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

GENERAL METHODOLOGY FOR ASSESSING COMPATIBILITY BETWEEN RADIO LOCAL AREA NETWORKS (RLANs) AND THE FIXED SERVIE

Oslo, December 1991

Reports are being issued from time to time by the European Radiocommunications Committee (ERC) of CEPT to inform industry, operators, users and other interested parties of the work in hand, provisional conclusions and future activities in specific areas of radio frequency management. Such Reports give more details than is normally possible in a Recommendation and allow an opportunity for comment to be made on the work carried out so far. In most cases, it would be hoped that a formal CEPT Recommendation could be issued on the subject of the Report in due course, taking into consideration any comments received on the Report.

Reports are formally approved by, and issued in the name of, the Committee itself. In general the detailed preparation of Reports, and further work on the subject, will be done by Working Groups or Project Teams. Thus, any reference in the Reports to the ERC should be taken to include the whole framework of the ERC, including its Working Groups, Project Teams, etc.

GENERAL METHODOLOGY FOR ASSESSING COMPATIBILITY BETWEEN RADIO LOCAL AREA NETWORKS (RLANs) AND THE FIXED SERVICE

Based on ERC Report I on harmonisation of frequency bands for Radio Local Area Networks (RLANs) the ERC has adopted CEPT Recommendation T/R 10-01 E recommending frequency bands and power levels to be used i RLANs.

The present ERC Report outlines the general methodology for assessing compatibility between RLANs using TDMA/TDD technology and stations of the fixed service in Appendix I and methodology for calculating interference between direct sequence spread spectrum systems and narrow band systems in Appendix 2.

The methodology described is intended for use by Administrations and users when performing compatibility calculations.

Appendix 1

GENERAL METHODOLOGY FOR ASSESSING COMPATIBILITY BETWEEN RADIO LOCAL AREA NETWORKS USING TDMA/TDD TECHNOLOGY AND FIXED SERVICES

1. INTRODUCTION

A report from the European Radiocommunications Committee within CEPT on "Harmonisation of frequency bands to be designated for Radio Local Area Networks" (ERC Report 1, Lisbon, February 1991) identifies three basic categories of Radio Local Area Networks (RLANs). The report notes that a RLAN has been developed which operates in the frequency band 18.8-19.2 GHz, uses TDMA/TDD technology and meets the requirements of Category (c) Systems, defined in the ERC Report 1 as giving "reasonable in-building penetration and medium data rates (at least 10-15 Mbits.)". In many CEPT countries, this frequency range is used to accommodate a dense network of fixed links, consequently a methodology has been developed to assess the compatibility between this type of RLAN and the fixed service. The methodology is sufficiently flexible to be used for similar sharing situations in any frequency range.

2. ASSESSMENT OF COMPATIBILITY

In order to assess the compatibility between systems, it is necessary to specify a system performance criterion which must not be degraded beyond a desired minimum level. This can usually be related to the maximum permissible level of received interference power in a reference bandwidth, or the minimum value for the carrier to interference (C/I) ratio.

By using either of these parameters, together with a suitable propagation model and the effective radiated power of the interfering source (in the direction of the receiver to be protected), the minimum separation distance between the different systems can be calculated.

As the separation distance decreases, fewer systems will be within the co-ordination range, so, at certain distance, the probability of interference between systems will be sufficiently low such that co-ordination may be considered unnecessary.

3. THE COMPATIBILITY MODEL

The compatibility model is derived from a series of system loss/gain equations combined into a single equation which enables the separation distance to be calculated.

The definitions for all the terms used are listed at Annex 1.

3.1 Power level received from the interfering source

The example RLAN considered (most RLANs will have a similar basic configuration) comprised a number of user modules (at each computer terminal) which communicate with, and via, a central control module. The control module and each user module must be considered as potential interfering sources; the received power into the fixed service receiver is given by the following equations:

Equ. 1 $P_u - T_u + G_u - L_{uf} - B + G_f(v)$

Equ. 2 $P_c - T_c + G_c - L_{cf} - B + G_f(v)$

3.2 Minimum attenuation required between systems

By substituting the maximum permissible interference power level (1) for the fixed service for the terms P_u and P_c in equations 1 and 2 above, and rearranging, equations can be obtained for the necessary attenuation between systems:

Equ. 3 $L_{uf} > T_u + G_u - B + G_f(v) - I$

and

Equ. 4 $Lc_f > T_c + G_c - B + G_f(v) - I$

Annex 1 (note 3) gives a detailed consideration of the value for (I). Table 1 lists values of (I) for various fixed systems.

3.3 Geographical separation requirements

The necessary isolation can be provided by the propagation loss obtained by geographical separation of the systems.

A first approximation of the minimum separation distance can be determined by using the simple free space path loss equation:

Equ. 5 $Lbf = 92.45 + 20 \log(f) + 20 \log(d)$ (dB)

where f = frequency (GHz); d = distance (km).

Alternatively, more detailed propagation models call be used which take into account diffraction loss, urban clutter, etc.

Where derailed terrain height and ground cover information is available, deterministic models may be applied to accurately calculate attenuation along the interference path using computer based prediction tools.

EXAMPLE CALCULATION

Fixed Link Parameters
(reference: CCIR IWP9/6)
I_{max} = – 147 dBW/MHz (Long term)
f = 18 GHz
Gf(0) = 45 dBi
Elevation = 0°
See Annex 1, Note 3 for more information on the value for I_{max}.

