

Mobile Test Summit Korea 2024

6G RESEARCH AREAS FROM T&M PERSPECTIVE

Yongsub Byun (Rohde & Schwarz Korea)
Seunggeun Yoo (Rohde & Schwarz Korea)

ROHDE & SCHWARZ

Make ideas real



MOBILE TEST SUMMIT KOREA 2024

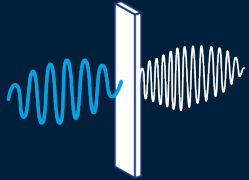
- ▶ 6G Research Areas
from T&M Perspective

- ▶ Overview of 6G Research Areas
 - ▶ Reconfigurable Intelligent Surface
 - ▶ Extreme-massive MIMO
 - ▶ THz communication and "FR3"
 - ▶ Integrated sensing and communication
- 



RESEARCH AREAS FROM A T&M PERSPECTIVE

THz communication, and "FR3"



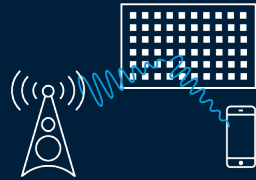
Integrated sensing & communication



Artificial Intelligence and Machine Learning



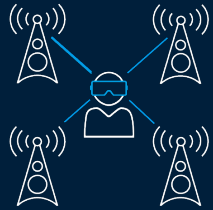
Reconfigurable Intelligent Surfaces



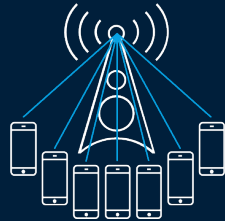
Photonics, Visible Light Communication



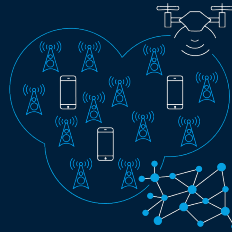
The Metaverse and eXtended Reality (XR)



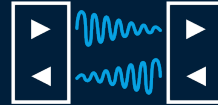
Multiple access, new waveforms, channel coding



Extreme-massive MIMO



New network topologies, distributed computing



Full-duplex communication



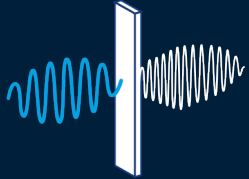
Security & Trustworthiness

A high-level overview of all these research areas is provided in one of our [#THINKSIX](#) videos



RESEARCH AREAS FROM A T&M PERSPECTIVE

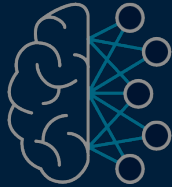
THz communication, and "FR3"



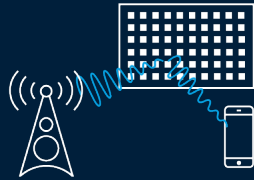
Integrated sensing & communication



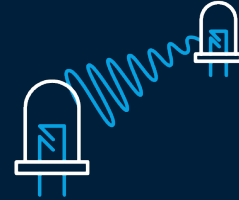
Artificial Intelligence and Machine Learning



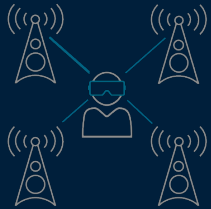
Reconfigurable Intelligent Surfaces



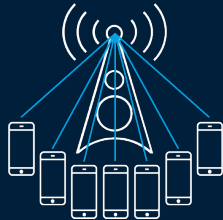
Photonics, Visible Light Communication



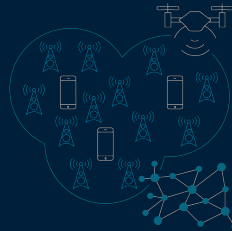
The Metaverse and eXtended Reality (XR)



Multiple access, new waveforms, channel coding



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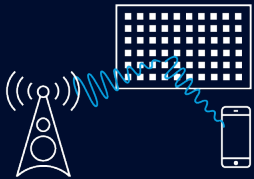
Full-duplex communication



Security & Trustworthiness

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Reconfigurable
Intelligent Surfaces

