Measurement of Building Shielding at 11GHz in the Australian Urban Environment.

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Abstract

Previous RSRG work (Kerans, *et al*, [1]), on analysing system deployment has demonstrated the sharing potential between the Fixed Service (FS) and the Fixed Satellite Service (FSS) in the 11GHz (10.7 – 11.7GHz) Band. The paper, however, assumed up to a maximum of 22dB of shielding in the study. There is then a need to conduct a measurement campaign in the 11GHz band to validate the assumptions made in this paper.

The goal of the measurement campaign is then to characterise additional attenuation introduced when an 11GHz radio wave is shielded by a building. Specifically, these shielding losses due to buildings are characterised as a function of receive angle and building material.

The findings of this measurement campaign provide a reasonable estimate of the average attenuation due to building shielding and terrain clutter in the Australian urban environment. With a range of 20 to 35dB, the measurements validate the assumptions that were made in [1], where up to a maximum of 22dB of shielding was assumed.

Introduction

This paper concerns itself with two main aspects of radio propagation.

- It investigates the attenuation due to propagation through objects constructed from various different materials or “shielding”; and
- It describes the bending of radio waves around these objects or “diffraction” [2].

Specifically, it addresses these phenomena through and around buildings at 11GHz. A few comments regarding terminology are appropriate at this point. This paper is concerned with the additional loss that an obstructing building introduces into a radio link. By "additional loss" we mean loss in excess of free-space spreading loss. Following common usage in the communications industry, we have termed this additional loss "shielding loss."

In Australia, the 11GHz band (10.7 – 11.7GHz) is primarily used by point-to-point fixed links. The deployment of ubiquitous FSS receivers is therefore limited by the deployment and growth of the FS. There is also regulatory concern that FSS deployment may place political constraints on FS. This paper deals solely with the technical feasibility of sharing.

Earlier this year, the Radio Spectrum Research Group (RSRG), University of Canberra, presented a paper [1] that reported on antenna performance studies in the case where terrestrial fixed services are to share spectrum with a number of Television Receive Only (TVRO) geostationary satellite service receivers. The paper assumed a receiver failure criteria based on a 12dB, C / (N + I) ratio.[1] This figure was then used with an increasing level of shielding assumed, to improve the performance. Up to a maximum of 22dB was assumed.

A need to validate the assumptions that were made in this paper was fulfilled by performing a physical propagation study in the 11GHz band. Physical measurements were made in the band, to determine the effect of building shielding and, to a lesser extent, terrain clutter.

Measurement Equipment

Fig. 1 shows a block diagram of the equipment used to perform the tests. The equipment consisted of an 11GHz continuous wave (CW) transmitter system using a GUNN diode oscillator and a horn antenna. On the receiver side, a horn antenna coupled to a low noise block downconverter (LNB) detected the signal. The receive signal level was then recorded manually from the spectrum analyser. The transmitter system remained fixed in location mounted on a tripod while the receiver system was mounted on a rolling trolley.

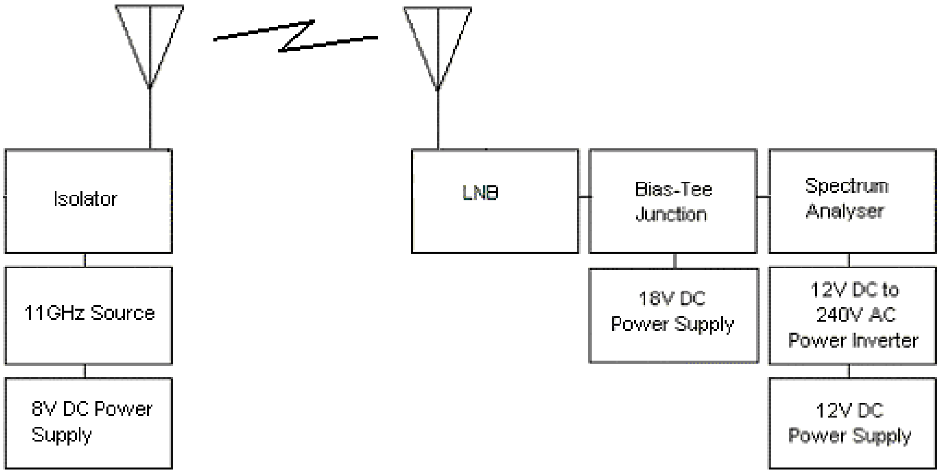

Figure 1: Block Diagram of Measurement Equipment.