RLAN Parameters

PARAMETER		User Module		Control Module	
		Best	Worst	Best	Worst
Peak transmit power	(dBW/MHz)	– 28	– 28	– 28	– 28
Antenna Gain	(dBi)	0	10	0	10
Building Loss	(dB)	{ 25	0	0	0
Window Loss	(dB)	{		5.6	0
Apparent e.i.r.p. density	(dBW/MHz)	– 43	– 18	– 33.6	– 18

Required separation distance (using equation 5)

Fixed link Antenna offset from boresight (v°)	Gain of fixed link antenna Gf(v°) dBi (from Annex 2)	Separation distance (d) km			
		User Module		Control Module	
		Best	Worst	Best	Worst
0	45	12	664	110	664
5	22	0.8	47	7.8	47
10	10	0.2	11.8	1.9	11.8
20	5	0.1	6.6	1.1	6.6
40	– 1	0.06	3.3	0.6	3.3
80	– 12	0.02	0.9	0.2	0.9

Results of detailed sharing analysis using computer based sharing analysis tools were made available to the project team by one Administration. The results were presented in graphical format, showing the interference zone around the fixed link receiver site as a series of colour contours corresponding to various values of effective RLAN e.i.r.p. (after building attenuation). The results of the detailed analysis indicated separation distances comparable to those indicated in the above table.

Annex 1

DEFINITION OF TERMS

where

P_u	=	Power from the RLAN user module received by the fixed service receiver (dBW/MHz).
P_c	=	Power from the RLAN control module received by the fixed service receiver (dBW/MHz).
T_u	=	RLAN user module transmitter power (dBW/MHz).
T_c	=	RLAN control module transmitter power (dBW/MHz).
G_u	=	Gain of RLAN user module antenna in direction of fixed service receiver (dBi).
G_c	=	Gain of RLAN control module antenna in direction of fixed service receiver (dBi) (see *Note 2*).
$G_f(v)$	=	Gain of fixed service antenna in direction v° off boresight (dBi).
L_{uf}	=	Path loss between RLAN user module transmitter and fixed link receiver (dB).
L_{cf}	=	Path loss between RLAN control module transmitter and fixed link reveiver (dB).
B	=	Building penetration loss (dB) (see *Note 1*).
I	=	Maximum permissible interference to fixed service (dBW/MHz).

NOTE 1.

The term B represents the effective reduction in e.i.r.p. of the RLAN resulting from confinement within the building. This is a combination of building penetration loss, in-building propagation effects, and the RLAN antenna directivity. In the case of the example RLAN, the user module antenna is designed to automatically direct energy into the room. The control module, if mounted in a room with a window, would, in the best case, have the penetration loss of glass, and in the worst case (window open) have no attenuation.

NOTE 2.

Assuming that the fixed link antenna radiation pattern, $G_f(v)$, is rotationally symmetric around boresight, the fixed link antenna gain in the direction x degrees from the fixed link azimuth and y degrees from the fixed link elevation, $G(\vartheta,\varphi)$, may be determined by first calculating the net separation angle from the boresight direction, υ, using equation 38 in Appendix 28 to the Radio Regulations. With the simplifying assumption that the elevation of the fixed link antenna is zero degrees, the net separation angle is given by:

$\cos \upsilon = \cos \vartheta \cos \varphi$

Preferably, radiation pattern envelopes derived from measured antenna patterns should be used (see Annex 2). In cases where these are not available, the off axis antenna performance characteristics given in CCIR Recommendation 699 should be applied:

$G = 52 - 10 \log (D/\lambda) - 25 \log \upsilon$ dBi for $(100\ \lambda/D)^\circ \leq \upsilon < 48^\circ$

$= 10 - 10 \log (D/\lambda)$ dBi for $48^\circ \leq \upsilon < 180^\circ$

where D and λ are in the same units.

The boresight gain may be estimated from the antenna diameter, D_r assuming efficiency factor $^n = 0.6$:

$$G(0) = \frac{\eta 4\pi A}{\lambda^2} \qquad \text{where:} \qquad A - \pi\left(\frac{D}{2}\right)^2$$

NOTE 3.

The specified interference powers listed in Table 1 will limit the degradation in the system fade margin to 0.5 dB and are intended for sharing between co-primary services. For sharing on a secondary basis, tighter interference criteria may be appropriate.

Note that the term I is the limit of aggregate interference to the fixed link from RLANs. Where interference can simultaneously occur from more than one RLAN transmitter, the single entry interference criterion must be reduced accordingly.

