



■ White Paper

Military Requirements for RF Channel Emulation

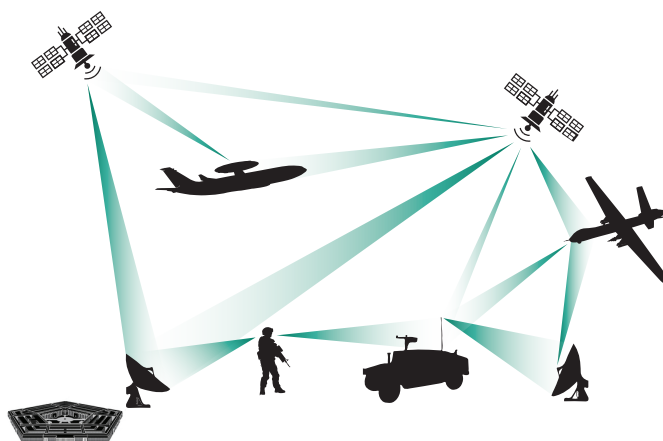
September 2019





Spirent, a global leader in communications device and network testing, brings their off-the-shelf solutions to the military and aerospace sectors through a strategic relationship with Dualos. This collaboration will leverage Dualos' deep understanding of applications for aero and defense programs and Spirent's technologies to lower program costs, and accelerate test cycles.

RF Channel Emulation is the creation of realistic signals by using precision physics-based RF propagation models in the lab to simulate real-world RF environments. They allow for accurate, efficient, flexible, and repeatable Hardware-in-the-Loop (HIL) tests for R&D, QA, and Production. Reducing the risks associated with live in-field testing, as well as reducing R&D and overall budget costs. Many test applications can benefit from RF Channel Emulation, including: Communications, Radar, Satellites, Unmanned Aerial Vehicles (UAVs), Weapons, RF Ground systems, and Aircraft.

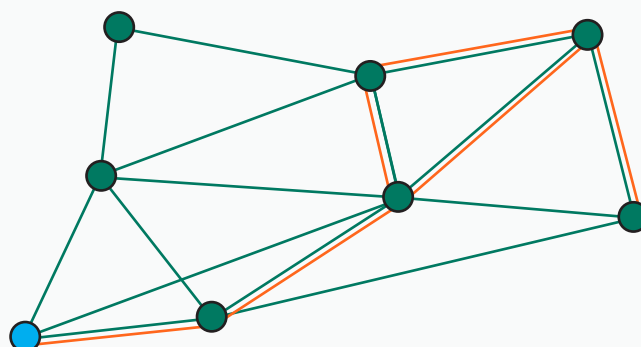


Channel Emulation

MESH NETWORKS

Typically, networks, like those used in our homes, are Centralized using a 'hub and spoke' architecture. However, most military communication takes place in the field where this approach is not feasible. This is where Mesh Networks come in; instead of having a central hub from which all communications flow, Mesh Network communication flows 'node-to-node' across all RF devices. Mesh Network architecture offers anti-congestion and anti-interference flow of data, while maintaining reliability, adaptability, and sustainability.

In the diagram below, the orange channel is under attack from interference causing some nodes to be dropped. However, the green channel is still maintaining field communications across all nodes.



DOPPLER SHIFT AND FADING

Two environmental effects that occur in RF Communications are Doppler Shift and Fading.

DOPPLER SHIFT

Occurs when RF Signals are being transmitted and received from moving points; like with Aircraft to Base Station or a Vehicle to Infantry.

Doppler Shift equation for moving Tx Signal

$$\text{Doppler Freq} = \frac{Vr}{\lambda} = \frac{Vr * Ftx}{C0}$$

Vr = radial speed of aim
 λ = wavelength (m)
 Ftx = freq of Tx
 $C0$ = velocity of light in free space



Doppler Shift equation for moving Rx Signal

$$\text{Doppler Freq} = \frac{2 * v}{\lambda} = \frac{2 * Vr * Ftx}{C0}$$

v = speed of wave source (m/sec)
 Vr = radial speed of aim
 λ = wavelength (m)
 Ftx = freq of Tx
 $C0$ = velocity of light in free space



FADING

Occurs when RF Signals passing through the air are distorted by atmospheric and environmental impairments. These signals are superimposed on each other either 'constructively' or 'destructively'. Communication signals indoors have more reflection points than in open space.

Causes of fading

- Multipath Propagation – in wireless communication multipath propagation is the result of the transmitted RF signal reaching the receiver by two or more paths.
- Shadowing (or Slow Fading) – in wireless communication shadowing is the effect when the received signal power fluctuates due to objects obstructing the propagation path.

