- Model 1 is intended for land mobile base station assignments outside the coverage areas of TV channels 2, 3 or 6. However under this model RCS assignments are permitted some distance inside the TV coverage area.
- Model 2 is to be applied to the co-ordination of base stations located within the coverage areas of those TV channels. Note, however, that assignments in this category must not be made until field trials have verified that such assignments will not cause unacceptable interference to existing TV broadcast receivers.
- To maximise the protection provided to TV services, each LMS assignment made under Model 1 or 2 should be made as far as possible from the relevant TV channel edge.
- No special provisions have been made within this RALI for protection to TV receivers in poor reception areas, which often use masthead amplifiers to achieve acceptable reception. Assigning officers should be aware of the increased potential for interference to such receivers resulting from LMS assignments made under this RALI.
- Television translator/repeater stations should be afforded the same protection as TV receivers. Thus where distances are established for the siting of LMS base stations and RCSs from TV receivers or the 50 dB uV/m contour, these same distances apply to TV translators/repeaters.
- Coordination must also be carried out with other LMS services according to the criteria detailed in RALI LM1. To assist the assignment/co-ordination process, the CHANEL frequency assignment software should be used.
- The assignment procedures in this RALI are based on horizontally polarised TV services, and the resulting protection afforded to TV receivers against vertically polarised LMS transmitters. This RALI is not to be applied in areas where the TV service is vertically polarised.

3.2 Areas of Operation

The frequency assignment procedures specified in this RALI are to be applied only in the following areas:

- Sydney - Newcastle - Wollongong (NSW).
- Sunshine Coast - Brisbane - Toowoomba - Gold Coast (Qld).
- Ballarat (Vic).
- Perth - Bunbury (WA).

These areas correspond to the following horizontally polarised television services:

- Sydney - ABN2 Gore Hill.
- Newcastle - NBN3 Great Sugarloaf Mountain.
- Wollongong - WIN3 Brokers Nose.
- Brisbane - ABQ2 Mt Coot-tha.
- Ballarat - VTV 6 Lookout Hill.
- Perth - ABW2 Bickley.
- Bunbury - SSW3 Mt Lennard.

In all other areas where TV channels 2, 3 and 6 operate, the procedure previously applied for assignments in spectrum adjacent to these TV channels is to be used.

As Model 1 is applicable only to situations where LMS base stations are sited external to the TV service area, it may not be useful in those localities in the above list where the TV service area coincides with the HSD areas defined in the VHF Mid Band (70 to 87.5 MHz) and VHF High Band (148 to 174 MHz) Frequency Band Plans (Statutory rules Nos 355 and 354). Currently most TV Channel 3 and Channel 6 transmit antennas are located external to HSD areas, but many TV Channel 2 services are located inside HSD areas. Model 1 is therefore most likely to be useful in Channel 3 and 6 areas, and Model 2 in Channel 2 areas.

3.3 Frequency Assignment Model 1 - Procedure

3.3.1 General Guidelines

The following general guidelines should be observed when applying Model 1:

- When making an assignment under Model 1, a field strength contour map for the TV service which occupies the adjacent TV channel should be used for co-ordination. At the time of writing of this RALI, maps were not available for the ABN2 Sydney, WIN3 Wollongong , and SSW3 Bunbury TV services. For these services it will be necessary to determine the received TV signal strength by other means, such as conducting a field strength survey or by using a mathematical terrain model.
- The separation distances for LMS base stations are given in Appendix A, and are relative to the 50 dB uV/m field strength contour for the TV service. Note that all base stations should be sited external to the 50 dB uV/m contour.
- The separation distances for RCSs external to the TV service area are given in Appendix B, and are relative to the 50 dB uV/m field strength contour for the TV service.
- The separation distances for RCSs sited within the TV service area are given in Appendix C and are relative to the TV receiver nearest to the RCS. The location of the nearest TV receiver should be determined by the frequency assigning officer using his/her knowledge of the service area and any other relevant information.
- Mobile stations, due to their low potential to cause interference to TV receivers, do not need to be coordinated.

- Where two TV coverage areas of the same service overlap, it should be assumed for assignment purposes that the greater of the two field strengths is available to TV receivers within that area.