ANNEX 2

Annex 2

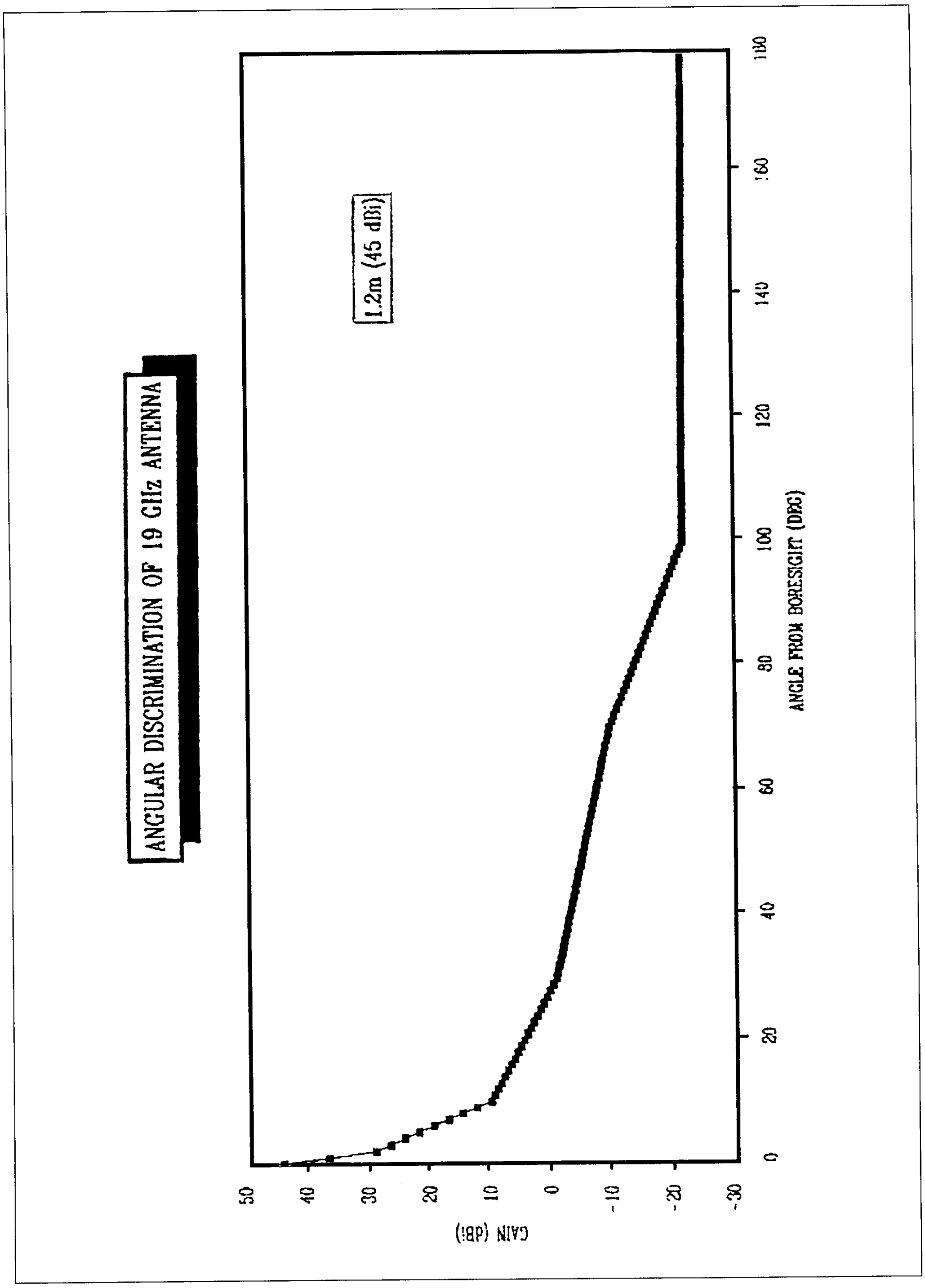
ANGULAR DISCRIMINATION OF 19 GHz ANTENNA
1.2m (45 dBi)
GAIN (dBi)
50
40
30
20
10
0
-10
-20
-30
ANGLE FROM BORESIGHT (DEG)
0
20
40
60
80
100
120
140
160
180

Table 1: PTO 18 GHz fixed services

FREQUENCY BAND (GHz)	17.7-19.7						
MODULATION	QPSK	4QAM	2FSK	4FSK	QPSK	BPSK	QPSK
CAPACITY	140 Mbit/s	140 Mbit/3	8 Mbit/s	8 Mbit/s	8 Mbit/s	8 Mbit/s	34 Mbit/s
CHANNEL PLAN	Rec. 595-1	Rec. 595-1	Rep. 936-1	Rep. 936-1	Rep. 936-1	Rep. 936-1	Rec. 595-1
CHANNEL SPACING (MHz)	110	55	20	20	20	20	27.5
ANTENNA GAIN [MAX] (dB)	48	48	45	45	45	45	45
ANTENNA GAIN [TYP] (dB)	43	43	45	38	38	38	38
FEEDER/MUX LOSS [MIN] (dB)	7	7	0	0	0	0	0
FEEDER/MUX LOSS [TYP] (dB)	10	10	3	3	3	3	3
ANTENNA TYPE [TYP]	0.3-1.8 m	0.3-1.8 m	0.6-1.2 m	0.3-1.2 m	0.3-1.2 m	0.3-1.2 m	0.3-1.2 m
ANTENNA R.P.E.	RC6691A	RC6691A	RC6691A	RC6691A	RC6691 A	RC6691A	RC6691A
MAX Tx OUTPUT POWER (dBW)	- 10	- 4	- 12	- 16	- 6	- 9	- 8
TYPICAL Tx OUTPUT POWER (dBW)	- 10	- 4	- 12	- 16	- 6	- 9	- 10
e.i.r.p. [MAX] (dB)	31	37	33	29	39	27	37
e.i.r.p. [TYP] (dB)	23	29	30	19	29	23	25
RECEIVER IF BANDWIDTH [3dB] (MHz)	68	68	4	8	4	8	18
RECEIVER NOISE FIGURE (dB)	7	8	11	13	7	7	7
RECEIVER THERMAL NOISE (dBW)	- 119	- 118	- 127	- 122	- 131	- 128	- 124
NOMINAL Rx. INPUT LEVEL (dBW)	-63	- 64	- 72	- 65	- 65	- 65	- 65
Rx I/P LEVEL FOR 10 E-3 BER (dBW)	-103	- 104	- 111	- 106	- 116	- 116	- 113
Rx I/P LEVEL FOR 10 E-6 BER (dBW)	-99	- 100	- 107	- 102	- 112	- 112	- 110
Rx I/P LEVEL FOR 10 E-10 BER (dBW)	-95	- 96	- 103	- 99	- 109	- 108	- 107
TYPICAL FADE MARGIN (dB)	40	40	35	50	50	40	45
TYPICAL SPAN LENGTH (km)	1-12	1-15	1-15	1-15	1-25	1-25	1-20
MAX. LONG-TERM INTERFERENCE (dBW)	- 129	- 131	- 137	- 132	- 141	- 138	- 134
Refer to notes	(B), (1)	(B), (1)	(B), (1)	(B), (1)	(B), (1)	(B), (1)	(B), (1)
EQUIVALENT P.S.D. (dBW/MHz)	- 147	- 149	- 143	- 141	- 147	- 147	- 147

