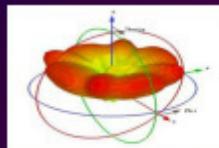


# **Realistic UWB MIMO Channel Model Considering Analogue Aspects and Antennas Effects**

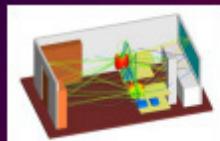
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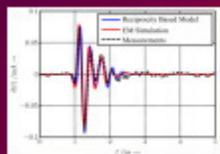
Reciprocity, Antenna modeling, UWB-IR MIMO, Mutual coupling, Ray-Tracing, Antenna Impulse Responses, Frequency dependence, Polarization, Multipath components are hot topics urgently required for a deterministic UWB MIMO channel model.



In this book, a deep investigation of the previous terms will be presented within the UWB world. A realistic UWB MIMO channel model based on a hybrid EM ray-tracing technique is fairly verified by a sophisticated comparison with raw data measurements.

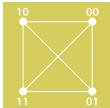


Furthermore, techniques used in MIMO systems as Antenna Diversity, Antenna Selection and Antenna Combining will be shown based on UWB-IR. In addition to that, different receiver structures and UWB MIMO signaling schemes will be applied.



Finally, a 2X2 UWB-IR MIMO Testbed is successfully constructed and performed with real-world VHDR BER curves.





# Realistic UWB MIMO Channel Model Considering Analogue Aspects and Antennas Effects

Von der Fakultät für Elektrotechnik und Informatik der  
Gottfried Wilhelm Leibniz Universität Hannover  
zur Erlangung des akademischen Grades

*Doktor-Ingenieur (Dr.-Ing.)*

genehmigte

## Dissertation

von

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I would like to dedicate this thesis to Baba ;Saleh - the wideband antenna engineer; who kicked me out to come to Germany for learning the life,

.. to Mama; Laila; who taught me how to respect the science,  
.. to my lovely wife ;Aisha; with her nice smile during the salty days,  
.. and to my lovely kids: the lion Hamza and the doll Nour ...

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Above all, I would like to acknowledge my God who has given me this great chance to make use of my life.

## **Abstract**

This work is presenting a deterministic real-world UWB channel model which realizes the required marriage between the High Frequency (HF) and Communication societies in the UWB range. This UWB channel model considers both the transmitting and the receiving antennas as non-ignorable important parts of the whole effective channel between the transmitter and the receiver.

This work has been extended to consider not only the polarization, orientation and directional gain properties of the antennas but also to take into account the influence of the mutual coupling between neighboring antennas in the UWB MIMO systems upon the whole channel and furthermore upon the overall system performance.

In addition to that, several MIMO signaling schemes as Bell Labs Layered Space Time Coding (BLAST) and Successive Interference Cancellation (SIC) have been developed and used for the realistic UWB Spatial Multiplexing testbed. Furthermore, many well-known techniques such as antenna selection and combining techniques have been applied based on the validated deterministic channel model.

Comparing different systems using omni-directional and directional antennas in different scenarios have been performed in fair comparisons considering the power constraints, FCC mask and standard regulations.

The developed hybrid EM Ray-tracing technique for the deterministic channel model tool will establish new guidelines and helpful tool for the antenna designers and the communication systems engineers to implement

realistic applicable UWB MIMO systems. This tool will enable the research groups working in imaging, positioning and inverse scattering techniques to examine their mechanisms and improve them without need to the real raw data measurements.

**Key words:**

UWB MIMO Deterministic Channel Modeling, UWB MIMO Channel Measurements, UWB Antennas Modeling, UWB Ray-Tracing, UWB MIMO Testbed, Mutual Coupling, UWB Spatial Multiplexing, UWB MIMO Antenna Selection -Diversity and -Combining.

## **Kurzfassung**

Im Rahmen dieser Arbeit wird ein deterministisches und anwendungsnahe UWB- Kanalmodell vorgestellt, dass der notwendigen Verknüpfung zwischen Hochfrequenz- und Kommunikationstechnik im UWB-Bereich gerecht wird.

Dieses UWB-Modell berücksichtigt sowohl die Sende- als auch die Empfangsannte als nicht zu vernachlässigende Bestandteile des effektiven Kanals zwischen Sender und Empfänger.

Diese Arbeit wurde dahingehend erweitert, nicht nur die Polarisation, die Orientierung und den direktonalen Antennengewinn, sondern auch die Beeinflussung durch gegenseitige Kopplung zwischen benachbarten Antennen im UWB MIMO System über den gesamten Kanal sowie die Leistungsfähigkeit des Gesamtsystems zu berücksichtigen.

Hinzu kommt, dass verschiedene MIMO Codierungen, wie Bell Labs Layered Space Time Coding (BLAST) und Successive Interference Cancellation (SIC) wurden entwickelt. Diese wurden in einer realistischen UWB Spatial Multiplexing Testumgebung eingesetzt.

Zusätzlich wurden bekannte Ansätze, wie Antennenselektion und -kombination, auf Grundlage von validierten deterministischen Kanalmodellen angewandt

Unterschiedliche Systeme aus omni-direktonalen und direktonalen Antennen für unterschiedliche Szenarien wurden in Bezug Leistungsverbrauch, FCC-Maske und Standardisierungen verglichen.

Der entwickelte EM Ray-Tracing-Ansatz für deterministische Kanalmodelle wird neue Richtlinien und hilfreiche Tools für den Antennendesigner und Kommunikationssystemingenieur bereitstellen, um realistisch anwendbare UWB MIMO Systeme zu implementieren.

Dieser Ansatz wird es Forschungsgruppen ermöglichen, die auf den Gebieten der Bildgebung, der Ortung und der inversen Streuung tätig sind, ihre Mechanismen zu überprüfen und diese zu verbessern, ohne reale Rohdatenmessungen durchführen zu müssen.

**Schlagwörter:**

UWB MIMO deterministische Kanalmodellierung, UWB MIMO Kanalmesung, UWB Antennenmodellierung, UWB Ray-Tracing, UWB MIMO Testbed, Antennenkopplung, UWB Spatial Multiplexing, UWB MIMO Antennen-Selektion, -Diversität und -Kombination.

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