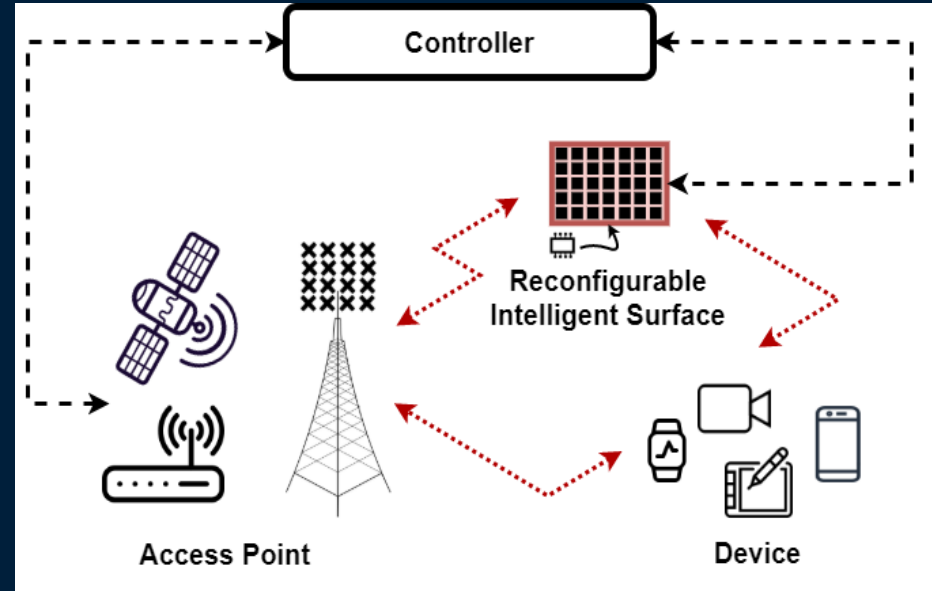


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RECONFIGURABLE INTELLIGENT SURFACE

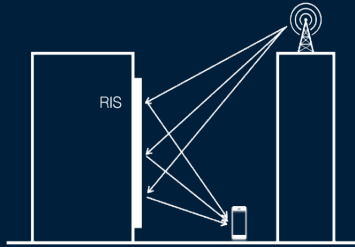
DEFINITION OF RIS

- ▶ RIS (reconfigurable intelligent surface) is a new type of network node leveraging smart radio surfaces, whose response can be adapted to the status of the propagation environment through control signalling

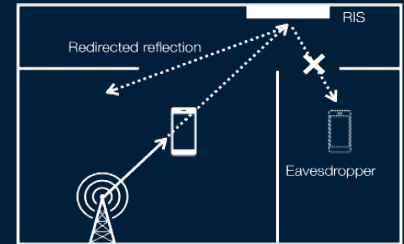
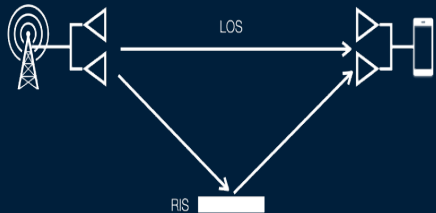