NOTES.

(A) Specified interference will reduce system C/N by 1 dB (interference 6 dB below receiver thermal noise floor).
(B) Specified interference will reduce system C/N by 0.5 dB (interference 10 dB below receiver thermal noise floor).
(C) FS/FSS sharing on a co-primary basis (see method in CCIR Reps. 382/448 and Appendix 28 to the Radio Regulations).

(1) The specified interference level is total power within the receiver 3 dB bandwidth
(2) The specified interference level should be divided by the receiver 3 dB bandwidth to obtain an average spectral density
(3) The interference spectral density, averaged over any 4 kHz within the receiver 3 dB bandwidth, must not exceed this value

APPENDIX 2

METHODOLOGY FOR CALCULATING INTERFERENCE BETWEEN DIRECT SEQUENCE SPREAD SPECTRUM SYSTEMS AND NARROW BAND SYSTEMS

INTRODUCTION

This document comprises two sections, the first gives a methodology for calculating the interference caused to a narrow band transmission from spread spectrum interference. The second section considers the reverse case of narrow band interference to spread spectrum transmissions.

METHODOLOGY FOR CALCULATING SPREAD SPECTRUM INTERFERENCE TO NARROW BAND TRANSMISSIONS

Note

All parameters and results should be expressed in dBs.

Assumptions

1) A typical e.i.r.p. can be defined for the spread spectrum interferer.
2) Free space propagation is assumed (as defined in CCIR Recommendation 525-1).
3) All spread spectrum transmitters transmit on the same centre frequency and spread their signals over the same bandwidth.

Definitions

$eirp_{SS}$	Typical e.i.r.p. per spread spectrum transmitter in the direction of the narrow band receiver.
D_I	Distance between spread spectrum interferer and the narrow band receiver.
N	Number of spread spectrum transmitters causing interference to narrow band system.
I_r	Interference power at narrow band receiver originating from a single spread spectrum interferer.
I_R	Total interference power at the narrow band receiver from spread spectrum transmissions.
I_{RN}	Total interference power contained within the receiver bandwidth of the narrow band receiver.
f_{cs}	Centre frequency of the interfering spread spectrum transmission.
f_{cn}	Centre frequency of the narrow band transmission.
$G(\vartheta,\varphi)_{nb}$	Gain of the narrow band receiving antenna in the direction of the spread spectrum transmitter.
$eirp_{nt}$	Effective isotropically radiated power from the narrow band transmitter in the direction of the narrow band receiver
D_w	Distance separation between the narrow band transmitter and receiver.
P_{NR}	Power received at the narrow band receiver.
N_T	Total thermal noise within the narrow band receiver.
λ_{cs}	Centre wavelength or the spread spectrum transmission.
λ_{cn}	Centre wavelength of the narrow band transmission.
T_c	Chip rate.
k	Added margin to account for out of band interference, adjacent channel interference, etc.
M	Carrier to interference ratio required to ensure satisfactory operation.

Methodology

Calculation of interference power (spread spectrum signal)

Figure 1 shows a schematic diagram which details the points where interference from the spread spectrum system can be calculated using this methodology.

