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MIMO to Increase Channel Capacity in Mobile Satellite Communication using Dual Circular Polarized Antennas

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Abstract: Multiple-Input Multiple-Output (MIMO) technologies has recently emerged as one of the most significant technical breakthroughs in modern digital communications due to its promise of very high data rates at no cost of extra spectrum and transmit power. MIMO-based systems take advantage of what is probably the last unexploited frontier in wireless communications, the *spatial domain*. No doubt the MIMO gain is achieved only when the signal reaches at the receiver via two or more independent paths resulting in multipath fading, which otherwise is an impediment to communication using Non Line of Sight (NLOS) mode of communication. MIMO technology offers many advantages and degrees-of-freedom, such as: (a) space and multiuser diversity gain, (b) spatial multiplexing gain, (c) array and coding gain, and (d) interference reduction. MIMO is of less or of no advantage in LOS (Line of Sight) communication. Mobile satellite communication channel can be modelled as a multipath fading channel in the case when the receiver with multiple antennas is moving on the road side with long trees on both sides of the road in urban areas and moving through vegetation in rural areas. Since there is limitation of increased volume and weight on board satellite due to which having two independent antennas is a difficult proposition, it is suggested to use Dual Circular Polarised Antennas on board satellite and two or more antennas on moving platform/s on ground. It has been found in simulates results that at high signal to noise ratio a multiplexing gain of nearly 1.6 has been achieved by using single antenna on board satellite but transmitting and receiving signal with dual polarised (Right Hand Circular Polarised (RHCP) & Left Hand Circular Polarised (LHCP) wave. The phenomenon of multipath fading is more pronounced at higher frequencies like Ku and Ka band compared to L or S bands, but for mobile satellite mobile communication the band L & S band (having frequency well below 10 GHz) is used. The only disadvantages of MIMO systems are basically its designing, multichannel synchronization, DSP engineers are required to implement more sophisticated baseband processing algorithm to better interpret the channel model. (1), (2)

Keywords: Multiple Input Multiple Output (MIMO), Dual Polarisation Per Beam (DPPB), Multiplexing Gain, Array Gain. Multipath Fading, Line of Sight (LOS), Low Elevation Angel, Channel Capacity, Non Line of Sight (NLOS).

I INTRODUCTION

Due to MIMO systems potentially high bandwidth efficiency, they are very promising especially with regard to satellite transmission. This is for two reasons: one due to Satellites is in a rising demand for transmission bandwidth, and secondly the usable frequency spectrum becomes short and congested due to ever increasing requirement of increased data rate. Available bandwidth, therefore, become particularly expensive. The traditional PSK-modulation schemes in satellite transmission are used due to the non-linearity of on board power amplifier/s. Use of strongly non-linear, but efficient power amplifiers, there is a little scope for a further enhancement of the data rate. Due to the on board non-linear power amplification, the use of higher-order modulation formats in most cases can only be realized at the cost of link-budget performance degradation. Consequentially, the use of the spatial dimension as a further resource besides time, frequency and code is very promising. *Mobile satellite* (MS) systems operating over GSO(Geo Stationary Orbit) orbits at frequency bands well below 10 GHz (e.g. L, S) serving *mobile satellite terminals* (MSTs) in propagation environments suffering from different degrees of obstruction (urban, suburban, rural).
The limitation of using MIMO techniques is that the satellites of today's technology are limited by space and weight constraints. To overcome this limitation satellite with dual polarisation per beam (DPPB) is considered. Utilization of polarization dimension is an attractive alternative for satellite systems. The feasibility of deploying dual-polarized antennas for communicating with a mobile terminal has been shown to be amenable for MIMO.

Dual circular polarisation of on board satellite antenna at low elevation angles is found to be useful to enhance the channel capacity. The mobility of ground terminals further adds to the advantage. Two approaches to multi antenna are possible by using two independent satellites with one antenna each, or one antenna on board the single satellite, with two polarisations (RHCP & LHCP). In the first case having two or more independent satellites in Geo-stationary orbit is a difficult proposition due to the fact independent parking slots for Geo-stationary satellites are limited, as the distance between two satellites is of the order of few hundred kilometres to take MIMO advantage. The second approach of having one antenna with a dual polarised feed to increase the channel capacity is of immense use.