Source: ETSI ISG RIS GR001

USE CASES

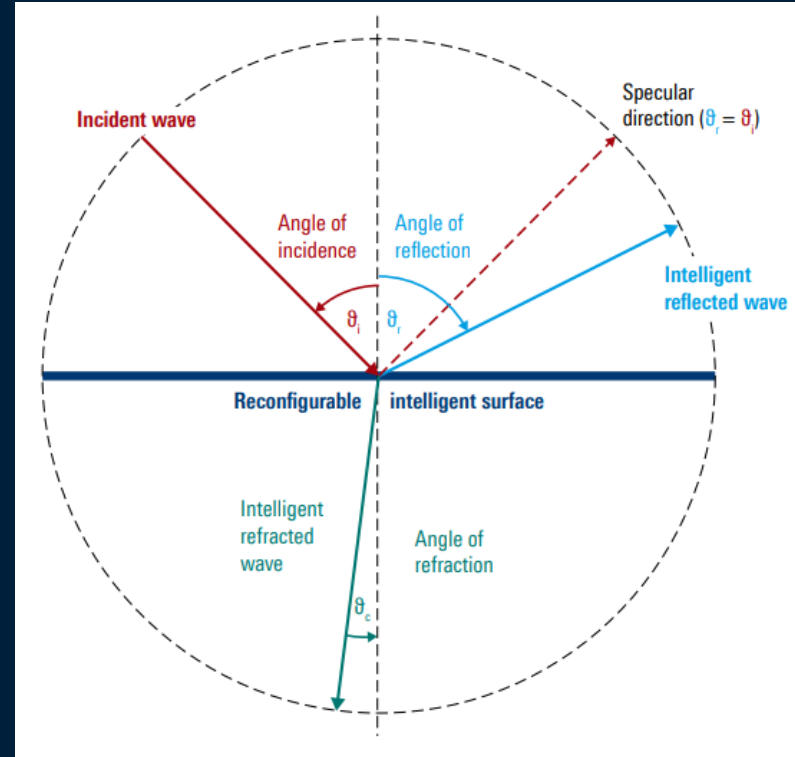


- Coverage enhancement
- Spectral efficiency improvement
- Beam management
- Secure communication
- Localization accuracy
- Sensing capabilities
- Energy efficiency



THE KEY TO RIS

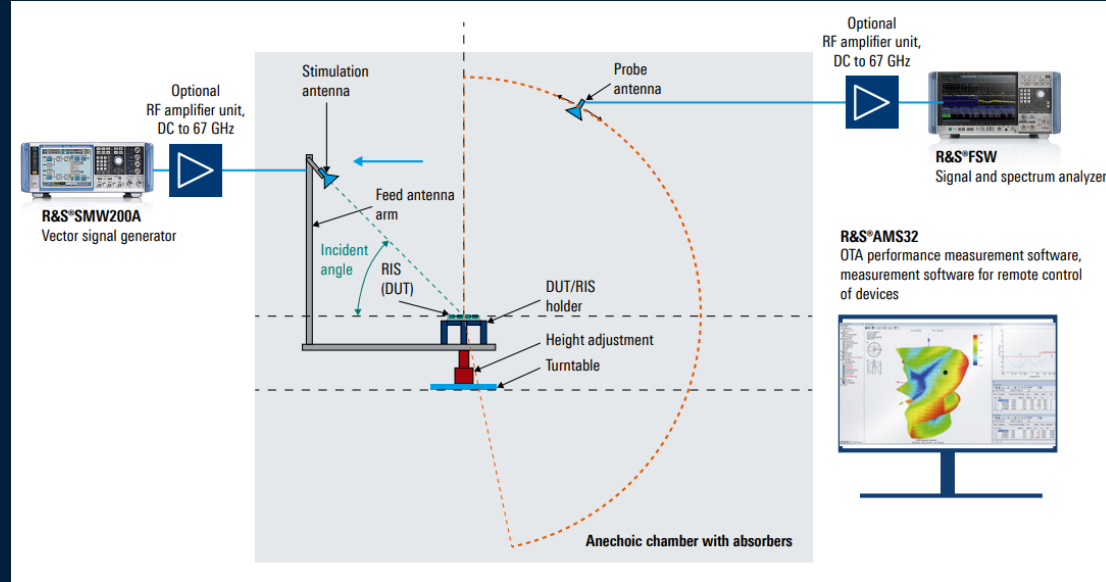
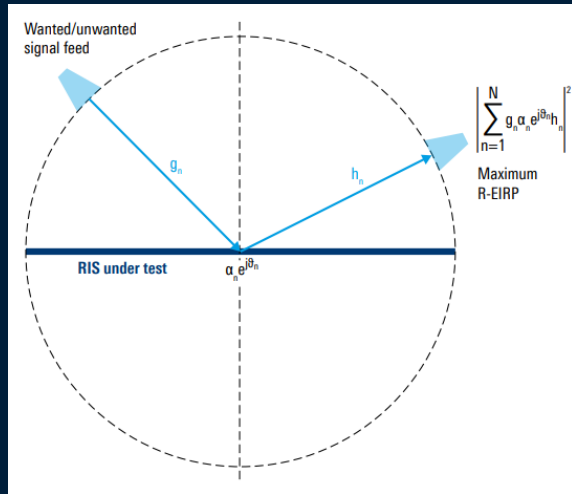
- ▶ The key to RIS involves **metamaterials** that allow manipulation of their inherent electro-magnetic reflection and refraction characteristics