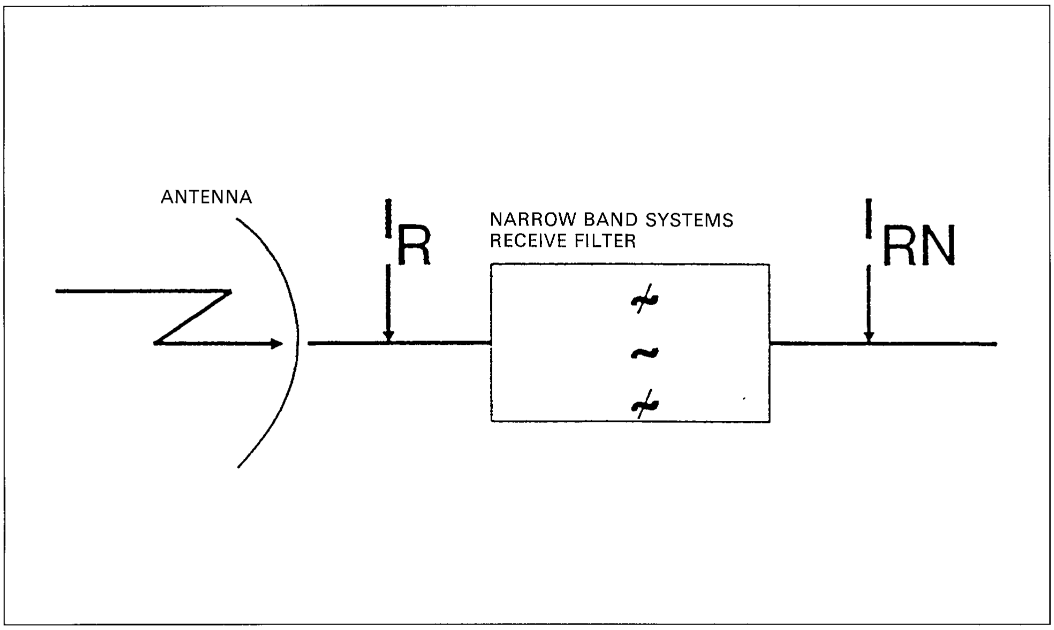

Figure 1. Points where received interference is calculated.

The interference power (I_r) received at the narrow band receiver due to a single spread spectrum transmission can be found using equation 1.

Equ. 1 $$I_r = eirp_{ss} + G(\vartheta,\varphi)_{nb} - 20\ log\ \frac{4\pi D_I}{\lambda_{cs}}$$

This equation assumes that free space propagation is considered, if any other propagation model is used (see CCIR Recommendation 370) or a measured value for loss is available, the term $[-20\ \log_{10} 4\pi D_I/\lambda_{cs}]$ can be replaced by that loss (L), this gives equation 2.

Equ. 2 $$I_R = eirp_{ss} + G(\vartheta,\varphi)_{nb} - L$$

In a spread spectrum interfering environment, more than one interfering transmission may occur simultaneously. To calculate the total interference received, the contribution from each source must be summed, note that the summation is of absolute powers and not dBs. This equation (equation 3) assumes a non-statistical addition of powers, an other summation method, which takes account of the statistical nature of interference is given in CCIR Rep. 945 (Simplified multiplication method for the assessment of interference).

Equ. 3 $$I_R = 10\ \log_{10} \sum_{n=1}^{N} \lambda^2_{cs} \times \frac{10^{\frac{eirp_{ss} + G(\vartheta_n,\varphi_n)}{10}}}{(4\pi D_{In})^2}$$

Where the subscript 'n' denotes the distance and direction to the n^{th} spread spectrum transmitter.

This interference power is obtained at the input to the narrow band receiver. Figure 2 below shows the power spectrum for a typical direct sequence spread spectrum signal. This spectrum has a $\left(\frac{\sin x}{x}\right)^2$ distribution with the first nulls at $f_{cs} \pm 1/T_c$. Two arbitrary points have been marked on the curve, f_l and f_u. These denote the lower and upper receiving band limits respectively for the narrow band receiver.

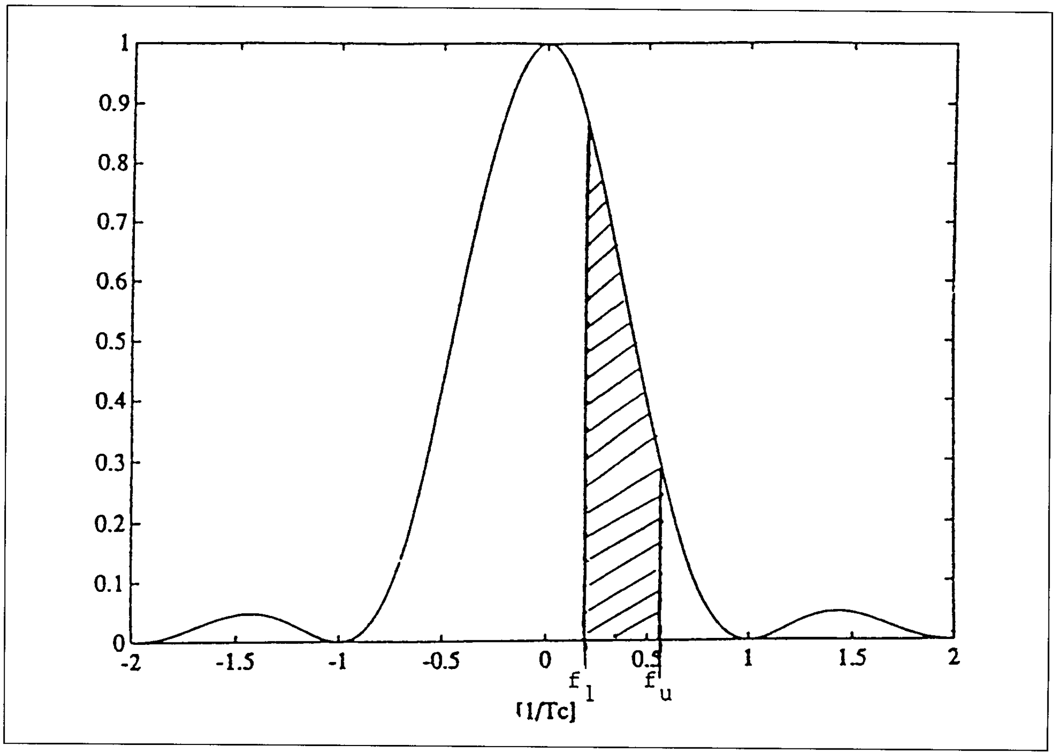

Figure 2. The ideal normalized spectrum of a direct sequence spread spectrum signal.

