Transcom Instruments
Product Brochure

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PATHRROT X2 Channel Emulator

Tackling 4G/5G Channel Emulation Test Challenges

——Application Note

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Pathrrot X2 Channel Emulator

Introduction

Wireless propagation characteristics are elementary factors to be considered in the communication system design. In the field of mobile communication technology, wireless channel is one of the main basis for communication system design, key technology R&S, and standard setting. The feasibility and quality of the services provided by the wireless communication system are greatly influenced by the channel characteristics between the base station and the mobile subscriber. All the time, as an effective means to improve the spectral efficiency and transmission reliability of the system, MIMO technology has been regarded as one of the key technologies to realize 4G/5G high-speed broadband wireless communication.

The **Pathrrot X2** channel emulator supports a wide range of channel models and specifically, focuses on the various channel models proposed in the broadband communication standards. It provides a powerful test method for dealing with the current and upcoming 4G/5G channel emulation challenges. At the same time, this channel emulator has an open channel model interface that supports user-defined model loading, or provides custom model development, so it can be widely used in the field of civil and military mobile communications, satellite communications, satellite navigation, unmanned aerial vehicles and unmanned ships.

This application note begins with a review of MIMO technology and its relationship with mobile communications, and goes on to introduce basic characteristics of wireless MIMO channels. It also demonstrates several typical applications of MIMO channel emulator, and finally describes how these complex wireless channels can be emulated by using commercially available instruments such as the **Pathrrot X2**, which is the latest wireless measurement instrument launched by Transcom.

MIMO Technology and Mobile Communications

MIMO (Multiple-Input Multiple-Output) technology refers to the use of multiple antennas at the transmitter and receiver respectively, so that the signal can be sent or received through these antennas, thereby improving the communication quality. It can make full use of spatial resources, and the channel capacity of the system is multiplied without sacrificing the spectrum resources and antenna transmission power. Therefore, MIMO technology is regarded as one of the core technologies for mobile communications.

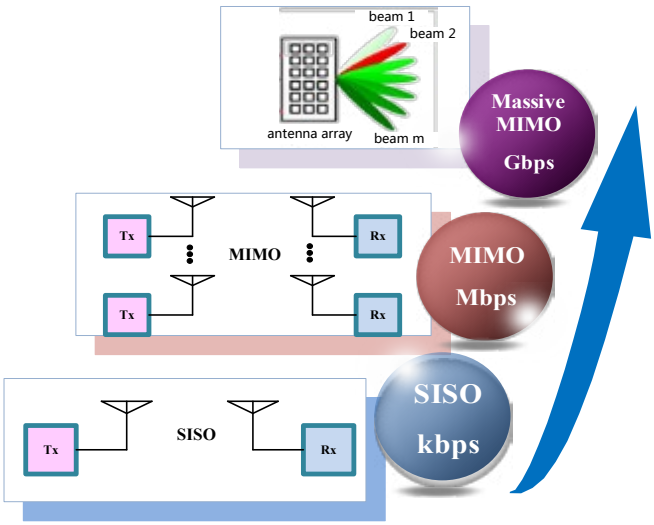

Figure 1：SISO--->MIMO--->Massive MIMO

The MIMO technology has been extensively used in various wireless standards, including WLAN/Wi-Fi, WiMAX, WCDMA, TD-SCDMA and LTE. The corresponding channel models are also specified in these standards. In 3GPP 802.11/802.16 and future 5G standards, some channel models are defined thoroughly, including 3GPP SCM and SCME. As MIMO channel modeling technology moves on, new models will be introduced as well.

