Mitigating Multipath Fading in Wireless Communication through Antenna Diversity

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Lecturelib International Publishers
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Dr. Gaurav Kumar is an Associate Professor in signal processing and design of optimal controller. He earned his doctorate from the Indian Institute of Technology, Roorkee in the field of seismic signals. He has developed two controllers to disseminate the command signal to the actuator for generating counter control force for mitigation of seismic vibrations. He has over 14 years of teaching & research experience various institutions including Henan University, China. Dr. Kumar promotes multidisciplinary research in areas such as swarm intelligence, genetic algorithms, A* algorithm, fuzzy logic, artificial neural network, and back propagation algorithm in multidisciplinary fields of research, machine learning, signal processing.

Dr. Sandeep Dhariwal received his doctoral degree in Electronics Engineering from Banasthali University, and M. Tech in VLSI Design & Embedded Systems from Guru Jambheshwar University of Science & Technology, Hisar. He received his B.E. from Maharshi Dayanand University, Rohtak. He has about nine years of experience in research, teaching, and industry in the field of electronics and communication engineering. His technical expertise includes VLSI design, low power digital VLSI design, advanced digital system design and nanomaterials. Dr. Sandeep Dhariwal has published many research papers in different reputed journals and conferences. He has reviewed various research papers from reputed journals including Organic Electronics (Elsevier), Pertanika Journal of Science and Technology and Journal of Engineering Science and Technology.

Dr. Harinath Aireddy completed his doctoral degree in Instrumentation & Device Fabrication from IIT Kharagpur, and his M.Tech. in Advanced Materials from NIT Rourkela. He is an Associate Professor and an active scientist in the Department of Electronics and Communication Engineering at Alliance University, Bangalore, India. He has specialized in Instrumentation (design, fabrication, testing, data acquisition, automation and computer control with LabVIEW, calibration and demonstration), spintronics, rapid prototyping RF modules for satellite applications, fabrication of medical devices, IoT and advanced materials. He bagged a major research project titled "Studies on selective laser melting of aluminum alloys for rapid prototyping of RF modules" from the reputed Department of Science and Technology (DST)-Science and Engineering Research Board (SERB) Government of India, under TARE. Through a series of investigations, he has developed Cantilever Beam Magnetometer (CBM) for electric field induced magnetic measurements, which is the first of its kind in the world. He has also developed an ultra-low-vibration Liquid Nitrogen (LN2) flow cryostat for low temperature measurements in optical cantilever beam magnetometer set-up. Further, Dr. Aireddy also developed a double cantilever beam set-up for simultaneous magnetostriction measurements of two different or same type of samples for sensor/actuator applications. He has also been one of the researchers in the world to fabricate and investigate semiconductor-based spin diodes and spin transistors for MRAM and MFRAM applications.

E-ISBN: 978-93-5747-171-8

9 789357 471718

MRP Rs. 250/-

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First Edition

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Title of the Book: Mitigating Multipath Fading in Wireless Communication through Antenna Diversity

First Edition - 2023

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E- ISBN: 978-93-5747-171-8

MRP Rs. 250/-

Publisher, Printed at & Distributionby:
Selfypage Developers Pvt Ltd.,
Pushpagiri Complex,
Beside SBI Housing Board,
K.M. Road Chikkamagaluru, Karnataka.
Tel.: +91-8861518868
E-mail:info@iiponline.org

IMPRINT: IIP Iterative International Publishers

Preface

In today's fast-paced world, the demand for portability has become ubiquitous. The need for wireless communication has gained significant attention due to its ability to provide connectivity and convenience in a portable manner. While wired communication networks offer superior performance, the main challenge with them lies in their lack of portability. Wireless communication, on the other hand, overcomes this limitation, allowing users to stay connected on the go. However, wireless transmission faces its own fundamental obstacle: time-varying multipath fading. Multipath fading is a phenomenon that occurs when signals reach the receiver from various paths due to reflection, diffraction, and other wireless propagation effects. Each signal path introduces different levels of attenuation, time delay, and phase shift, causing fluctuations in signal strength.

To mitigate the adverse effects of multipath fading, several techniques have been developed, with diversity being a practical and effective approach widely employed. Diversity in wireless communication refers to the use of multiple copies of the same signal to combat fading. By having multiple signal replicas, the chances of at least one of them being of good quality increase, enhancing the overall reliability of the communication link. Diversity can be achieved through different means, including temporal diversity, frequency diversity, and antenna (spatial) diversity.

Temporal diversity involves transmitting replicas of the information-bearing signal in different time slots, where the separation between the time slots exceeds the coherence of the channel. Frequency diversity, on the other hand, relies on transmitting replicas of the signal in different frequency bands, where the separation between the frequencies exceeds the coherence bandwidth of the channel. Antenna or spatial diversity leverages the observation that antennas with a spacing greater than half a wavelength led to spatially uncorrelated channels. By transmitting replicas of the signal over these uncorrelated spatial channels, spatial diversity is achieved. Implementing diversity techniques can be broadly categorized into three categories: techniques with implicit or explicit feedback, techniques with feedforward without feedback, and techniques without feedback or feedforward. Implicit or explicit feedback techniques utilize information from the receiver to configure the transmitter, adjusting its parameters based on the observed channel conditions. Feedforward techniques involve transmitting information across multiple antennas using linear processing at the transmitter and compensating for the channel response at the receiver. Finally, techniques without feedback or feedforward rely on multiple transmit antennas combined with channel coding to provide diversity.

Among the various diversity techniques, space-time coding has emerged as a powerful tool for combating multipath fading in wireless channels. Space-time codes (STC) offer both coding gain and diversity gain, enhancing the bit-error rate performance. There are two main types of STC: space-time trellis codes (STTC) and space-time block codes (STBC). STTC distributes multiple redundant copies of a trellis or convolution code over time and antennas, whereas STBC operates on a block of input symbols, producing a matrix output representing time and antennas. Both STTC and STBC have advantages and complexities associated with their encoding and decoding processes. In this book, we focus on comparing the performance of STBC with and without channel coding.

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Acknowledgement

We wish to express my heartfelt gratitude and thanks to all our teachers and our supervisors for the master's and doctoral program for their committed involvement, insightful discussions, valuable advice, invaluable guidance, supportive encouragement, and more importantly the level of trust that he placed on us throughout the duration of study without which my study and the preparation of this library dissertation would not have been possible. We sincerely wish to express our gratitude to the Thapar University where this work was carried out. We wish to express thanks to colleagues for their encouragement which made this work possible. Lastly, we would like to express sincere gratitude to our respective families for their extended support and cooperation.

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