II. DIFFERENT CONFIGURATIONS OF MIMO HAVE BEEN DISCUSSED AS BELOW.

We take the example of Multi path, a typical Rayliegh fading wireless channel MOMO configuration. Here if we assume M transmit antennas and N receive antennas the multiplexing gain is given by:

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Min (M,N)

Where M are transmitting antennas and N are receiving antennas.

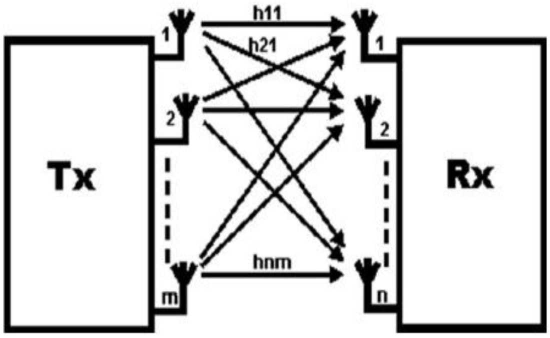


Fig 1, m x n MIMO

In MIMO systems both spatial diversity and multiplexes gains can be simultaneously obtained, but there is a trade-off between how much each type of gain any MIMO scheme can extract, higher spatial multiplexing gain comes at the price of sacrificing diversity gain. To be more specific and focusing on the high – SNR regime the fundamental trade off curve can be drawn where spatial multiplexing gain is understood as the fraction of capacity attained at high-SNR and diversity gain indicates the high-SNR results in reliability of the system.

A MIMO channel with M transmit and N receive antennas offers potentially MxN independent fading links and, hence, a spatial diversity of the order of MxN.

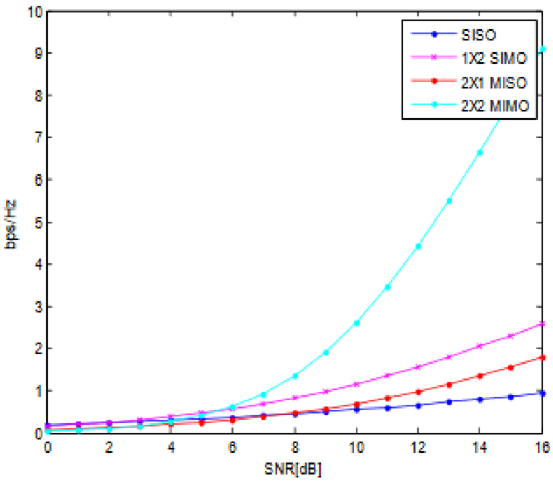
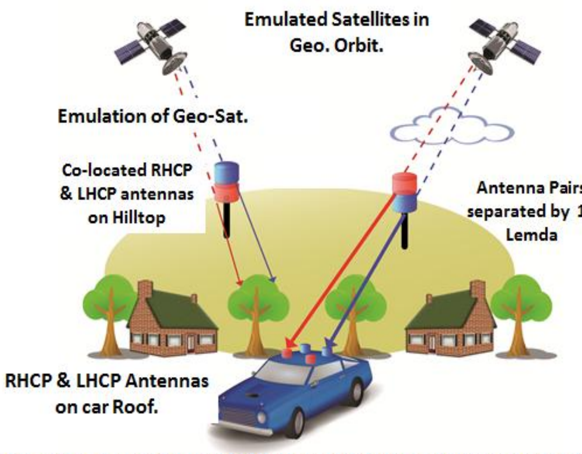


Fig 2 Comparasion between SISO,MISO AND MIMO(Simulated Results) (SOURCE: Channel Capacity Enhancement of wireless communication using MIMO Technology. BY Akhilesh Kumar & Anil Chaudhry, International Journal of Science & Technology research, Vol 1, Issue 2, March 2012, pp 91-100.)



Emulated Two Geo-Sat on Hill top with RHCP & LHCP antennas on Car Roof.

Fig. 3

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Figure 3, this configuration emulated a two-satellite dual circular polarised LMS MIMO channel and also provided data for the more viable one-satellite LMS MIMO system. The measurement routes covered tree lined roads, suburban and urban environments and the topography ensured that satellite elevation angles varied from 5° to 18° (3), (4), (8).