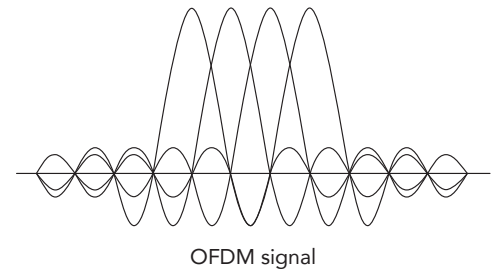
Military applications affected by fading

- Digital Radio Communications – multipath may affect the quality of the communication by introducing interference and crosstalk.

Combating Fading

DIGITAL RADIO COMMUNICATIONS

- Orthogonal Freq Division Modulation (OFDM) – a method of digital signal modulation in which a single data stream is split across several separate narrowband channels. It is especially effective to reduce interference and crosstalk.
- OFDM is used today for 4G-LTE and will also be used in 5G New Radio (NR).
- Other methods to combat Fading: Rake Receivers, Space Time-coding, and MIMO.



CLASSIFICATIONS OF FADING

- Fast and Slow Fading – based on Doppler Spread
- Flat and Freq Selective Fading – based on Multipath Time Delay Spread

Flat Fading

- BW of Signal is less than BW of Channel
- Delay Spread is less than Symbol Period

Freq Selective Fading

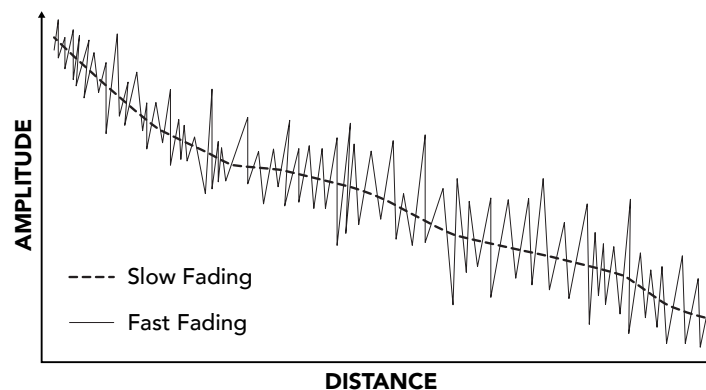
- BW of Signal is more than BW of Channel
- Delay Spread is more than Symbol Period

Fast fading

- High Doppler Spread
- Coherence Time is less than Symbol Period
- Caused by scattering of the signal by object near Tx

Slow fading

- Low Doppler Spread
- Coherence Time is more than Symbol Period
- Caused by large objects between the Tx and Rx



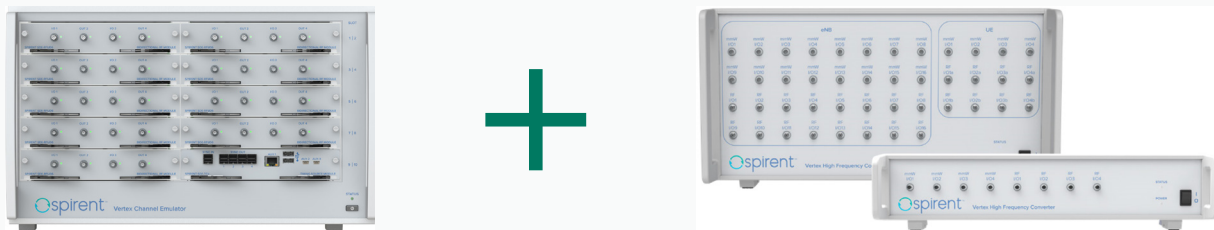
Introducing the Spirent Vertex RF Channel Emulator

The world's most scalable emulator platform. Spirent's Vertex is an advanced test and measurement system that accurately emulates the effects of signal impairments on wireless communications.



The **Vertex** enables the test and evaluation of a broad range of applications with a variety of channel densities, from basic applications like 2-channel SISO, to complex, high channel density applications like MIMO OTA, MIMO beamforming and carrier aggregation needed for 5G test scenarios.

The Vertex platform combines modularity, scalability and ease-of-use into a powerful test and measurement solution that addresses the needs of a constantly evolving wireless market. The Vertex employs state-of-the-art DSP and FPGAs to implement complex channel models.