OVERVIEW OF RIS TYPES

	PIN diode	Varactor diode	Liquid crystal (LC)
Equivalent circuit			
Stack (3D view)			

FUNDAMENTAL TEST SETUP



Source: ETSI ISG RIS GR002



6G-LICRIS

► Liquid crystal reconfigurable intelligent surfaces for 6G mobile networks

Objective

Enhance coverage and capacity of future 6G networks while minimizing power consumption with Reconfigurable Intelligent Surfaces (RIS)

Contributions

- Use cases and requirements
- Technology, concept and RIS development
- Simulation models and measurement methods
- Radio environment and channel modeling
- Network integration
- Demonstration

Partners



CONTENTS



Webinar: RIS – shaping the radio channel for best connectivity

This webinar explains the technology behind RIS, discusses possible use cases and applications and examines what this means for testing.

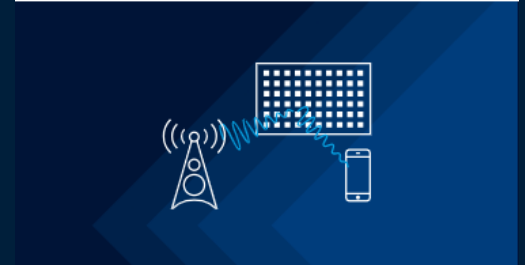
→ [Register to watch](#)



Video: 6G Reconfigurable Intelligent Surfaces (RIS)

This video introduces the topic and the test requirements of reconfigurable Intelligent Surfaces (RIS).

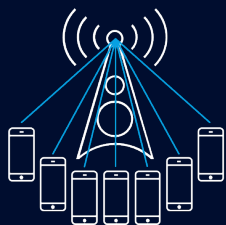
→ [Watch Video](#)



Whitepaper: Reconfigurable intelligent surfaces (RIS)

Read this white paper now for an in-depth information on the principles of metamaterials, different RIS types and T&M requirements.

→ [Download now](#)



Extreme-massive
MIMO

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EXTREME-MASSIVE MIMO

6G EXTREME MASSIVE MIMO

5G massive MIMO

- ▶ Frequency
 - 3.4 ~ 3.7GHz in Korea
 - 100MHz BW
- ▶ TRx
 - 32
 - 64
- ▶ Antenna Elements
 - 192
 - 384

6G extreme massive MIMO

- ▶ Frequency
 - Upper-mid Band / 7 ~ 24GHz
 - > 400MHz
- ▶ TRx
 - 256
- ▶ Antenna Elements
 - > 1000