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[1] Based on average C / (N + I) quoted in ITU satellite fillings.

Analysis of Measurement Results

Figures 2 – 6 show a plan view of each of the test sites along with the measurements taken. All measurement results have been normalised with line of sight reference measurements.

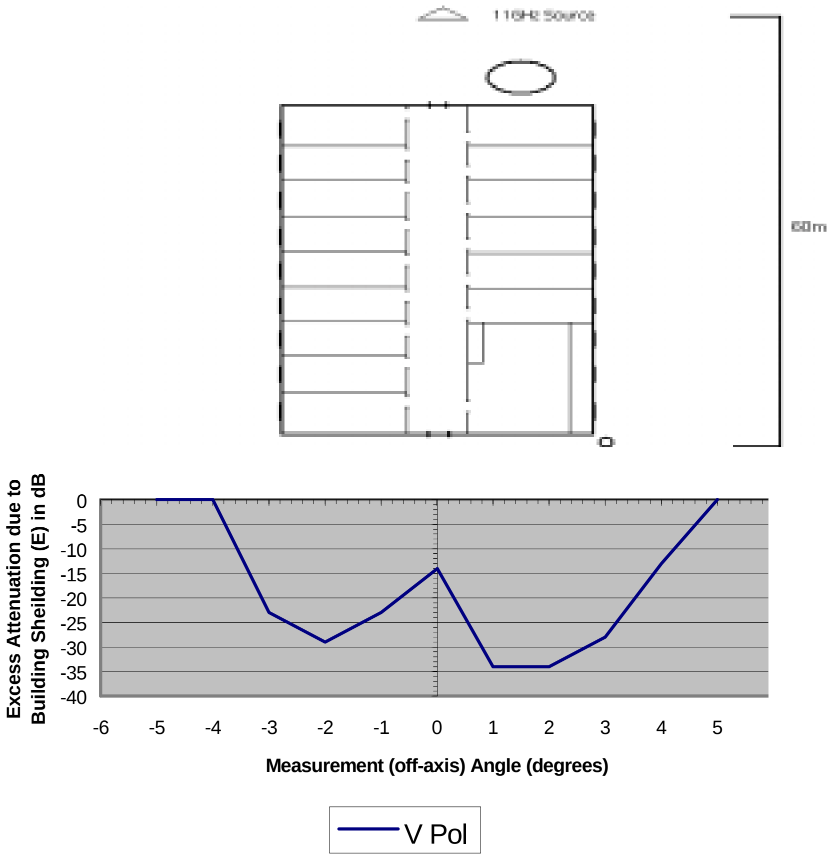

Figure 2: Excess Loss due to building shielding, Test Site #1. Z-Block, North-South Orientation. Average = -26.43, Std Dev = 7.09.

Test Site #1: Z-Block, student residences, University of Canberra (UC). Building construction was wooden fibro-board with raised floor (on brick stilts) and tiled roof. The ground surface was slightly sloping grass. Two sets of measurements were made here, one for each orientation; North-South and East-West. The radio path was obstructed by a large tree at certain angles, causing an increase in attenuation of up to 10dB. The average attenuation is 26.43dB, this is as expected due to the wood construction material of the building. The minimum attenuation of 15dB occurred at the 0° angle which corresponded to the end of the corridor, where the radio path was only obstructed by two external doors.

Fig. 3 displays the results of the East-West oriented measurements. The average attenuation here of 8.32 to 10.03dB is considerably less than the previous case. This is mainly due to the lower number of walls that the signal passes through and is hence attenuated by, on its way from transmitter to receiver. Also, at various points, there was almost line of sight between transmitter and receiver due to the configuration of windows and internal doors. Again, some attenuation is experienced when the ray passes through vegetation (-16° point).