In the era of 5G, the base station will be configured with a large number of antennas (usually several tens or even hundreds times of existing antennas), and will simultaneously serve many users on the same time-frequency resource. 5G is different from the existing mobile communication system, in one of its key enabling technologies: Large-scale antennas (Massive MIMO). Compared with the existing MIMO technology, the advantages of massive MIMO lie in the following aspects: First, massive MIMO significantly enhances spatial resolution, fully exploit the spatial dimension of resources, thereby making multiple users in the network communicate with the base station in the same time-frequency resource, providing the spatial freedom brought by massive MIMO. By this way, there is no need to increase the base station density or bandwidth to improve the spectral efficiency; Second, massive MIMO leads to the “narrow beam” , which makes beam power concentrated and substantially reduces interference; Third, massive MIMO can significantly reduce the transmission power, thereby improving power efficiency; Fourth, when the number of antennas is large enough, the most simple linear pre-coding and linear detector tend to be optimal, and the noise or uncorrelated disturbances become negligible.

Overview of Wireless MIMO Channels

MIMO technology is considered to be one of the key technologies to realize future high-speed broadband wireless communication. It has a wide application in the fourth generation (4G) and beyond (B4G) mobile communication system. The performance of MIMO system is closely related to the multipath environment in which the signal is located, especially with respect to the correlation between these paths, the delay spread and the angular spread. Therefore, if we understand and master the characteristics of wireless MIMO channels in both indoor and outdoor environments, it becomes simpler to realize the potential huge channel capacity, achieve the desired performance, select the appropriate system structure and design the excellent signal processing algorithm. In addition to some necessary practical measurements, a suitable channel model must be established to predict the performance of the system and evaluate the merits of the algorithm.

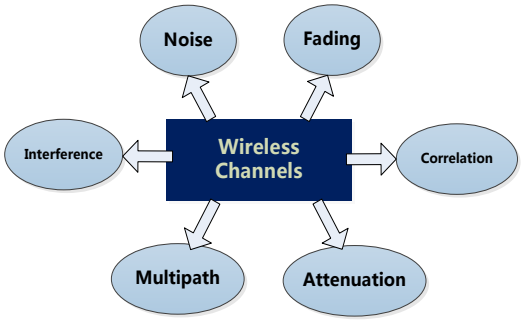

Figure 2：Characteristics of Wireless Channels

Unlike the traditional channel with one dimension only , the MIMO channel is composed of two dimensions, i.e., spatial components and time components. Hence the MIMO channel model is much more complex than before. The present MIMO channel model is assumed to be narrowband with quasi-static flat fading. But in practice, especially in the cellular environment, a variety of factors, such as the correlation between the transmitter and the receiver antenna, singular value distribution of channel matrix, have to be considered in addition to some conventional parameters, e.g. path loss, shadow effect, Doppler spread, delay spread, Rician factor distribution. Also, more attention should be paid to the time-varying broadband channel. As a result, it is very difficult to emulate or test the space-time channel due to its high complexity, which means it is time-consuming, labor-intensive and expensive. In order to shorten R&D cycle and save the cost, the designers need to make virtual implementations of these various channel characteristics, for the sake of debugging the designed system. Therefore, the space-time channel emulator is one of the indispensable hardware debugging tools for wireless communication system, which will definitely become a competitive product in the wireless communication market. In recent years, with the in-depth study on 3D MIMO/Massive MIMO and 5G high frequency channel characteristics, the channel models have gradually evolved into those with higher dimensions, more antennas and wider frequency coverage. 5G channel emulation is generally recognized as further expansions of present 4G channel emulation with respect to the channel model, operating band, channel bandwidth, and the number of channels.