The total interference power from the spread spectrum signal which occurs within the receiving bandwidth of the narrow band receiver must now be calculated. To find this the peak level of the spread spectrum interfering signal must be found, the peak level is found by dividing the total power in the spread spectrum signal by the bandwidth of that signal. Equation 4 expresses this in terms of the chip rate of the spread spectrum signal, and converts the result to dBs.

Equ. 4 $$I_{peak} = I_R + 10 \log_{10} (T_c/2)$$

Once this is found, the spread spectrum signal's power spectrum (figure 2) can be integrated between the limits f_u and f_l to find the total interference power within the narrow band receiver's bandwidth.

Equ. 5 $$I_{RN} = I_{peak} \int_{f_l}^{f_u} \left[\frac{\sin (\pi T_c f)}{\pi T_c f} \right]^2 df$$

Calculation of wanted signal (narrow band signal)

The power received at the narrow band receiver from the narrow band transmitter can be calculated as follows (assuming that the transmitting narrow band antenna is located in the boresight orientation of the receiving antenna);

Equ. 6 $$P_{NR} = eirp_{nt} + + G(0,0)_{nb} - 20 \log_{10} \frac{4\pi D_w}{\lambda_{cn}}$$

As in equation 1, the free space loss term [20 $\log_{10} 4\pi D_I/\lambda_{cs}$] in equation 7 can be replaced by either an other loss model (see CCIR Recommendation 370) or a measured value.

Calculation of total interference

The spread spectrum interferer will not be the only source of interference to the narrow band system, other sources will include; thermal noise (N_T), co-channel narrow band interference, adjacent channel narrow band interference and others. In equation 7 an extra margin (k) is included to account for interference sources other than those emanating from the co-channel spread spectrum system and thermal noise.

Equ. 7 $$P_{NR} - (I_{RN} + k + N_T) > M$$

Provided the inequality in equation 7 is met, a direct sequence spread spectrum system can share with a narrow band system.

METHODOLOGY FOR CALCULATING NARROW BAND INTERFERENCE TO SPREAD SPECTRUM TRANSMISSIONS

Note

All parameters and results are specified in dBs.

Assumptions

1) Free space propagation is assumed throughout the calculation (see CCIR Ref. 525-1).

Definitions

$eirp_{ss}$	e.i.r.p. of a typical spread spectrum transmission in the direction of the spread spectrum receiver.
P_{sp}	Power in the de-spread information at the spread spectrum demodulator.
$eirp_{ns}$	e.i.r.p. of the narrow band interferer in the direction of the spread spectrum receiver.
I_{ns}	Total power received from the narrow band interferer at the spread spectrum receiver.
I_{np}	Power in the 'spread' narrow band signal within the information bandwidth of the wanted signal.
D_w	Distance between the spread spectrum transmitter and receiver.
D_i	Distance between the narrow band transmitter and the spread spectrum receiver.
$G(\vartheta, \varphi)_{ss}$	Gain of the spread spectrum receiving antenna in the direction of the spread spectrum transmitter.
$G(\vartheta,\varphi)_{sn}$	Gain of the spread spectrum receiving antenna in the direction of the narrow band transmitter.
BW_I	Information bandwidth of the spread spectrum transmission.
BW_T	Transmission bandwidth for the spread spectrum signal.
f_{cs}	Centre frequency of the spread spectrum transmission.
f_{cn}	Centre frequency of the narrow band transmission.
PG	Processing gain.
N_T	Thermal noise.
λ_{cs}	Centre wavelength of the spread spectrum transmission.
λ_{cn}	Centre wavelength of the narrow band transmission.
k	Added margin to account for out of band interference, adjacent channel interference, and the loss in processing gain due to the physical realisation of the spread spectrum receiver, etc.
M	Carrier to interference ratio required to ensure satisfactory operation.

Methodology

Calculation of wanted signal (spread spectrum signal)

In a spread spectrum system the data to be transmitted will have an information bandwidth BW_I, this is spread across a bandwidth BW_T by the spread spectrum modulator, the ratio of BW_T to BW_I is the processing gain (PG) of the spread spectrum system. At the spread spectrum demodulator the 'spread' transmission is de-spread back to its original bandwidth and any interfering signals are spread over the bandwidth BW_T. Figure 3 shows a schematic representation of this.

The signal received at the spread spectrum receiver as a result of the spread spectrum transmission can be calculated using equation 8, given below.

Equ. 8 $$P_{sp} = eirp_{ss} + G(\vartheta,\varphi)_{ss} - 20 \log_{10} \frac{4\pi D_w}{\lambda_{cs}}$$

This equation assumes that free space propagation is considered, if any other propagation model is used (see CCIR Recommendation 370) or a measured value for loss is available, the term $20 \log_{10} 4\pi D_I/\lambda_{cs}$ can be replaced by that loss (L). Thus equation 8 becomes:

Equ. 9 $$P_{sp} = eirp_{ss} + G(\vartheta,\varphi)_{ss} - L$$

Once this signal has been received by the spread spectrum demodulator it is de-spread back to the original data signal.

Calculation of interference power (narrow band signal)

The level received at the spread spectrum demodulator due to a narrow band interfering signal can be calculated using a similar technique to that used to calculate the wanted signal. Equation 10 is used to calculate the received power in the interfering narrow band signal before it is 'spread' by the spread spectrum demodulator.

Equ. 10 $$I_{ns} = eirp_{ns} + G(\vartheta,\varphi)_{sn} - 20 \log_{10} \frac{4\pi D_i}{\lambda_{cn}}$$

After demodulation by the spread spectrum receiver, the narrow band interferer is spread over a bandwidth BW_T Figure 4 shows the idealized output from the spread spectrum demodulator.