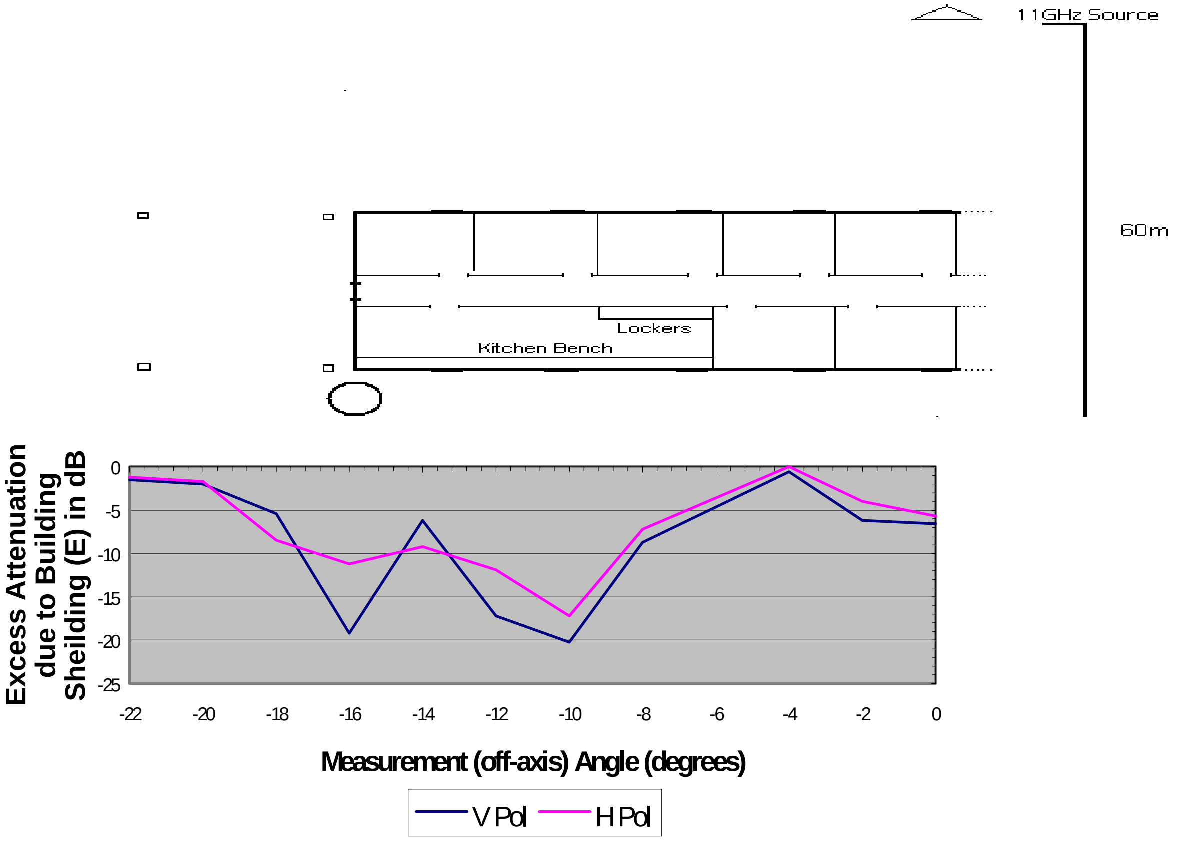

Figure 3: Excess Loss due to building shielding, Test Site #1. Z-Block, East-West Orientation. V Pol: Average = -10.03, Std Dev = 7.00. H Pol: Average = -8.32, Std Dev = 4.96

Test Site #2: Brick building corner (1 storey high) and wicker fence 2m high and 20cm thick (Fig. 4). The ground surface was flat grass between the transmitter and obstacles. The surface that the receiver was positioned on was a concrete foot-path. The attenuation due to the brush fence itself was very minimal, in the order of about 1dB. The brick building corner causes significant attenuation, as the receiver is moved into its shadow, with a maximum of about 35dB. Again, vegetation plays a significant role, in this case contributing up to 17dB in attenuation.