The first measurement campaign was carried out in the summer of 2009 with the aim of recording LOS and NLOS propagation scenarios where obstruction in the channel is mainly caused by tree matter and occasional rural buildings (11), (12), (13). The measurement route chosen for this campaign was the Newlands Corner area of Guildford, U.K., a location that can be described as being predominantly rural. As shown in Figure 3, the route traverses a large area densely vegetated by tall road side trees and low growing crops interspaced with occasional farm houses(14), (15). This allowed the receiver, which was roof mounted on a mobile vehicle to experience a channel that varies from LOS to NLOS and vice versa. This location was chosen to enable extensive propagation data to be collected such that LMS MIMO broadcasts to rural environments can be characterized and the expected large scale MIMO channel fading possibly modelled using a Markov switching process. A schematic cross-section of the measurement campaign environment showing Fresnel zone clearance and elevation angle range is shown in Figure 3 (5), (9), (10), (18). dual circular polarised LMS MIMO channel in a suburban environment. conditions –with the urban and suburban environments causing more signal depolarisation than the tree lined road/rural environment. The signal XPD (Cross Polarisation Discrimination) level, computed from the receive power levels at the RHCP and LHCP antennas, was found to strongly depend on environmental conditions.

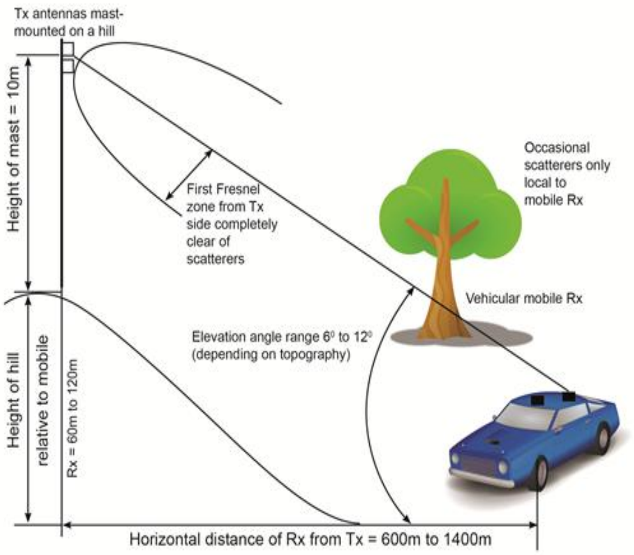

Fig. 4

Measurements of Dual circular polarised LMS MIMO channel in a suburban environment

III.MEASUREMENT CAMPAIGN II

The second measurement campaign carried out in the summer of 2010 aimed to uncover the characteristics of the dual circular polarised LMS MIMO channel in a suburban environment. A low density residential area in the town of Guildford, U.K. was chosen for this measurement campaign and the routes were specifically selected so that the mobile receiver views the emulated satellite from higher elevation angles than was achieved in previous measurements such as (7) and (6). Routes covered in this suburban environment measurement campaign as shown in Figure 5. are Millmead Terrace, Portsmouth Road and Bury Fields. Figure 5. Shows a schematic cross-section of the measurement campaign environment while Figure 5. gives a pictorial view of the satellite

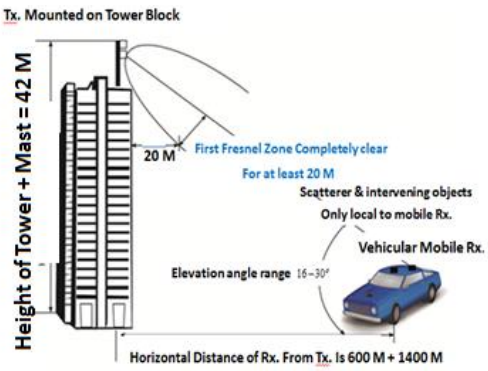

Fig. 5

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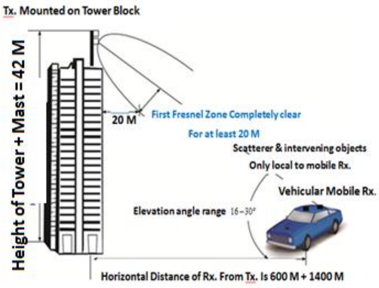

Fig. 5

emulated by tower block-mounted transmitting antennas and the vehicular mobile receiver. Here the elevation angle is from 16-30 degrees.

The second measurement campaign carried out in the summer of 2010.

IV. THE SECOND APPROACH OF ONE SATELLITE WITH DUAL CIRCULAR POLARISED FEED

to communicate with a mobile vehicle having two independent polarisation is discussed as below.

