Tutorial B2: Propagation characteristics of satellite-to-mobile and satellite-to-indoor links

Prof. Istvan Frigyes
Siena, Sept. 8, 2005

Two main physical phenomena determine propagation characteristics of any mobile wireless link – terrestrial or satellite – i.e. multipath propagation and shadowing. Indoor or indoor-to-outdoor links, different in some aspects from their land mobile counterparts are essentially also driven by these phenomena. Main consequences of these are investigated since the advent of mobile communications. Properties are well known – at least in the case of terrestrial links. Satellite links, on the other hand, are influenced by these physical processes in many aspects in a different way. This is mainly due to the significantly different environment. The purpose of this tutorial is to show and discuss some of these different effects. After a brief survey of the main propagation characteristics three phenomena are dealt with in some detail. Differences between satellite and terrestrial links and also between satellite to mobile and satellite to indoor links are pointed out.

Subjects to be covered:

1. Main propagation effects in mobile satellite links: multipath and shadowing. Modeling of the shadowed and multipath satellite -to-mobile link.

2. Doppler effect in LEO satellite links. Doppler effect: generalities. Recall of Doppler characteristics of terrestrial links. General modeling of Doppler effect in satellite links. Doppler spectrum of a LEO satellite link; significant differences to terrestrial. System aspects. Extrapolation to GEO satellites.

3. Antenna effects in diffuse fields: gain and apparent gain, spatial correlation. The concept of *shadowed line-of-site* (S-LOS) links. Description of the scattered field in S-LOS. General formula for the received field. Apparent gain of the ground terminal antenna. Correlation properties in diffuse fields.

4. Polarization effects, polarization diversity and polarization-time coding. Characterization of polarization states: the Stokes space, the Stokes scattering matrix. Expression for polarization mismatch loss. Diffuse field and random polarization. Error probability with random polarization. Polarization diversity – diversity gain and diversity improvement. MIMO satellite links with polarization time coding (PTC). Special problems in satellite MIMO systems making PTC particularly well suited.

ISTVAN FRIGYES - CURRICULUM VITAE

István Frigyes was born in Budapest, Hungary. He graduated from Budapest Technical University as electrical engineer and received the PhD. degree from the same university and the Hungarian Academy of Sciences, and later the PhD. Habil. degree (habilitation, 1995). He is also holder of the degree Dr. Sc. of the Hungarian Academy of Sciences (1996).

Earlier he worked with industrial and research organizations and had part-time positions at Budapest Technical University. In the industry he led the development of digital microwave radio systems. Since 1983 he has been in full-time job with Budapest Technical University, first as Associate Professor and later Full Professor. Since Jan. 2003 he is Professor Emeritus. He is teaching courses in the general aspects of digital communications, on fixed and mobile digital radio and on optical communications. He was visiting professor at Institut National des Télécommunications at Evry, France at Ecole Nationale Supérieure des Télécommunications in Paris, France, at Technical University of Malaysia. He was Academic Visitor at University College, London UK.

His research interests were first in microwave antennas and circuits, and in digital communications in the latest three decades or so. In the latter field he was active in synchronization topics earlier and has been mainly in investigations in the system effects of propagation phenomena; these include terrestrial digital microwave radio and also terrestrial/satellite mobile/personal communications. In the last decade or so he is also interested in the field of optical communications and microwave/optical interactions.

His main achievements in these fields in recent years were: theory of frequency diversity in wideband digital radio; theory of Doppler effect in LEO satellite channels; operation of polarization diversity; antenna effects in diffuse fields; coded diversity in diagonal MIMO channels; noise and loss properties of fiber radio systems; joint effects of nonlinearity and dispersion in fiber radio; etc.

He is co-author of 9 books, 6 of which appeared also in English; among these, main author of Digital Microwave Transmission (Elsevier, Amsterdam), co-author of Al Rawashidi ed.: Radio over Fiber (Artech House, 2002). Further he is author or co-author of more than 100 papers, in the above topics, in periodicals and technical conferences. and also co-author of more than 20 patents. He gave tutorial lectures or instructed courses at several points of the world, including Brazil, Canada France, India, Italy, the UK. the US and Taiwan. (Recently: System and Propagation Aspects of Digital Mobile, in San Francisco, CA, US; a short course on Radio Propagation and Digital Communications at National Taiwan University; a tutorial at PIMRC in Osaka Japan on Radio over Fiber systems (1999) and on similar topics at ISMOT conference, Montreal, Canada (2001) and at the research institute ITRI, Hsinchou, Taiwan (2002).

He is member of the Hungarian Scientific Society for Infocommunications, HTE, Senior Member of the IEEE. He was founder and chairman for about a decade of the Joint Chapter Microwave & Communications of the Hungary Section. At present he is vice chairman of the IEEE Communication Society Radio Communication Committee and member of several committees of that Society. He is holder of several awards including Hungarian Award of Outstanding Inventors, Gold Medal of HTE and Certificate of Appreciation of IEEE Societies MTT-COM-AP-ED.