CHALLENGES IN ANTENNA TEST MULTI-PORT NETWORK ANALYZER

- ▶ Frequency Range : up to 24GHz
- ▶ Number of Ports : up to 256 ports

5G massive MIMO



8.5GHz / 64TRx



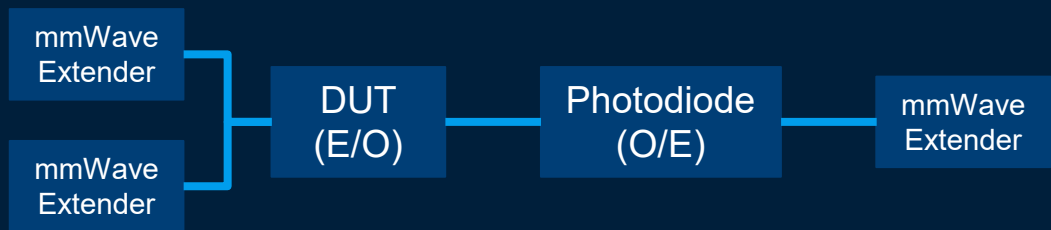
6G Extreme massive MIMO



26.5GHz / 256TRx

WIRED NETWORK 6G FRONTHAUL OPTICAL LINK

- ▶ > x 10 Data Rate with 6G Extreme massive MIMO
- ▶ Ultra-high Speed/Capacity Optical Component for 6G fronthaul
 - Up to 110GHz VNA with Photodiode
 - DUT : E/O and O/E Converter



R&S ZNA



Photonics, Visible
Light Communication



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PHOTONICS, VISIBLE LIGHT COMMUNICATION

THE ROLE OF PHOTONICS IN 6G

Photonic integrated circuit (PIC) for miniaturization / commercialization

<https://www.forschung-it-sicherheit-kommunikationssysteme.de/projekte/6g-adlantik>

Courtesy of Lionix Structured Light

THz and VLC (6G-ADLANTIK)

- Generation of THz radiation by optical mixing on a photodiode
- **VLC (visible light communication) also known as LiFi:** modulation of commercial LEDs, cost-efficient with easy integration into existing infrastructure mainly for line-of-sight indoor applications
- optical generation of microwave oscillators with ultra-low phase noise

All-Photonic networks (APN)

- **Innovative Optical and Wireless Networks Global Forum (IOWN GF)**
- end-to-end optical path between points in the networks with minimal photo-electric conversion to realize **large-capacity, low-latency, and low-energy** consumption infrastructure

Quantum communication and quantum networks

- **trustworthiness** for ultra-secure and reliable communication
- inherently secure way of **quantum key distribution (QKD)** by exchange of entangled photons

6G-ADLANTIK

► Photonic THz generation and analysis for 6G communication and T&M

Objective

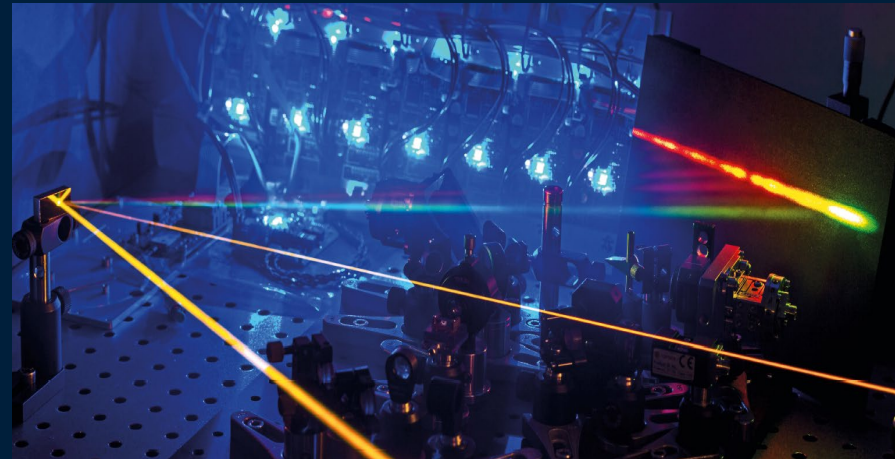
Ultra-stable tunable THz system for 6G wireless communication and test & measurement based on photonics

Scope of work

- Use cases and requirements definition
- Photonic generation of tunable THz signals, modulation and demodulation for 6G wireless communication
- Test and measurement for component characterization with coherently received THz signals
- THz waveguide architecture simulation and design
- Ultra-low phase noise photonic reference oscillator
- Proof-of-concept demonstrator