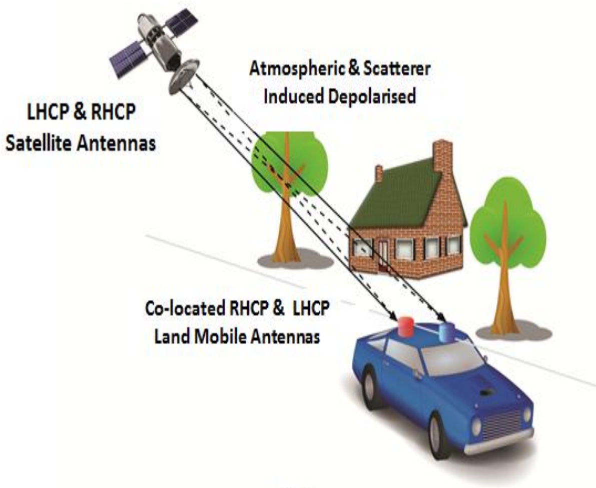

Fig.6

The second approach of one satellite with dual circular polarised feed.

Only one satellite is required and only one antenna to consume less space, weight and power consumption, resultantly a cheaper and affordable system.

Removes the need for synchronisation between two or more satellite and allows for orthogonally polarised antennae, using only one antenna with modified feed. Orthogonal polarisations can alone effectively create independently fading channels. For a 2X2 MIMO system dual circular polarisation (LHCP & LHCP) on board satellite and two ground station antennae separated by a distance of the order of $\lambda / 4$ wavelength, on moving vehicle.

Notice that at 1 GHz, for Linear Polarisation, at a Ground station antenna placed at an elevation angle of 30^{o} the Faraday rotation will be of the order of 108^{o}. Also for a Geo-satellite orbital dynamics results in continually change in satellite's position with the condition it stays in the same orbital slot (16),(19),(17). Due to this reason at L & S band of frequencies LHCP & RHCP are used, as circular polarization is not affected by rotation of EM (Electromagnetic Wave). The following main models are present to Model Land Mobile MIMO channel

Author has simulates the 2×2 MIMO in comparison to SISO, the graph is given as Fig. 7. It has been found that 2×2 MIMO gives much better capacity (Bits/ Second/ Hz.) compared its counterpart SISO System without transmitting any additional power.

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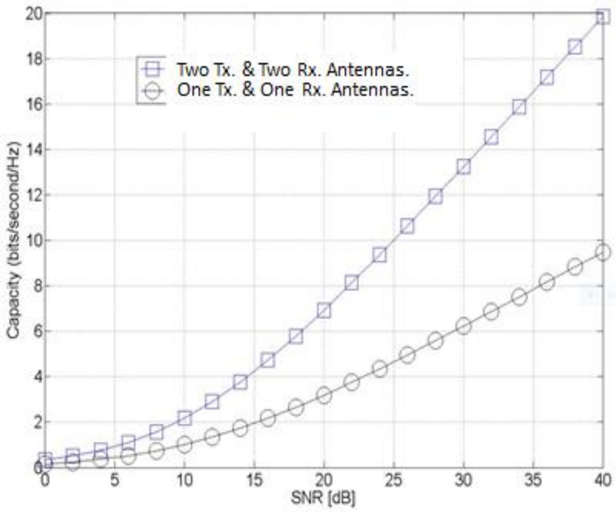

Simulated Comparison of 2 by 2 MIMO & SISO

Fig. 7

It is to be noted that MIMO performance out performance at higher SNR availability. At 10 dB. SNR MIMO gives 2 bit/second/Hz.compared to SISO provides one bit/second/Hz. Whereas at 20 dB. SNR MIMO is capable of channel capacity of 7 bits/second/Hz. Compared to SISO channel capacity is limited to 3 bits/second/Hz.

V. SIMILARLY THE CHANNEL CAPACITY

simulation has been done at different elevation angles of satellite's Rx. Signal strength vs channel capacity and comparison results 2×2 MIMO at different elevation angles has been given in fig 8. It is found that MIMO provides better channel capacity and reliable communication at lower altitude places (Regions of the Earth) near North pole.