The bandwidth occupied by the wanted spread spectrum signal once it has been de-spread is taken to have an upper frequency limit f_u and a lower frequency f_l. These limits are symmetrical about the centre frequency of the spread spectrum transmission. The narrow band interferer which is now spread across the bandwidth BW_T is centred on the centre frequency of the narrow band transmission. The level of interference experienced by the spread spectrum signal from the narrow band interiors its determined by the peak level of the 'spread' narrow band signal, the relative positions of the signals centre frequency's find the information bandwidth BW_I.

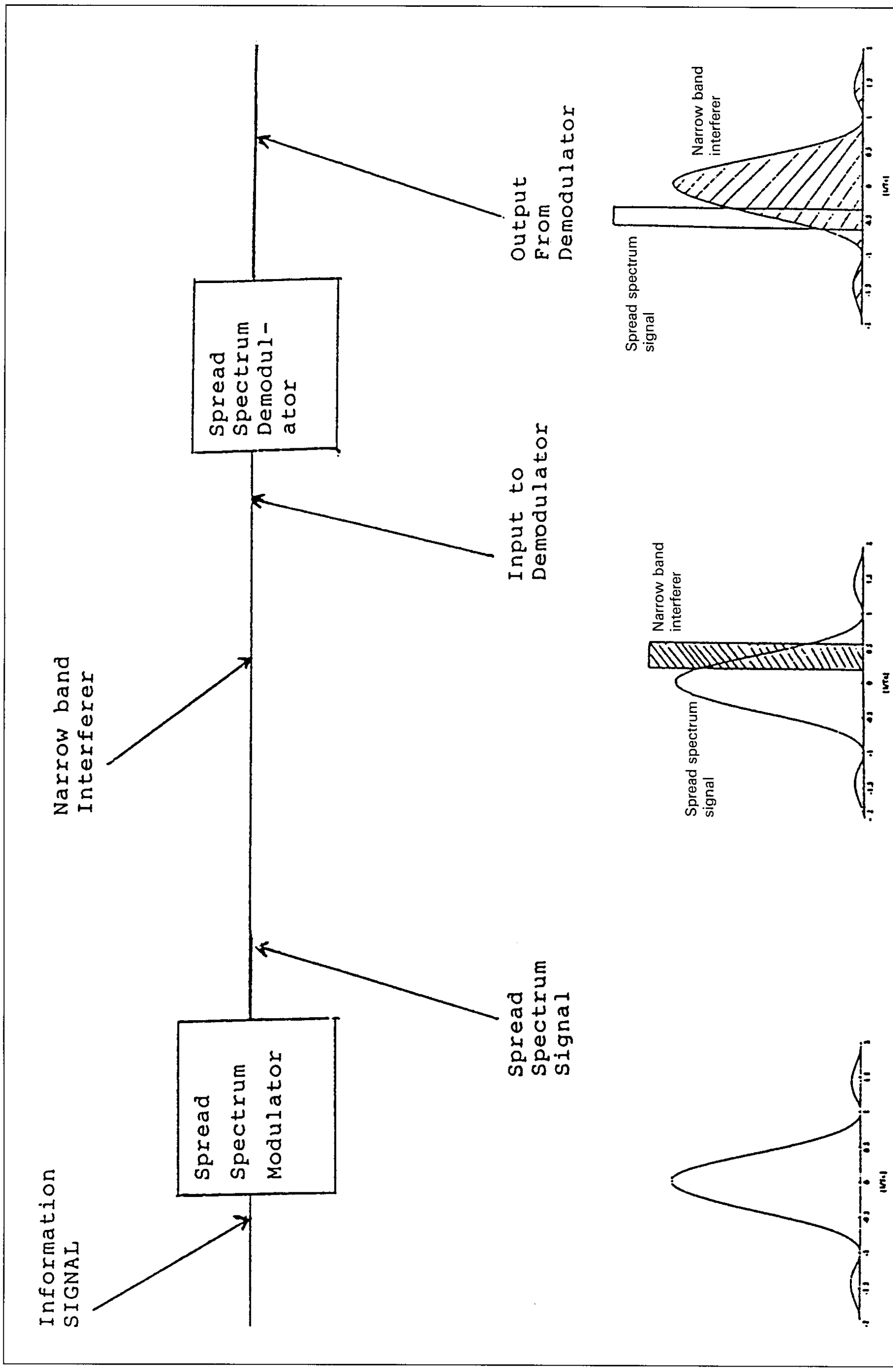

Figure 3. Schematic representation of a spread spectrum transmission.