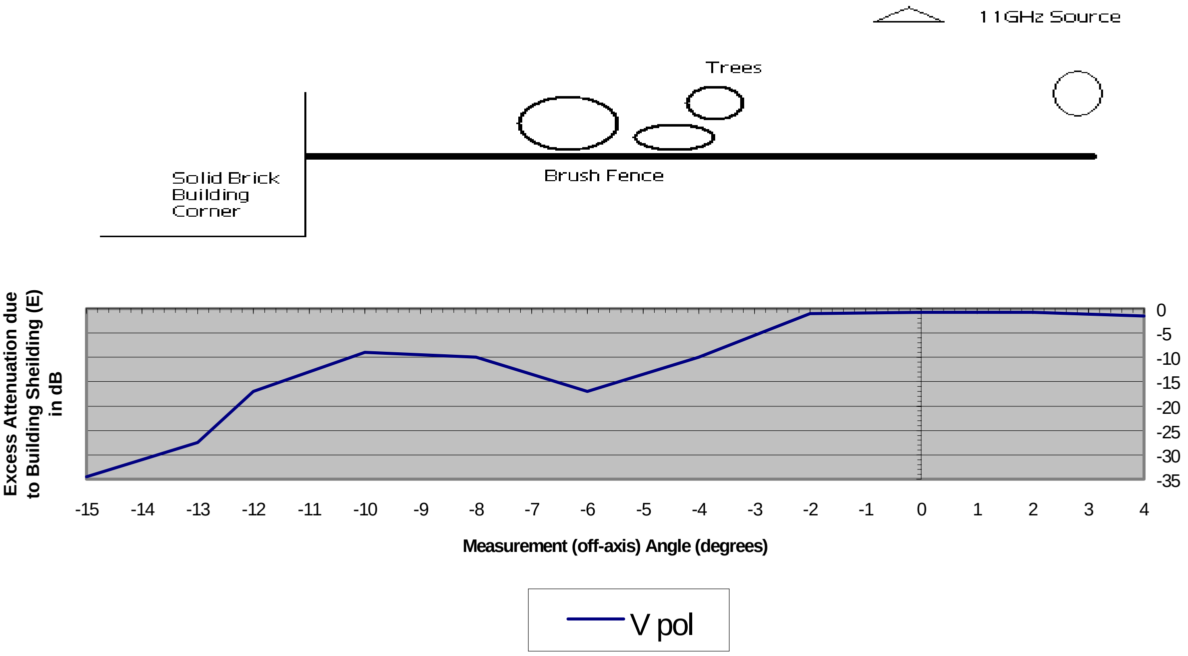

Figure 4: Excess Loss due to building shielding. Test Site #2, Building Edge and Brush fence.