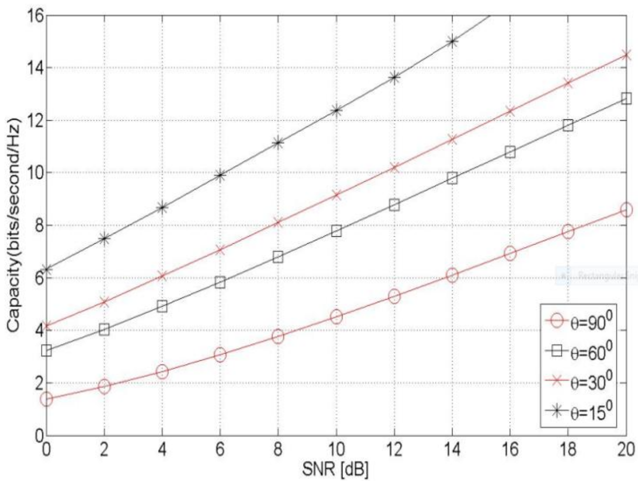

Fig. 8 Simulated Results of Satellite channel capacity vs SNR at different elevation angles.

As shown in fig. 8,The simulation results of different elevation angles

$(15^o, 30^o, 45^o, 60^o \& 90^o)$

The satellite channel capacity and BER is better, at low altitude places when MIMO is used. This is due to the fact that the electromagnetic wave has to travel a longer path in the Earth's atmosphere and encounters multipath fading due to high-rise buildings on earth and long trees along roadside in urban environment and other greenery in sub-urban and rural environment. Fig. 8 gives Metlab simulated graph is and it is clearly seen that for low elevation angles of satellite antenna(whih is due to high altitude of the region on the Earth), the capicty iccreases from $15^o, 30^o, 45^o, 60^o \& 90^o$ The capacity is decreases from about 12 bits/S/Hz. to about 4 bits/S/Hz, as we increase the elevation angle from 15,30,45,60 and 90 degrees, at 10 dB SNR, using 32 APSK at 10^{-2} BER.

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VI. MIMO is useful in Mobile communication.

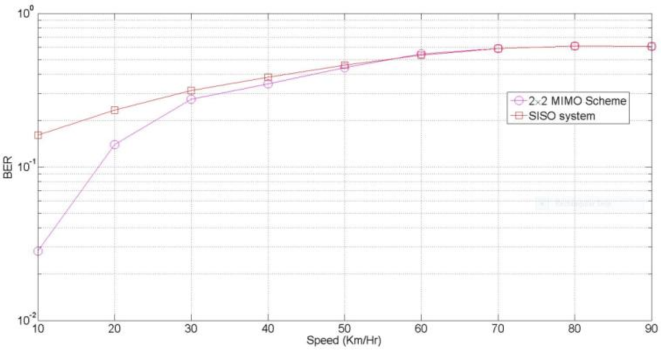

Fig.9 Simulated results of Speed VS BER of 2 by 2 MIMO and SISO

MIMO systems perform better compared to their SISO counterpart in mobile communication. It is observed from simulation that BER decreases for 2by2 MIMO as compared to SISO counterpart, at the same SNR while communicating from satellite in L and S Band satellite transponders. Up to 50 Km/S there is a significant increase in BER (the quality of the communication link), beyond 50 Km/S to 90 Km/S MIMO is at par with SISO counterpart.

CONCLUSION

The satellite channel has been studied and analysed in depth. Since no practical satellite MIMO system exists worldwide as on today. Some of the researchers like P.King's etc. have carried out some emulated practical systems, by utilising a satellite like transmitter and receiver on top of a hill in U.K. as early as 2005 and some other similar emulated studies in 2010. From these studies the utility if MIMO satellite systems has been ascertained. In this paper MATLAB Software simulations using satellite channel has been carried out, for 2 by 2 MIMO as compared to SISO. It has also been established by simulated a result that at low altitude angles the MIMO Satellite channel capacity increases which can be attributed to more multipath fading as the electromagnetic wave has to travel longer distance in earth's atmosphere in rural and urban areas with either a lot of greenery or high rise buildings, giving birth to multipath fading. It has also been found that in mobile communisation MIMO gives better BER compared to its SISO counterpart using the same bandwidth and transmit power. The extra cost is the increase in complexity of the system but the advantages of MIMO over- weigh its complexity limitation.