The following paragraphs provide guidelines specific to the TV services near which assignments under Model 1 may be made.

3.3.2 Specific Guidelines - Assignments in Spectrum Adjacent to TV Channel 2

The minimum distance that an LMS station can be assigned from a TV receiver in a Channel 2 service area is indicated by the line designated "Upper Adjacent Channel" on the graphs in Appendices A, B and C. M5: 3.3.3 Specific Guidelines - Assignments in Spectrum Adjacent to TV Channel 3

- The minimum distance that an LMS station can be assigned from a TV receiver in a Channel 3 service area is indicated by the line designated "Lower Adjacent Channel" on the graphs in Appendices A, B and C.
- In areas where spectrum between 85 MHz and 87.5 MHz has been "dropped through" by the Australian Broadcasting Authority (i.e. passed to the SMA to manage for radiocommunications purposes), assignments may be made in that band in accordance with the VHF Mid Band Frequency Band Plan. Note, however, that for the band 87.5 - 88 MHz, a RALI is being prepared to facilitate assignment of Low Power Open Narrowcasting (LPON) Services in areas where Channel 3 does not operate; and a 300 kHz guardband should be observed to protect these services.

Accordingly, in areas where an LPON service operates, no LMS base station or RCS assignments should be made in the 300 kHz below the 87.5 MHz LPON band edge.

3.3.4 Specific Guidelines - Assignments in Spectrum Adjacent to TV Channel 6

- The minimum distance that an LMS station can be assigned from a TV receiver in a Channel 6 service area is indicated by the line designated "Lower Adjacent Channel" on the graphs in Appendices A, B and C.
- Segments V and W of the VHF High Band should be observed as a guard band for assignments in the vicinity of a TV Channel 6 transmitter. No assignments should be made in these segments within 20 km of the 50 dB uV/m contour, or in the case of an RCS within the TV service area, within 20 km of the nearest TV receiver.
- Applicants for an area-wide LMS trunking licence should be assigned channels from the subband 165.19375 - 167 MHz (base transmit frequencies) only. However channels in the subband 167 - 168.19375 MHz (base transmit frequencies) may be assigned to trunking operators wishing to establish only a metropolitan or regional service, contingent on the location of TV Channel 6 services. Note that all assignments to LMS trunked services must accord with RALI 1/E/10.

3.4 Frequency Assignment Model 2 - Procedure

3.4.1 General Guidelines

The following general guidelines should be observed when applying Model 2:

- An LMS base station should not be located within 1.5 km of a TV receiver, and an LMS RCS should not be sited within 150 m of a TV receiver.
- Base stations and RCSs must not be assigned within the inner radius (measured from the TV transmit antenna) of the annulus given in Appendices D and E. Whether Appendix D or E is used depends on whether the assignment is adjacent to the upper or lower edge of a TV channel.
- Base stations and RCSs must not be assigned beyond the outer radius (measured from the TV transmit antenna) of the annulus given in Appendix F. The graphs at Appendix F plot outer radius as a function of frequency offset from the TV channel edge.
- It is possible that a TV receiver sited in close proximity to both the TV and LMS transmitters may suffer intermodulation interference if the received field strengths are collectively great enough to drive the TV receiver's front end into a non-linear state. Area offices should be aware of this possibility when considering a site for licensing under this model.
- After annulus radii have been established and a prospective site confirmed as falling within the radii, an assignment may only be made after field trials have been conducted. Such field trials require the prospective LMS licensee to demonstrate to the relevant broadcast operator, and the SMA, that the assignment(s) will not cause unacceptable TV interference.

The following paragraphs provide guidelines specific to the TV services near which assignments under Model 2 may be made.

3.4.2 Specific Guidelines - Assignments in Spectrum Adjacent to TV Channel 2

- For assignments adjacent to Channel 2, the inner radius of the annulus is determined by consulting the graph in Appendix D, which describes the inner radius of the annulus as a function of frequency offset from the upper edge of a TV channel.
- LMS base station or RCS assignments must not be made within 500 kHz of the upper edge of TV Channel 2. Within this frequency range the inner and outer radius graphs at Appendices D and F are not valid.