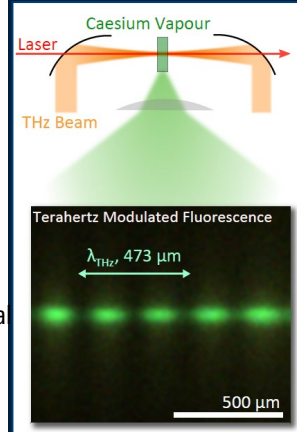
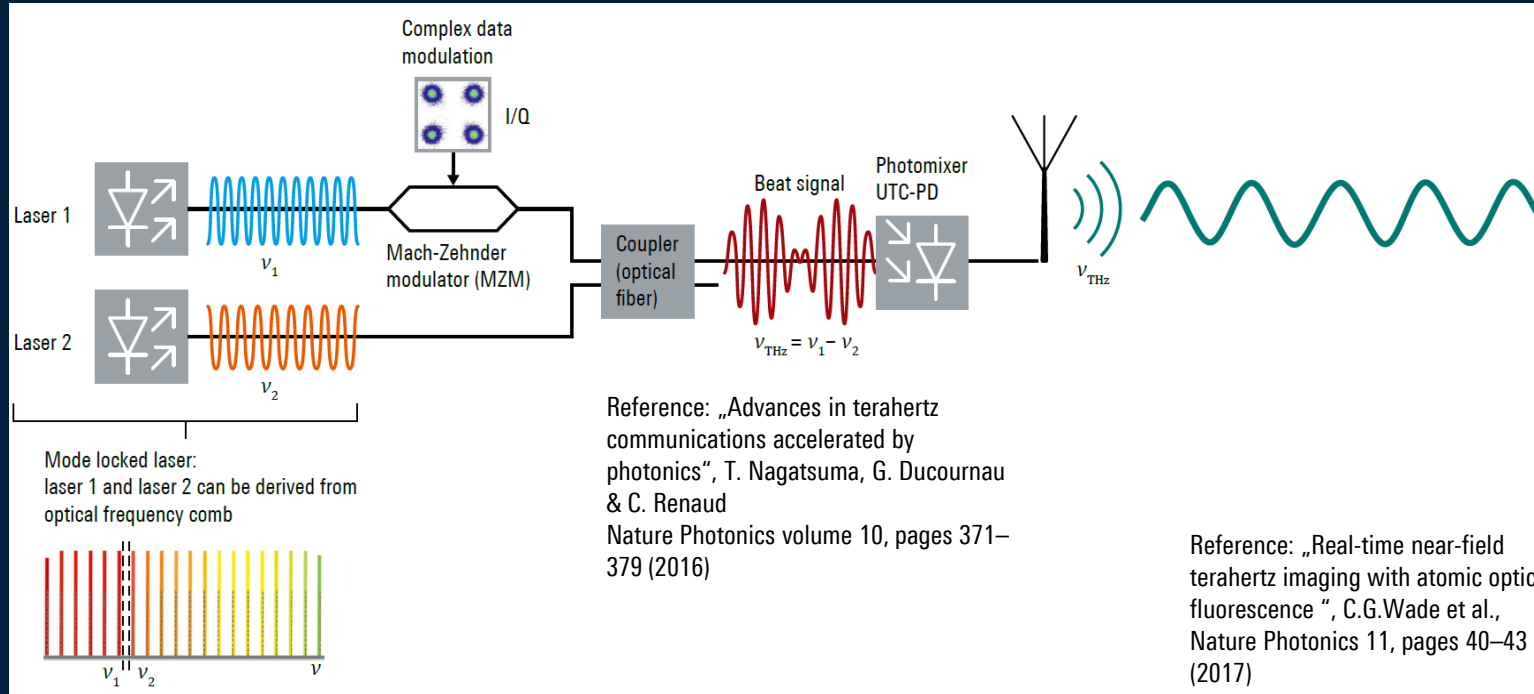
Partner

ROHDE & SCHWARZ
Make ideas real



DOWN-CONVERSION: OPTOELECTRONIC THZ GENERATION

► Photomixer: unitttraveling carrier photodiode (UTC-PD)



THZ WAVES FOR COMMUNICATIONS IEMN AND R&S PRESS RELEASE

► 300GHz bi-directional link over 650m



Courtesy of: Prof. G. Ducournau, IEMN, CNRS-Université de Lille
PhLAM, CPER Photonics, Hauts de France Region, FRANCE