REFERENCES

1. MIMO over satellite : A Review by Pantelis-Daniel Arapoglou, Member IEEE, Konstantinos Lidis etc IEEE Communication Survey and Tutorials vol 13, No1, First quarter 2011.
2. Ph.d Thesis : Performance Limits of spatial Multiplexing MIMO Systems. Author Luis Garcia Ordonez. Jordi Girona 1-3, Campus Nord, Ed:fici D5 08034 Barcelona, Spain)
3. R. T. Schwarz, A. Knopp, D. Ogermann, and C. A. Hofinann, and B. Lankl, "Optimum-capacity MIMO Satellite link for fixed and mobile services," in International ITG Workshop on smart Antennas, 2008, pp. 209-216.
4. F. P. Fontan, M. Vazquez-Castro, C. E. Cabodo, J. P. Garcia, and E. Kubista, "Statistical modelling of the LMS channel," IEEE Transactions on Vehicular Technology, vol. 50, pp. 1549-1567, 2001.
5. P.R. Kind and S. Stavrou, " Low Elevation Wideband Land Mobile Satellite MIMO Channel Characteristics, " IEEE Transactions on Wireless Communications. Vol. 6, pp.2712-2720, 2007.
6. M. A. N. Parks, G. Butt, M. J. Willis, and B. G. Evans, "Wideband propagation measurements and results at L- and S-bands for personal and mobile satellite communications," in fifth International Conference on Satellite Systems for Mobile Communications and Navigation, 1996, pp. 64-67.
7. T. Heyn, E. Eberlein, D. Arndt, B. Matuz, F. L. Blasco, R. Prieto-Cerdeira, and J. Rivera-Castro, "Mobile satellite channel with angle diversity: The MiLADY project," in 44th European Conference on Antennas and Propagation, 2010, pp. 1-5.
8. D. Arndt, A. Ihlow, A. Heuberger, T. Heyn, E. Eberlein, and R. Prieto-Cerdeira, "Mobile satellite broadcasting with angle diversity – performance evaluation based on measurement," in IEEE International Symposium on Broadband Multimedia Systems and Broadcasting, 2010, pp. 1-8.
9. P. Arapoglou, P. Burzigotti, M. Bertinelli, A. Alanmancac, and R. De Gaudenzi, "To MIMO or Not To MIMO in Mobile Satellite Broadcasting Systems," IEEE Transactions on Wireless Communications. vol. PP, pp. 1-5, 2011.
10. K. Liolis, J. Gomez-Vilardebo, E. Casini, and A. Perez-Neira, "Statistical Modeling of Dual-Polarized MIMO Land Mobile Satellite Channels," IEEE Transactions on Communication, vol. 58, pp. 3077-3083, 2010.
11. Recommendation ITU-R P. 833-3, "Attenuation in Vegetation," The ITU Radio Communication Assembly, 2001.
12. U. M. Ekpe, T. W. C. Brown, and B. G. Evans, "Measuring, Modeling and Simulating the Dual Circular Polarized Land Mobile Satellite MIMO Radio Channel for DVB-SH/NGH Application," IEEE Transactions on Wireless Communications, 2012.
13. A. Kyrgiazos, "Land mobile satellite MIMO: Channel modeling for in vehicle line of sight links," MSc Dissertation, University of Surrey, Guildford, UK, 2010.
14. M. H. Hashim and S. Stavrou, "Measurements and modeling of wind influence on radiowave propagation through vegetation," IEEE Transactions on Wireless Communications, vol. 5, pp. 1055-1064, 2006.
15. U. M. Ekpe, T. W. C. Brown, and B. G. Evans, "Channel characteristics analysis of the dual circular polarized land mobile satellite MIMO radio channel," in IEEE APS Topical Conference on Antennas and Propagation in Wireless Communication, Turin, Italy, 2011, pp. 781-784.
16. C. Oestges, "Indoor Wireless Communications with Multiple Antennas and Polarizations: From Channel Characterization to Performance Simulation," IEEE 19th International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), pp. 1-6, Sept. 2008.
17. J. Goldhirsh and W. J. Vogel, "Mobile satellite systems fade statistics for shadowing and multipath from roadside trees at UHF and L-band", IEEE Trans. Antennas Propagat., vol 37, no 4, pp. 489-498, 1989.

ISSN (Online) 2278-1021
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18. M. F. B. Mansor, T. W. C. Brown, and B. G. Evans, “Satellite MIMO Measurement With Colocated Quadrifilar Helix Antennas at the Receiver Terminal”, IEEE Anten. And Wirel. Propag. Letters, vol 9, pp. 712-715, 2010.
19. Evans, J. V. : “Satellite systems for personal communications”, Proceedings of the IEEE, vol 86, no 7, 1998, pp. 1325-1341