3.4.3 Specific Guidelines - Assignments in Spectrum Adjacent to TV Channel 3

- For assignments adjacent to Channel 3, the inner radius of the annulus is determined by consulting the graph in Appendix E, which describes the inner radius of the annulus as a function of frequency offset from the lower edge of a TV channel.
- In areas where spectrum between 85 MHz and 87.5 MHz has been "dropped through" by the Australian Broadcasting Authority (i.e. passed to the SMA to manage for radiocommunications purposes), assignments may be made in that band in accordance with the VHF Mid Band Frequency Band Plan. Note, however, that for the band 87.5 - 88 MHz, a RALI is being prepared to facilitate assignment of Low Power Open Narrowcasting

- (LPON) Services in areas where Channel 3 does not operate; and a 300 kHz guardband should be observed to protect these services.

Accordingly, in areas where an LPON service operates, no LMS base station or RCS assignments should be made in the 300 kHz below the 87.5 MHz LPON band edge.

3.4.4 Specific Guidelines - Assignments in Spectrum Adjacent to TV Channel 6

- For assignments adjacent to Channel 6, the inner radius of the annulus is determined by consulting the graph in Appendix E, which describes the inner radius of the annulus as a function of frequency offset from the lower edge of a TV channel. Segments V and W of the VHF High Band should be observed as a guard band for assignments in the vicinity of a TV Channel 6 transmitter. No assignments should be made in these segments within 20 km of the 50 dB uV/m contour, or in the case of an RCS within the TV service area, within 20 km of the nearest TV receiver.
- Applicants for an area-wide LMS trunking licence should be assigned channels from the subband 165.19375 - 167 MHz (base transmit frequencies) only. However channels in the subband 167 - 168.19375 MHz (base transmit frequencies) may be assigned to trunking operators wishing to establish only a metropolitan or regional service, contingent on the location of TV Channel 6 services. Note that all assignments to LMS trunked services must accord with RALI 1/E/10.

4.0 Licence Conditions

All licences issued under this RALI are to carry Special Condition No. **LK**. This Special Condition states the following:

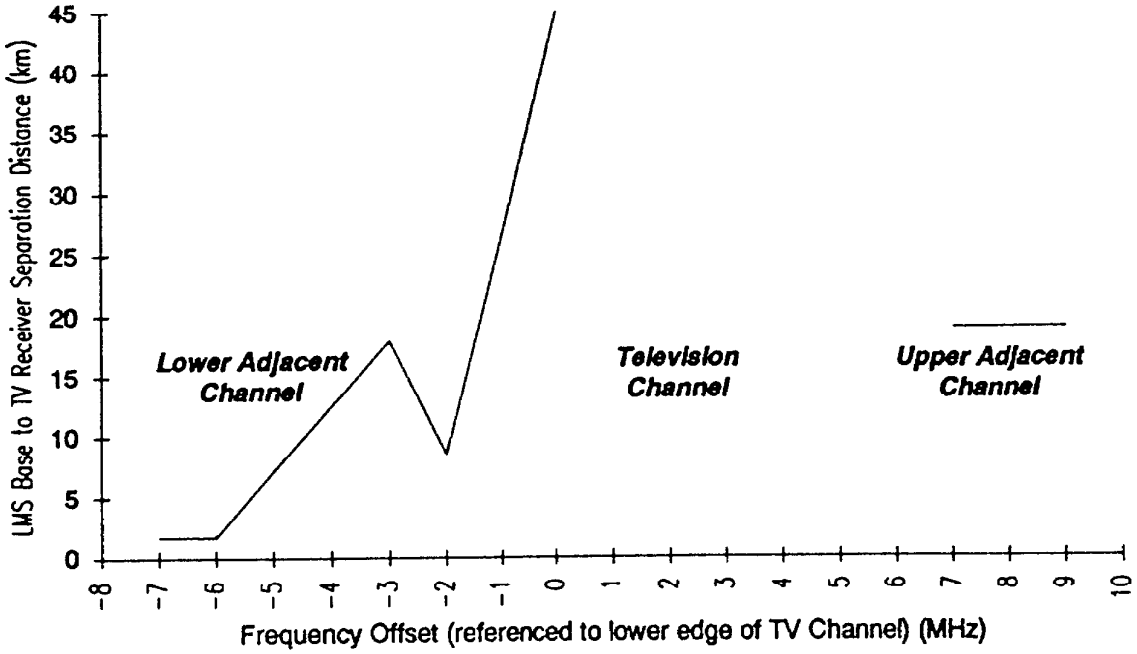
> "Unacceptable interference shall not be caused to television receivers tuned to television stations transmitting on channels 2, 3 or 6, where the receivers are sited within the 50 dB microvolts/metre field strength contour of the coverage area of those stations."