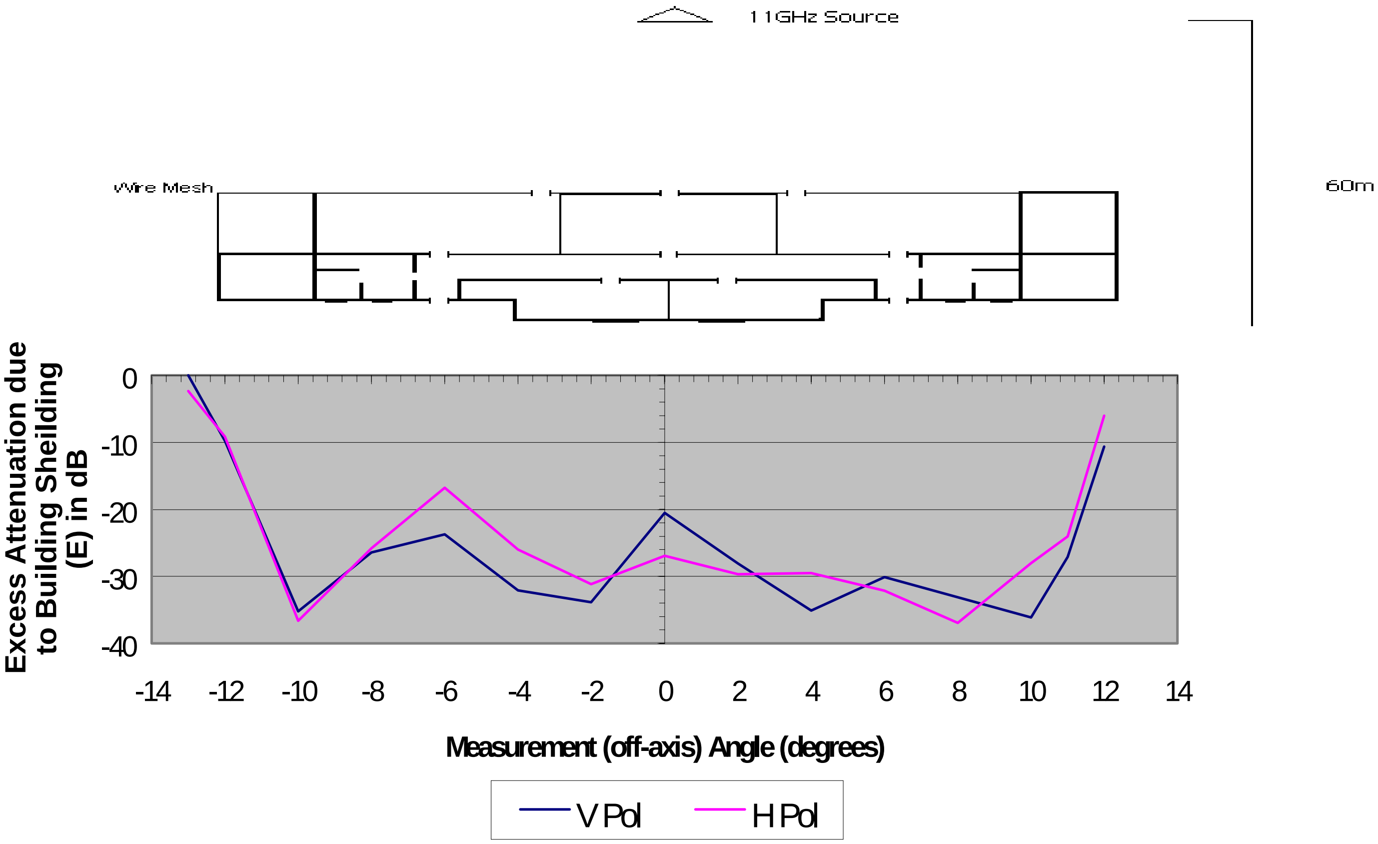

Figure 5: Excess Loss due to building shielding. Test Site #3, ANU AFL Football Club. V Pol: Average = -30.11, Std Dev = 4.99. H Pol: Average = -28.63, Std Dev = 5.50.

Test Site #3: Australian National University (ANU), Australian Rules Football Club-house. Building construction was mainly concrete brick and wood. Transmitter was positioned on an adjacent oval and the receiver was on a concrete foot-path. As alluded to previously, the attenuation due to the concrete/brick construction is notably higher than wood. The average attenuation in this case ranging from 28.63 to 30.11dB. The variation in attenuation values is due to the varying paths that the signal can take. Depending on the internal layout of the building and the positioning of windows, the results will fluctuate considerably.