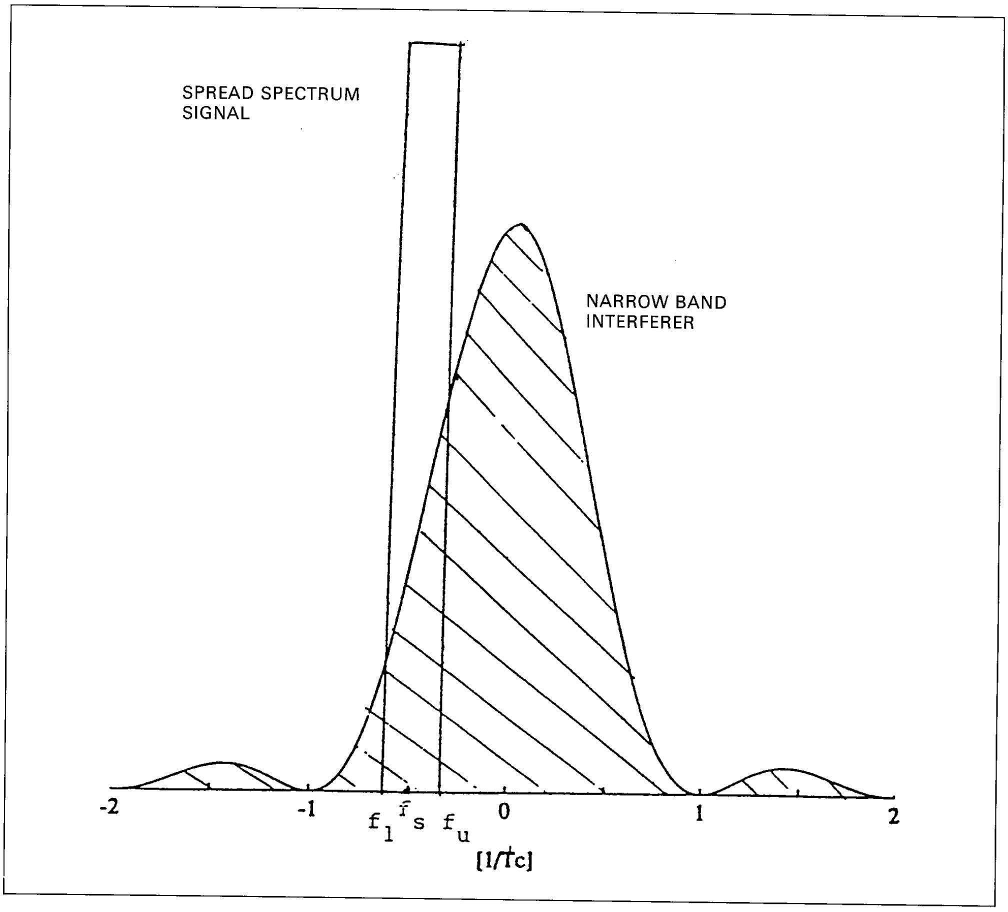

Figure 4. The output from the spread spectrum demodulator.

The interference in the spread spectrum systems information bandwidth due to the narrow band transmission is found by integrating the 'spread' narrow band signal between the limits f_u and f_l, as shown in figure 4; to perform this integration the peak interference level caused by the narrow band signal must be found, using

Equ. 11 $I_{peak} = I_{ns}/BW_T$

Once this peak interference level has been found the following integration can be performed:

Equ. 12 $$I_{np} = I_{peak} \int_{f_l}^{f_u} \sin[\frac{(\pi \frac{BW_I}{2} f)}{(\pi \frac{BW_I}{2} f)}]\, df$$

Calculation of total interference

In order to ensure satisfactory operation in the spread spectrum system, the power received from the spread spectrum transmission must be greater than the total unwanted signal by a margin (M). The unwanted signal is comprised of a number of signals, these include the interfering narrow band signal, thermal noise, other spread spectrum signals, etc. A factor k is included to account for sources of interference, other than thermal noise and the 'spread' narrow band interferer. Inefficiency in the spread spectrum receiver which reduce its processing gain is also accounted for in the factor (k). Equation 13 expresses the required inequality mathematically.

Equ. 13 $P_{sr} - (I_{nb} + N_T + k) > M$

Provided that this inequality is met, satisfactory direct sequence spread spectrum operations can take place in the presence of a narrow band interference.

GENERAL METHODOLOGY FOR ASSESSING COMPATIBILITY BETWEEN RADIO LOCAL AREA NETWORKS USING FREQUENCY HOPPING SPREAD SPECTRUM TECHNOLOGY AND NARROW BAND SYSTEMS

1. INTRODUCTION

CCIR Report 652 "Considerations of interference from spread spectrum systems to conventional voice communications" gives a method for calculating the interference power within the IF filter bandwidth of a conventional communication system from an FH spread spectrum system. The method assumes that, for conventional communication systems, approximately the same performance would be obtained for a given amount of undesired power within the IF filter resulting from an FH signal or a pulsed signal. An FH signal randomly occurs on a channel, while a pulsed signal occurs regularly. However, with a repeating pseudo-random sequence, an FH signal will have very nearly the same effect as a periodic pulsed signal.

2. The compatibility Model

The interference power within the IF filter bandwidth of the victim receiver can be obtained from:

Equ. 1 $$I_{IF} - I_E - G_R + 10 \log (\tau_f I_f) + 10 \log \left[\sum_{I-1}^{1-n_f} R(\Delta f_I) \right] - L$$

Where:

I_E = The e.i.r.p. of the interfering FH transmitter.
G_R = The antenna gain of the receiving system in the direction of the interfering FH transmitter.
τ_f = The dwell time in seconds on each carrier frequency.
r_f = The mean rate of occurrence in occurrences/second of each carrier frequency.
n_f = The number of frequencies used for hopping.
L = Path Loss between FH transmitter and victim receiver.
Δf_i = The difference between the i[th] carrier frequency of the FH interfering transmitter and the receiver-tuned frequency.
$R(\Delta f_I)$ = The numerical value of the off tune rejection to the interfering FH carrier provided by the receiver filter characteristic.

3. REQUIRED SEPARATION DISTANCE

The required separation distance can be obtained by using equation 1, a suitable propagation model for L and the required C/I ratio for the wanted signal.