RALI Authorisation

Geoff Hutchins
Acting Executive Manager
Business Directions Group
Spectrum Management Agency

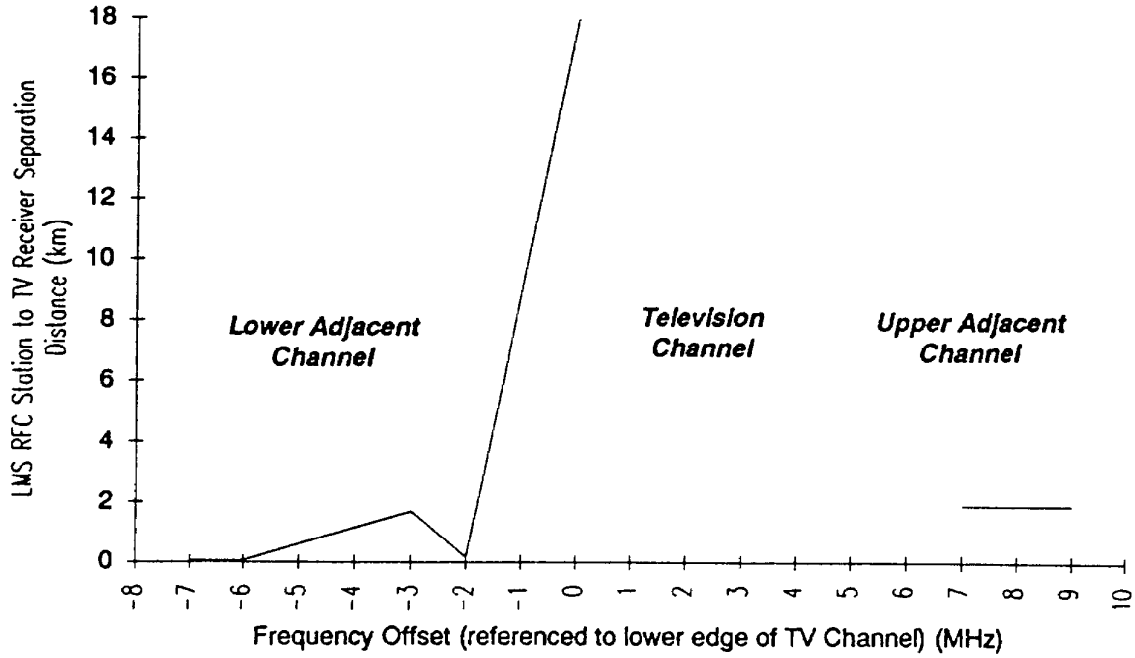
Appendix A

Model 1 : Frequency/Distance Separation Criteria for LMS Base Stations



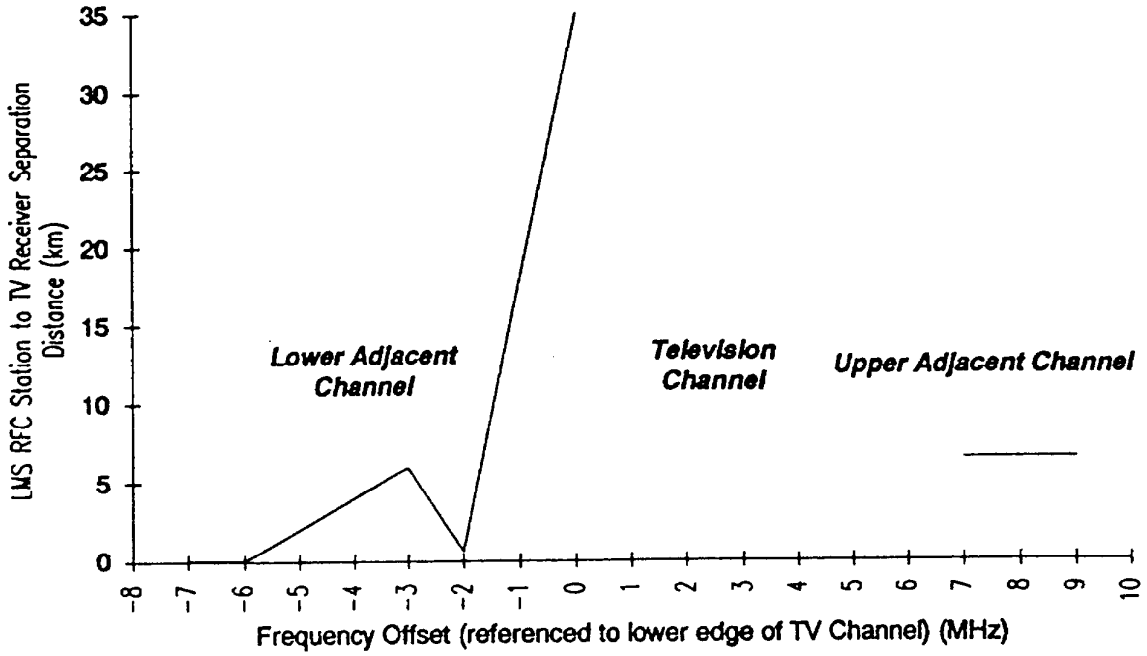
Appendix B

Model 1 : Frequency/Distance Separation Criteria
for an LMS RCS
External to a TV Service Coverage Area