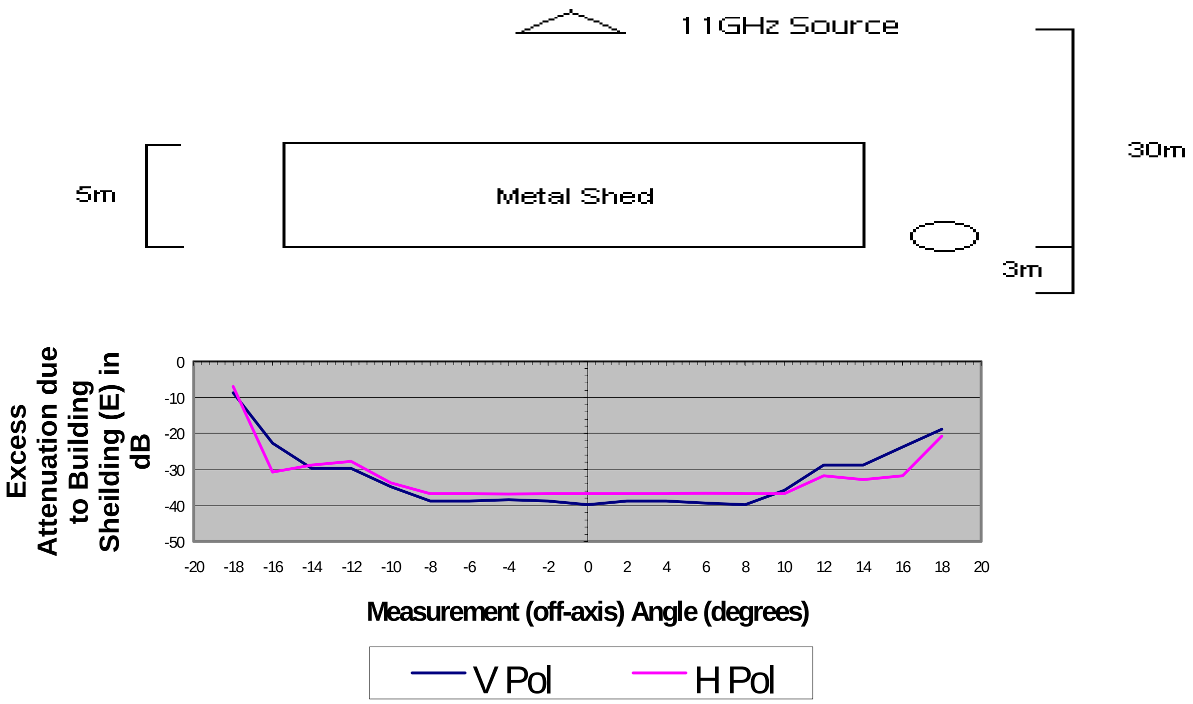

Figure 6: Excess Loss due to building shielding. Test Site #4, Metal Storage Shed. V Pol: Average = -36.42, Std Dev = 4.05. H Pol: Average = -34.96, Std Dev = 3.21.

Test Site #4: Metal Shed. This was a very basic structure made entirely out of metal. It had no windows or protruding doors. Due to lack of space, the transmitter was placed 30m from the building rather than the preferred 60m. The average attenuation here is between 34.96 and 36.42dB. This is primarily due to diffraction effects since, due to the electrical properties of metals, radio waves tend to reflect, not penetrate, when they hit a metallic surface.

Conclusions

The findings of this measurement campaign provide a reasonable estimate of the average attenuation due to building shielding and terrain clutter in the Australian urban environment. With a measured range of 20 to 35dB on average, it is possible to position TVRO such that significant shielding from interference from FS is available in the majority of cases. This result validates the assumptions that were made in [1], where up to a maximum of 22dB of shielding was assumed and sharing between FS and FSS TVRO is technically and physically possible.

References

[1] Kerans A, Lensson E, Lovatt J, French G, “*Analysing antenna performance at 11GHz taking into account the requirement to share with (TVRO) geostationary satellite systems*”, RSRG, University of Canberra, 2001.

[2] Recommendation: ITU-R P.526-7, *“Propagation by Diffraction”*, Radiocommunication Bureau, International Telecommunication Union (ITU), Geneva, 1999.

Biographical Notes:

John Lovatt is an Engineer in the Space Systems Team of the Australian Communications Authority. He recently completed the degree of Bachelor of Engineering in Electronics and Communications Engineering from the University of Canberra. His ongoing interests include the study of radiowave propagation and electronic communication systems.

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Graham French holds a PhD in microwave telecommunications engineering and has had extensive experience and has taught for many years in the area of microwave circuit and system design, antennas and propagation. He was responsible for the initial development of the microwave tracking system for the Department of Environmental Physics at Sydney University. He has been involved in projects and consultancies involving microwave interferometry, electromagnetic compatibility, high-power RF systems, novel matching techniques as well as photonic device characterisation

Christopher Hose is an Engineer in the Space Systems Team of the Australian Communications Authority. He completed a Bachelor of Electrical and Electronic Engineering from the University of Queensland in 1998. Continuing interests include radiofrequency propagation and satellite system coordination.