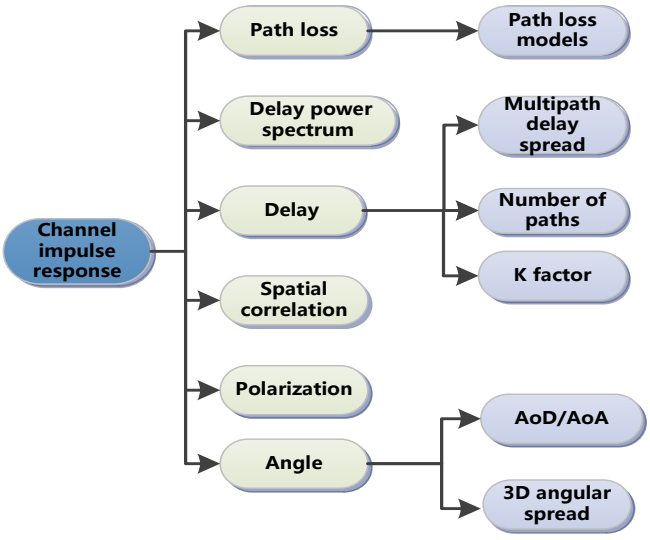

Figure 3：Typical parameters for characterizing the MIMO channels

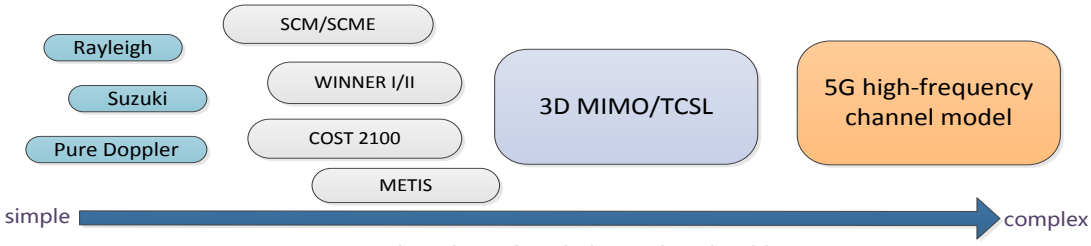

Figure 4：The evolution of standard MIMO channel models

Applications of MIMO Channel Emulator

Wireless propagation characteristics are elementary factors to be considered in the communication system design. A thorough understanding of the wireless communication environment is essential for the R&D of a wireless system. Engineers are required to have a sound grasp of the channel characteristics, so as to design a wireless communication system with high quality. The feasibility and quality of the services provided by the wireless communication system are largely affected by the channel characteristics between the base station and the mobile subscriber. It is necessary to carry out experiments under certain propagation conditions. Because of geographical limitations, it is impossible to carry out field testing during the whole R&D process. The channel emulator is a new generation of test instruments developed to emulate the fading signals in the outdoor environments.

As a high-end generic test instrument, channel emulator plays an important role in the development, verification and subsequent industrialization procedure of a product. First, the wireless channel emulator can provide R&D test environment for the prototype of base stations; Second, it affords the user terminals and chips with the laboratory performance evaluation, certification support, and stability test; Third, the channel emulator is an indispensable part of the entire mobile communication test system, which contributes to the verification of a new solution, new networking policy and helps with the compatibility test within some frequency bands. Specifically, the channel simulator is suitable for:

1) End-to-end performance tests of wireless device and network infrastructure. The test environment can be built indoors to vividly simulate outdoor channel characteristics instead of field testing.

2) Quality tests of wireless devices and network infrastructures. Fully demonstrate the influence of channels on the receiving and transmitting performance of terminals or base station equipment, and add reference specifications to improve equipment quality.

3) Algorithm verification for wireless channel models. Provide an integrated software and hardware platform to verify the model algorithm.

4) Simulate wireless channel characteristics. Include path loss, multipath fading, delay spread, Doppler shift, polarization, correlation and spatial parameters, which have significant influence on the performance of MIMO system.

5) Simulate the vivid interference scenario. Support the generation of AWGN and single-tone interference signals.

In a word, the extensive application of channel emulators is expected to promote the standardization of channel modeling and testing, and provide sustained support for the R&D of communication technologies, specifications and commercial products.

Configuring MIMO Channels Using the Pathrrot X2

Pathrrot X2 channel emulator is a high-end wireless communication test instrument based on the transformation of the achievements from “National Science and Technology Major Project”. It supports various types of MIMO channel models and it is featured by excellent RF performance, rich models, and friendly user experience. Customers can carry out simulation tests of various field environments in the laboratory.