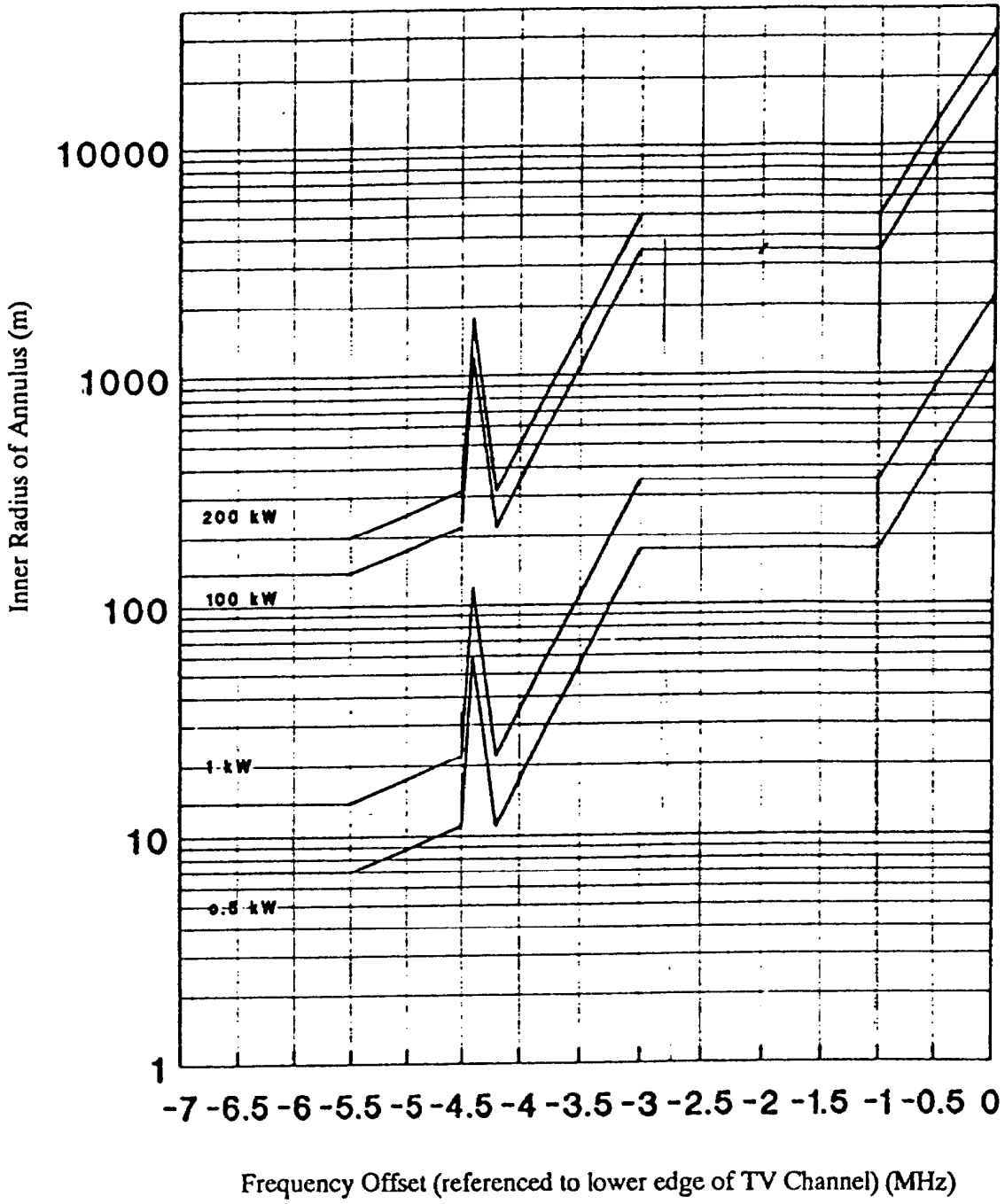
Appendix C

Model 1 : Frequency/Distance Separation Criteria
for an LMS RCS
Within a TV Service Area



