Building Shielding Loss at 5GHz

An RTCG Project Report

3rd September 1997

The Radiocommunications Agency is an Executive Agency of the Department of Trade and Industry (www.radio.gov.uk)

Radiocommunications Agency

Radio Technology & Compatibility Group

Building Shielding Loss at 5GHz

Amended Report

Prepared for
Annette Henley and Steve Bond

RTCG Project no. 424

27th October 1997

Project Engineer: Peter Burton
C.Eng., M.I.E.E.

Issue Approved : Peter Burton

Date 27th October 1997

RADIOCOMMUNICATIONS AGENCY
Radio Technology & Compatibility Group,
Whyteleafe Hill,
WHYTELEAFE,
Surrey. CR3 OYY

Tel. Int. +44-(0)181-763-4004
Fax. Int. +44-(0)181-668-9856

Contents

1.0 Abstract

Concern has been expressed within CEPT SE 28 about the possibility that widespread deployment of HIPERLAN devices may cause excessive aggregate interference to MSS fixed earth-to-space links.

There is some dispute over the density, power levels and dispersion of HIPERLANs across Europe that would be necessary to cause a significant aggregate level of interference. One of the parameters on which there is a divergent view between the Satellite Operators and ETSI EP BRAN members is the figure to use for the "Building Shielding Ratio" in any interference calculations.

This paper draws together the results of a number of measurements carried out by several different organisations throughout Europe and U.S.A. and concludes with a single figure that is shown to be representative of many hundreds of such measurements. This, therefore, suggests that previous work in SE28 may have assumed too low a figure for Building Shielding Loss.

2.0 Introduction

At a CEPT SE 28 meeting held in London on 28/29th May 1997, some concern was shown by the Satellite representatives about the possibility of large numbers of HIPERLAN devices causing excessive aggregate interference to the MSS fixed earth-to-space links in the 5GHz band.

There have been several documents presented by both parties detailing a number of parameters on which calculations of interference may be made. One of the parameters on which there is a divergent view between the Satellite Operators and ETSI EP BRAN members is the figure to use for the "Building Shielding Ratio". BRAN working group 2 was tasked with producing evidence to substantiate the various claims made.

When initially considering a project to measure the actual building shielding ratio/attenuation loss of typical wall and roof materials, it became apparent at an early stage that a very large number of measurements would be required to take account of the variety of building materials used in both modern and older style buildings. Furthermore, it transpired that a significant number of published results exist, that have already covered these measurements carried out by several different organisations throughout Europe and U.S.A..

This paper, therefore, analyses those documents that could be obtained, summarises them and draws out a single range of figures that could be justifiably used in interference and compatibility issues.

3.0 The Analyses

3.1 Reference 1

This reference describes the channel sounding technique used in measurements carried out in Germany at the campus of Deutsche Telkom in Darmstadt, and at the main Frankfurt railway station and presents the measurement results in terms of delay spread and received power.

It concludes "in indoor and outdoor environments, high path loss values have been observed even for relatively short distances, depending on building structures (number of walls penetrated, blocking by buildings, etc. The additional attenuation with respect to free space is in the order of 15 .. 30 dB."

3.2 Reference 2

This reference describes a physical propagation model of an indoor radio channel, calculates the theoretical transmission characteristics and compares them with actual measured results at 1.9GHz, 5.8GHz and 10GHz.

The measured results at 5.8GHz give penetration losses as follows :

Building Material	Parallel Polarization	Perpendicular Polarization
Typical Interior Walls		
PVC plate	0.4dB	0.6dB
Gypsum plate	0.8dB	0.7dB
Plywood	0.9dB	0.9dB
Gypsum wall	1.2dB	3.0dB
Rough chipboard	1.3dB	1.0dB
Veneer board	2.2dB	2.0dB
Glass plate	3.2dB	2.5dB
6.2cm Sound proof door	3.4dB	3.6dB
Typical Exterior Walls		
Double-glazed window	6.9dB	11.7dB
Concrete block wall	11.7dB	9.9dB

Taking into account typical building constructions, this table gives an average figure of approx. 10dB for both types of polarization for external walls.

3.3 Reference 3

This reference details measurements carried out at the University of Wales in Swansea, measuring delay spread and received power at 2GHz, 5GHz and 17GHz. The building is of steel framed reinforced concrete construction with exterior curtain

walling, breeze block interior walls and concrete floors. Interior furniture includes desks, wooden and metal bookshelves and metal filing cabinets.
The average figures for relative path loss at 5GHz within the building were measured between 0dBr at 1m (reference) up to 45dBr for paths of 20m penetrating two interior walls. A single interior (concrete block) wall was measured to have typically 10dB attenuation.

3.4 Reference 4

This reference describes measurements taken within buildings at 2, 5 and 17GHz using a frequency domain measurement system incorporating a vector network analyser. Magnitude and phase were measured for distances up to 20m. Interior construction was of breeze block walls and concrete floors. Furniture included desks, wooden and metal bookshelves and metal filing cabinets.
The average figures for relative received power at 5GHz were found to be between 0dBr at 1m (reference) up to 40dBr for paths of 20m.

3.5 Reference 5

This reference provides some results taken at 1-2GHz, 5GHz and 17GHz in older style office buildings both in Central London and Outer London. The buildings were of a 1930's style brick construction with interior walls either of brick or modern plaster board. Furniture included wooden chairs and tables. Delay spread and signal attenuation were measured at distances up to 30m.
The average figures for relative signal attenuation at 5GHz were found to be between 0dBr at 5m (reference) up to 28dBr for paths of 30m.