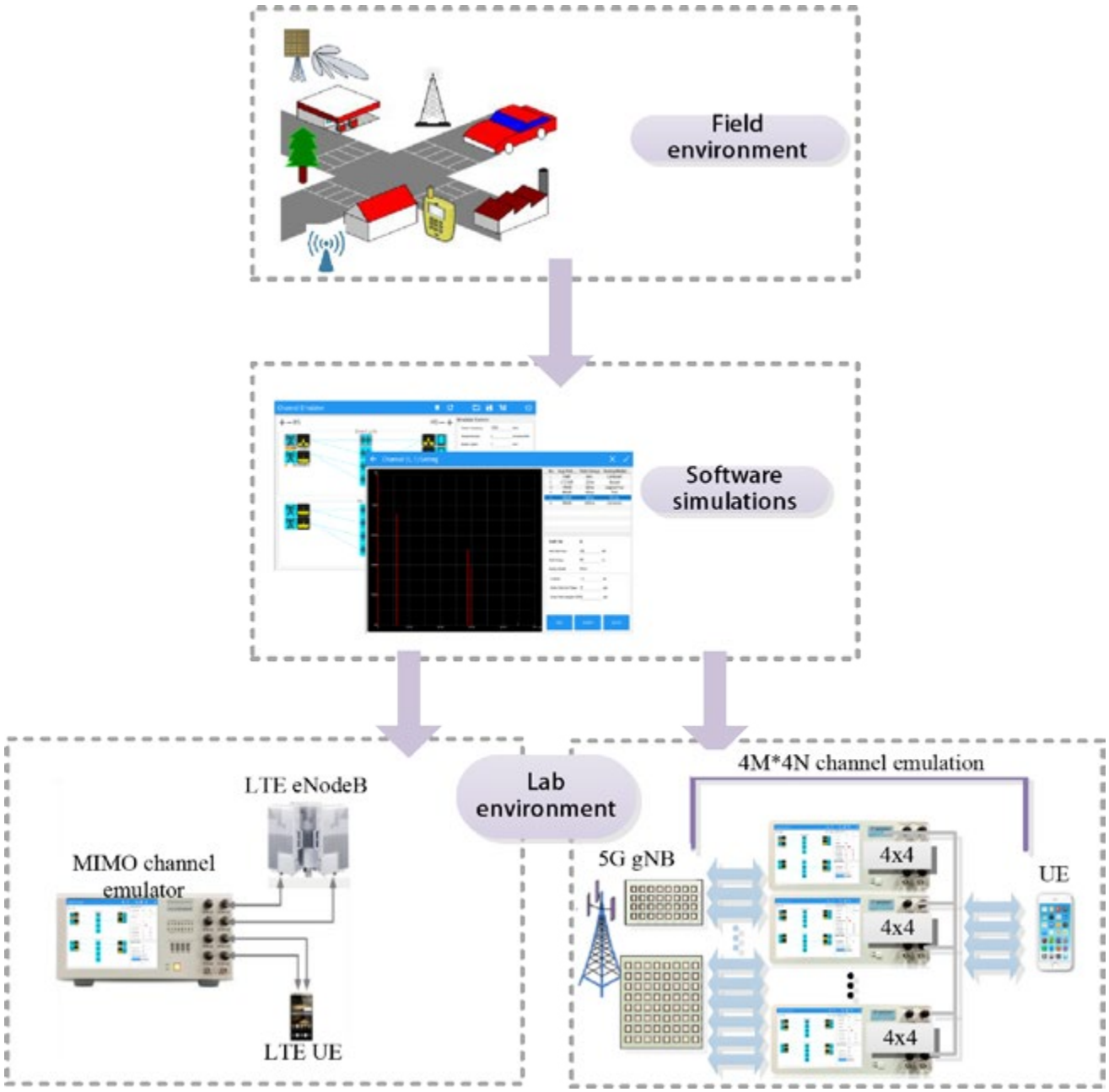

Figure 5: Setup of test systems with the channel emulator

Innovative Features & Benefits

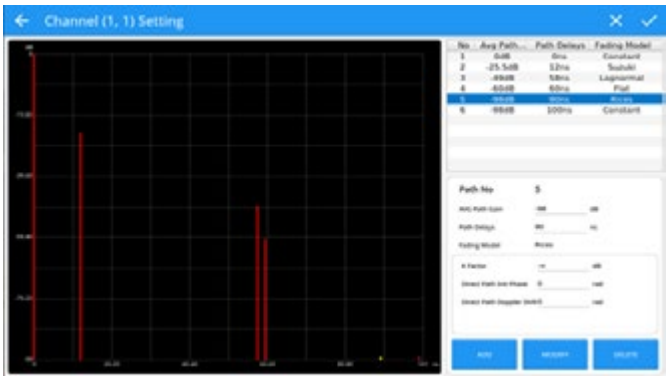

Figure 6：Configure the multipath

Figure 7：Load standard channel model / user-defined model

Figure 8：Bi-directional signal emulation

- Use the graphic user interface (GUI), support touch screen and provide friendly interaction experience

- Excellent RF performance. Based on the secondary exploration of existing platform with high-performance, it has continuous coverage of wide frequency bands & large dynamic range of input/output power

- Support Constant, Rayleigh, Rice and other conventional channel models, as well as various complex 4G/5G channel models

- Patented technology enables the bi-directional signal simulation with high dynamic range

- Flexible channel configurations (SISO, 2*2 MIMO, 4M*4N), satisfying diverse needs of customers

- Have an open interface, and support user-defined channel models

Technical Specifications

General Specifications	
RF interface channel configurations	2 or 4（8, 16 optional）
MIMO emulation	2x2（4x2, 4x4, 8x4, 8x8 optional）
Number of paths per channel	Up to 48
Path delay resolution	Minimum 10ns
Noise Type	AWGN, CW
Doppler shift	Maximum 10kHz
Maximum time delay	30us
Bi-directional RF signal	Supported
Duplex mode	TDD（FDD optional）
Input power measurement	Supported
Input power meter modes	Instantaneous power detection, average power detection, frame power detection
Integrated phase and amplitude calibration	Supported
RF Specifications	
Frequency range	500MHz~4GHz (30MHz~6GHz optional)
RF channel signal bandwidth	60 MHz (100 MHz optional)
RF input power range	-50 ~ +15 dBm (-60 ~ +15dBm optional)
RF output power range	-100 ~ -10 dBm (-110~ -10dBm optional) , resolution 0.1 dB