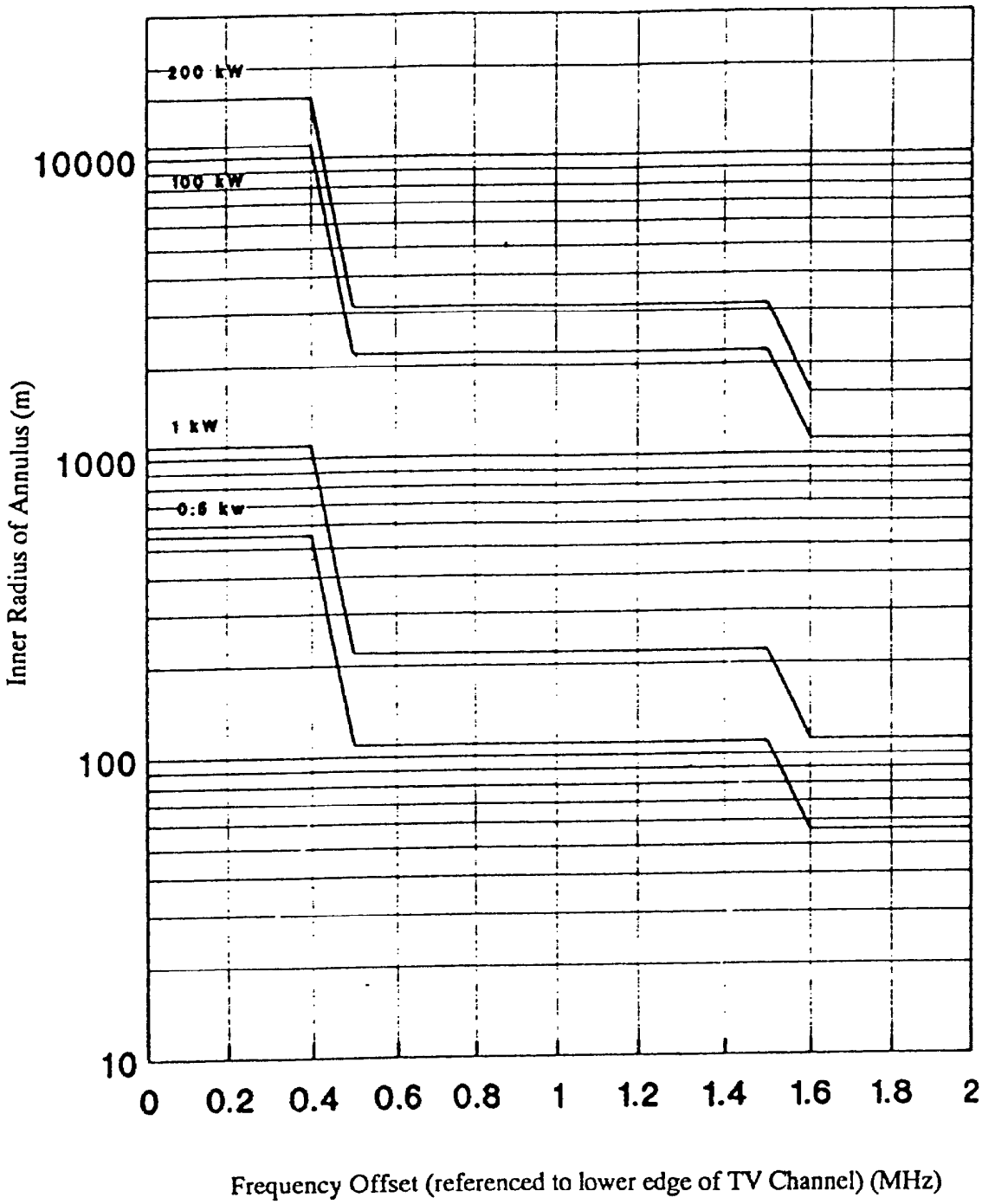
Appendix D

Model 2 : Inner Radius of Annulus vs. Frequency Offset from the Upper Edge of a TV Channel



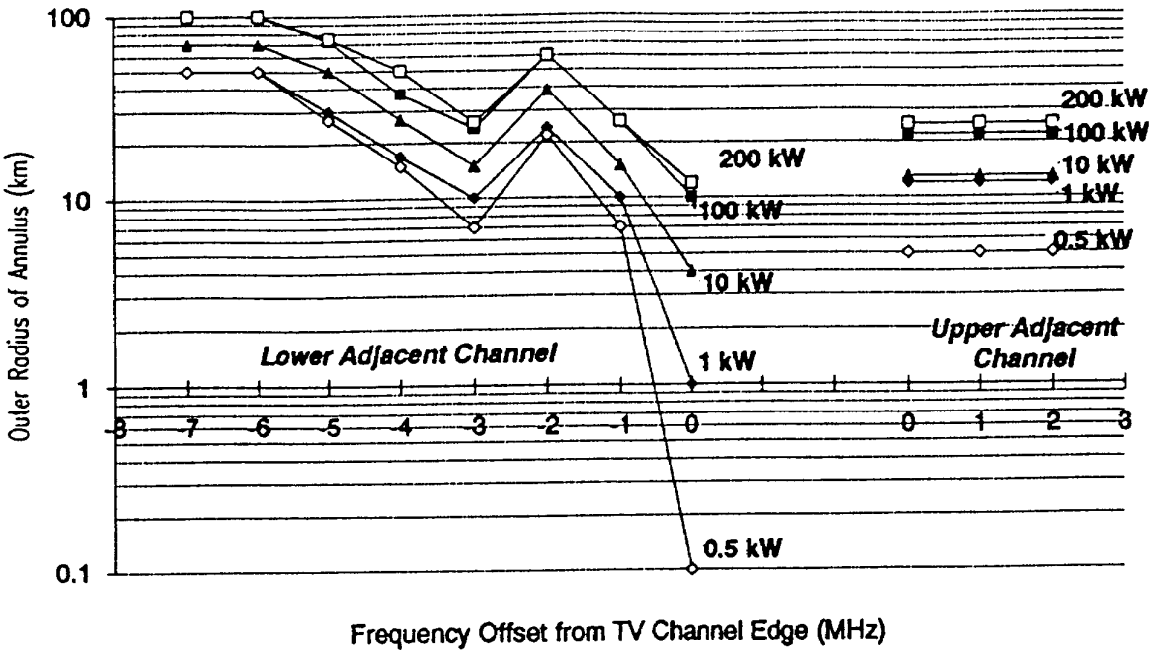
Appendix E

Model 2 : Inner Radius of Annulus vs. Frequency Offset from the Lower Edge of a TV Channel



Appendix F

Model 2 : Outer Radius of Annulus vs. Frequency Offset from a TV Channel



The curves shown have been developed for various TV transmitter powers.