TestConX+E

Virtual Archive

October 26 – 29, 2021 Virtual Event

www.testconx.org

© 2020 TestConX– Image: Toa55 / iStock

With Thanks to Our Sponsors!



Distinguished

TSE smiths interconnect

Feldman Engineering







5G / mmWave

From 5G mmWave to 6G THz: What's Next in RF Test Challenges

Jeorge S. Hurtarte, PE Teradyne

Virtual • October 22-29, 2021



TERADYNE

TestConX China Workshop

TestConX.org

Session 2 Presentation 1

5G / mmWave

Mobile/FWA Data Traffic and Mobile Devices Trends



TestConX China Workshop

TestConX.org

TestConX China 2021

5G / mmWave



TestConX China Workshop

TestConX.org

Session 2 Presentation 1

5G / mmWave

6G Brings "Human-Grade" Wireless Sensory Technologies

Attribute	5 G	6G
Application Types	eMBB URLLC mMTC	MBRLLC mURLLC HCS MPS
Device Types	Smartphones Sensors Drones	Sensors and DLT CRAS XR and BCI Smart implants
Rate requirements	1 Gbp/s	1 Tbp/s
Latency Requirements	5 ms	< 1 ms
Reliability requirements	99.999%	99.99999%

HCS: Human-centric services DLT: Distributed Ledger Technologies CRAS: Connected Robotics and Autonomous Systems BCI: Wireless Brain-Computer Interactions





From 5G mmWave to 6G THz: What's Next in RF Test Challenges

5G / mmWave

mmWave & THz Applications – The Potential for 6G

Wireless Cognition	Robotic Control [27, 28] Drone Fleet Control [27]	
Sensing	Air quality detection [5] Personal health monitoring system [6] Gesture detection and touchless smartphones [7] Explosive detection and gas sensing [8]	
Imaging	See in the dark (mmWave Camera) [9] High-definition video resolution radar [10] Terahertz security body scan [11]	
Communication	Wireless fiber for backhaul [12] Intra-device radio communication [13] Connectivity in data centers [14] Information shower (100 Gbps) [15]	
Positioning	Centimeter-level Positioning [9,16]	

[1] T. S. Rappap Above 100 GHz: Opportunities and Challenges for 6G and Beyond (Invited)," IEEE ACCESS, submitted Feb. 2019.



Source: https://docs.fcc.gov/public/attachments/DOC-356643A1.pdf ^₅ 2021

From 5G mmWave to 6G THz: What's Next in RF Test Challenges

Session 2 Presentation 1

5G / mmWave



TestConX.org

TestConX China 2021

5G / mmWave

The 5G Era Brings 2X-3X RF Test TAM Multiplier



TestConX China Workshop

TestConX.org

5G / mmWave

Electromagnetic Spectrum and Applications



TestConX China Workshop

TestConX.org

Session 2 Presentation 1

5G / mmWave



Photonics IC Units (millions)

High Volume Photonics ICs nm Test Challenges Ahead!



5G / mmWave

Global Snapshot of Allocated/Targeted 5G Spectrum



Session 2 Presentation 1

5G / mmWave

Why Test?

If 5G fails, your brand fails.

- 5G mmWave devices early in product lifecycle, performance risks need sound test strategies
- 5G mmWave premium phones will demand 0 DPPM quality levels
- Need to establish a reliable <u>5G brand</u>



- High quality brand strategy requires more functional tests at probe and module insertions
- Poor upstream module, sub-assembly & final product OTA yields drive more functional test
- Characterization tests uncover failure mechanisms
- 5G use cases that drive volume and performance turn drive more device functional testing
- Any "emergency" massive field failures require functional-test-ready ATE on site



From 5G mmWave to 6G THz: What's Next in RF Test Challenges

₁₁ 2021

TestConX China Workshop

TestConX.org

5G / mmWave

nput 1 d

What to Test?

mmWave RFIC

- Gain
- P1dB and IP3
- Band pass filter(channel select) gain/flatness/outband attenuation
- PLL lock
- ACLR
- EVM
- Phase trimming
- OTA beamforming?
- Others (DC, leakage, pattern-scan and BIST)



mmWave RFBB (IFIC)

- Gain
- IP3
- Low pass filter (channel select) gain/flatness/outband attenuation
- PLL lock
- ACLR
- EVM
- IQ mismatch / IQ cal (phase and gain cal for image rejection & carrier suppression)
- Others (DC, leakage, pattern-scan and BIST)

From 5G mmWave to 6G THz: What's Next in RF Test Challenges





12

5G / mmWave

TestConX China 2021

What Type of "OTA" Test? $0.62 \frac{D^3}{\lambda}$ $2 D^{2}$ Large Antennas $D \ge \lambda/2$ $R \equiv Distance from antenna$ D ≡ Maximum extend of the **Small Antennas** $D < \lambda/2$ λ 2λ antenna aperture mmW RFIC + AA Radiative Reactive Radiated Near Field D Near Field Far Field R Transition Near Field Far Field Zone

Smaller Physical Size of the Device Handler or Test Socket or Shield Cavity

Reactive near-field region: It is the region where stored energy dominates. These reactive fields are generally created by strong **EM coupling** within the antenna or between antennas and very nearby electrical components. No radiative energy exists.



Radiative near-field region (NF):

This is the region where the near fields still exist but is not dominant. Radiative near-fields start to dominate. However, the shape of the radiation pattern may still vary appreciably with distance.

From 5G mmWave to 6G THz: What's Next in RF Test Challenges

Far-field region (FF): the shape of the radiation pattern does not change with distance. The spherical fields propagating outward can be considered as plane waves.

₁₃ 2021

TestConX.org

Larger

Session 2 Presentation 1

5G / mmWave



TestConX China Workshop

TestConX.org

TestConX China 2021

5G / mmWave

ATE with a Simple Upgrade from Sub-6 GHz to mmWave: *UltraWaveMX44*

- Zero change to existing DIB load board standard
- No system reconfiguration required to switch between sub-6GHz and mmWave applications
- Performance specified at blind-mate with fully integrated calibrations
- No change to docking or Z-height





TestConX China 2021

5G / mmWave

Summary

- The 5G Era is here and ramping faster than 4G
 - 2X-3X RF Test TAM Multiplier
- 6G only 4-5 years away
 - Integrated multi-band transceivers will require microwave/mmWave/THz test
 - Need to continue innovation on test techniques for mmW/THz contacted signal delivery and OTA
- Fronthaul 5G clogging the Backhaul and Data Center Networks
 - Need innovation on high-volume photonics ICs nm test
- 5G is changing the strategy for device testing
 - Teradyne millimeter wave test solutions are at the forefront of the 5G Era



From 5G mmWave to 6G THz: What's Next in RF Test Challenges

¹⁶ 2021

TestConX China Workshop

COPYRIGHT NOTICE

The presentation(s)/poster(s) in this publication comprise the proceedings of the TestConX China 2021 virtual event. The content reflects the opinion of the authors and their respective companies. They are reproduced here as they were presented at TestConX China. The inclusion of the presentations/posters in this publication does not constitute an endorsement by TestConX or the workshop's sponsors.

There is NO copyright protection claimed on the presentation/poster content by TestConX. However, each presentation/poster is the work of the authors and their respective companies: as such, it is strongly encouraged that any use reflect proper acknowledgement to the appropriate source. Any questions regarding the use of any materials presented should be directed to the author(s) or their companies.

TestConX, TestConX China, the TestConX logo, and the TestConX China logo are trademarks of TestConX. All rights reserved.



www.testconx.org

2021