STANDALONE VERTEX

- Standard Freq Range 30 – 5920MHz
- 200MHz Instantaneous BW¹
- Applications supported
 - 2-Channel SISO
 - MIMO OTA
 - MIMO Beamforming
 - Carrier Aggregation for 5G

ADD HIGH FREQUENCY CONVERTER (HFC)

- Extend Freq Range up to 39GHz
- Available in 4 or 20 Channel formats
 - 4-Channel (2x2) bidirectional tests
 - 20-Channel (16x4 or 64x4) bidirectional tests

¹when Vertex units are stacked together –
up to 1GHz Instantaneous BW is achievable

SPIRENT MIL/AERO COMMUNICATIONS TESTING SOLUTIONS ADDITIONAL INFO

<https://www.spirent.com/solutions/military-defense-aerospace-communications-testing>

Vertex Emulation Modeling

MESH NETWORK

Vertex can handle 'node-to-node' and mesh network scenarios where a dozen or more endpoints are communicating with each other, each with a different propagation model comprised of varying effects.

DOPPLER SHIFT

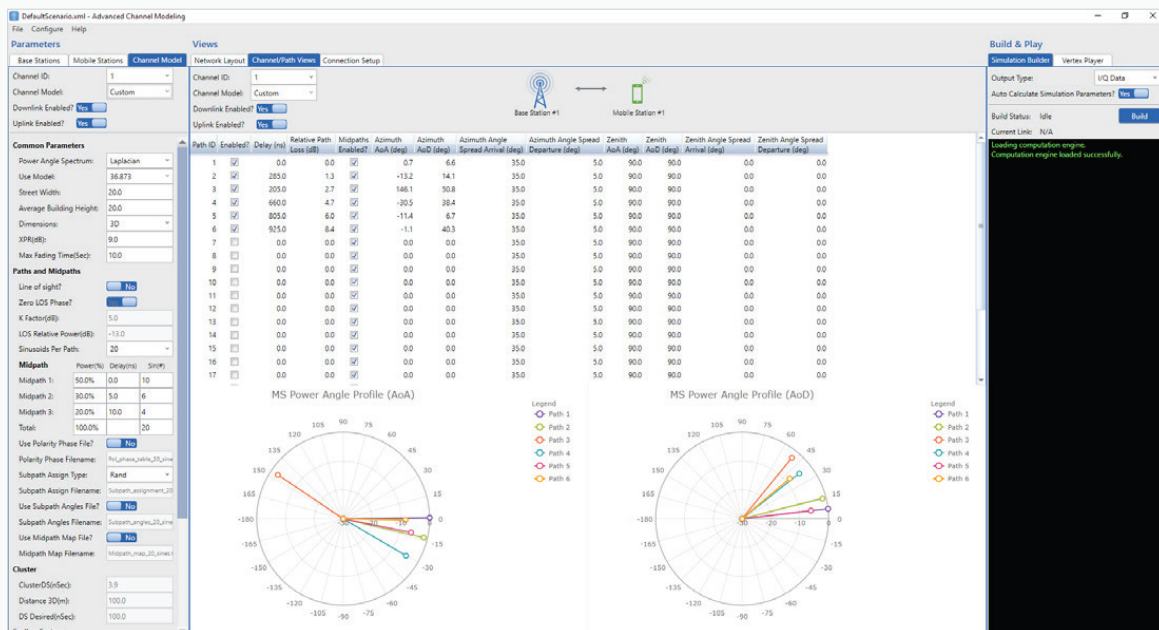
Vertex connects and simulates the ground base station with the airframe flight path. It calculates the signals received by the airframe, adjusting for phasing, and Doppler shift at high speed, and permits the testing of beam tracking algorithms.

FADING

- Rayleigh
- Rician: K factor - 30 to +30dB
- Pure Doppler: up to 12,000Hz
- Freq Shift
- Phase Shift: 0 to 360 degrees, 0.1 degree resolution

Advanced Channel Modeling (ACM) Software

An easy to use GUI add-on that simplifies the design of 3D propagation scenarios, allowing for visual design and playback found in real-world environments.



ACM Screenshot

Conclusion

A RF Channel Emulator is a vital tool for generating realistic test signals that exercise hardware and software in real-world, as well as worst-case fashion. As a result, channel emulator-enhanced testing significantly increases system quality while decreasing costs.

Industry Awards

Spirent was named the Outstanding Test and Measurement Vendor for the Telecommunications industry for the 2nd straight year by Light Reading.



2018 Leading Lights Award for Outstanding Test and Measurement Vendor Press Release

https://www.spirent.com/newsroom/press_releases/releases/2018/may/05-18_spirent-wins-2018-leading-lights-award

ADDITIONAL CAPABILITIES SPIRENT CAN PROVIDE

- Location Based Services testing (GNSS, Assisted GNSS).
- Security testing
- Consultation on test strategy and definition
- Test development and automation
- Test environment setup and automation
- Field test data performance tools and test services



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