3.6 Reference 6

This reference compares the results of various previously published papers with actual measurements at frequencies between 815MHz and 60GHz.
At 1625MHz a typical wall loss figure of 15.6dB was obtained.
From work carried out in references 2, 3, 4 and 5, the loss figure for operation at 5GHz will be no less than this figure and probably several dB higher.

3.7 Reference 7

This reference describes measurements taken within a building at 1.3 and 4.0GHz using a time-domain, dual-channel radar device which uses 5nS RF pulses. Measurements were recorded in four buildings, including one sports arena, two factory buildings and one modern, closed-plan office building for distances up to 100m.
The average figures for relative received power at 4GHz were found to be between 0dBr at 1m (reference) and 20dB at 10m, 30dB at 20m and up to 40dBr for paths of 65m.

3.8 Reference 8

This reference describes time delay spread and signal level measurements taken within the New York Stock Exchange building complex in New York using wide-band omni-azimuthal antennas at distances up to 85m. The building is of typical masonry construction with some large glass windows and reinforced concrete floors. Much of the interior is effectively of open plan construction.

The average figures for relative received power at 4GHz and 5.8GHz were found to exceed 20dB for distances of 4m compared with the signal level at 0.3m, and to exceed 80dB for distances of 85m.

3.9 Reference 9

This reference describes propagation measurements conducted in an indoor office environment at 2.4, 4.75 and 11.5GHz. The data were obtained in small clusters of six measurements, using a coherent wideband measurement system taken at the TNO Physics and Electronics Laboratory at The Hague, Netherlands. The walls were of brick/stone, floors of concrete and internal walls of plasterboard or brick.

The average figures for relative received power at 4.75GHz were found to be between 0dBr at 1m (reference) and 20dBr at 10m.

This paper also describes some evaluations of the effect of people on the path loss figure and concludes that a figure of 4-5.5dB extra attenuation is typical.

4.0 Conclusions

When considering the radiated signal level from an indoor device, there are two dominant factors that should be taken into account :

1 - the actual building wall transmission loss
2 - the actual path loss between the device and the wall.

From the references noted in this paper, actual measured figures for these two parameters are as follows :

	Minimum	Average	Typical @ 5m	Maximum	Reference
Building wall loss		10dB			2
		15.6dB			6
Internal path loss	15dB			30dB	1*
			37dB	45dB	3
			28dB	40dB	4
				28dB	5
		40dB	18dBr		7
			20dBr	80dBr	8
			12dBr		9

* Note : reference 1 is based mainly on measurements carried out externally. A figure for internal path loss is likely to be higher than this.

As can be seen from the above, a figure of 10dB would be a practical figure to use for building wall loss BUT this figure assumes that all the devices are positioned immediately adjacent to the outside walls. This is clearly not a "real-life" situation and to get a true figure for the building shielding loss, one needs to add the internal path loss. This figure depends on the actual location of the device(s) within the building, but for quite short distances (say 5m) is typically 15dBr (relative to 1m distance).
In addition to these figures, some additional (variable) loss is likely to be introduced by the presence of people; this might add an additional 5dB.

The overall conclusion, therefore, is that in any calculations involving indoor devices operating in the 5GHz band, a figure of 25dB would be a conservative (low) average figure to use in interference and compatibility studies (the actual range of figures being between approx. 10dB to over 80dB).

5.0 References

[1] Gerhard Kadel (Deutsche Telkom AG): "Wideband channel characteristics at 5GHz in outdoor environments and resulting requirements for HIPERLAN/2"; ETSI EP BRAN WG3 TD18, 30 June 1997.

[2] Pei Hou: "Investigation of the Propagation Characteristics of Indoor Radio Channels in GHz Wavebands"; published by Cuvillier Verlag, Goettingen, 1997.

[3] P. Nobles and F. Halsall: "Radiowave Propagation Measurements Within a Building at 2GHz, 5GHz and 17GHz"; Wireless '97 Conference paper, Calgary, July 1997.

[4] P. Nobles, D. Ashworth and F. Halsall: "Indoor Radiowave Propagation Measurements at Frequencies up to 20GHz"; IEEE 44th Vehicular Technology Conference, Sweden, 8-10th June 1994.

[5] John Airs: "Comparative Indoor RF Channel Soundings at 2, 5 & 17GHz"; Wireless Personal Communications, 1996.

[6] Simon Black, Dr T.A. Wilkinson and Prof S.K. Barton: "Personal Communications Research Programme, Wireless Local Area Networks"; DTI/SERC LINK Report, March 1993.

[7] D.A. Hawbaker and T.S. Rappaport of Virginia Polytechnic Institute and State University, U.S.A. : "Indoor Wideband Radiowave Propagation Measurements at 1.3GHz and 4.0GHz"; Electronics Letters, 11th October 1990.

[8] D.M.J. Devasirvatham, C. Banerjee, R.R. Murray and D.A. Rappaport : "Four-Frequency Radiowave Propagation Measurements of the Indoor Environment in a Large Metropolitan Commercial Building"; IEEE 1991.

[9] Gerard J.M. Janssen, Patrick A. Stigter and Ramjee Prasad : "Wideband Indoor Channel Measurements and BER Analysis of Frequency Selective Multipath Channels at 2.4, 4.75 and 11.5GHz"; IEEE Transactions on Communications October 1996.