Baseband Specifications	
ADC width	14 bits
DAC width	16 bits
Digital baseband clock rate	122.88MHz
Channel Modeling	
Fading profiles	Constant, Rayleigh, Rice, Normal, Suzuki, pure Doppler, Jakes
Fading profiles (optional)	Nakagami, Flat, Gauss, Butterworth
Standard channel models (optional)	GSM、DCS、TETRA、ITU 3G、JTC、3GPP standard、3GPP extended、3GPP2 (IS-54, IS-95)、3GPP LTE MIMO、indoor hotspot、WiMAX MIMO、MIMO Kronecker、SCM/SCME、IMT-A、EPA、EVA
User-defined channel model loading	Supported

Keep innovating for excellence!

About us

Transcom Instrument Co., Ltd. founded in 2005 and headquartered in Shanghai, is a leading manufacturer and provider of RF and wireless communication testing instruments and overall solutions in China. Based on its independent brands and a wide range of core patented technologies, Transcom became national high-tech enterprise with independent intelligent property rights and has been listed into Shanghai Enterprise Recognition Award for High Growth SMEs in Technology.

Transcom is backed by a experienced and dedicated research team in mobile communication, radio frequency and microwave, and network optimization testing instrument. Through "Industry-University-Research" cooperation with universities, Transcom founded Southeast University-Transcom Electronic Measurement Technology Center at Southeast University to futher ensure technology and talent reserve, and secure future visionary and sustainable technology development.

Transcom's product portfolios focus 4 areas: cellular network critical communication planning/maintenance/optimization, Manufacturing testing solution, educational instrument/equipment, spectrum monitoring sensor for system integration.

ISO14001

ISO9001

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Company Profile