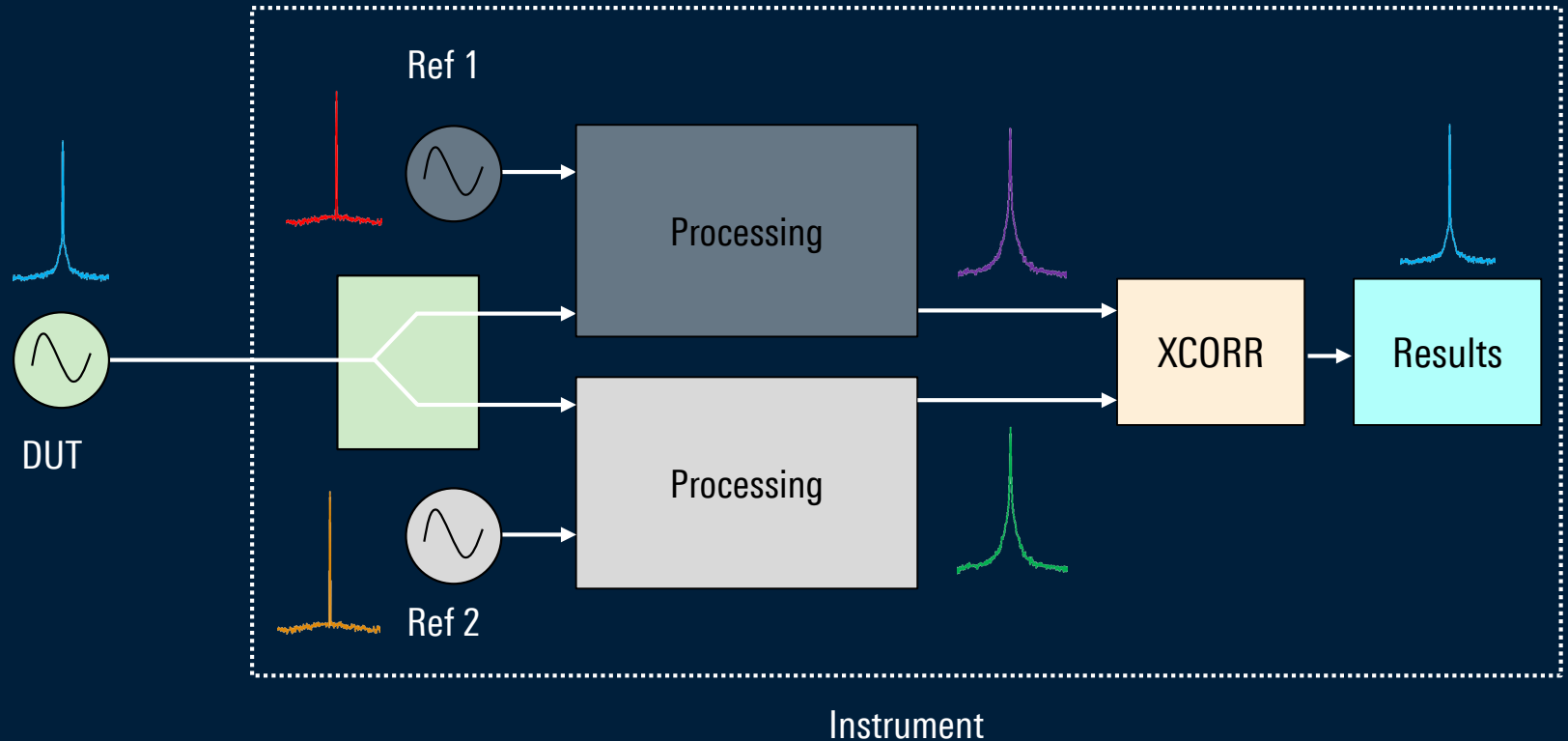
https://www.rohde-schwarz.com/about/news-press/all-news/rohde-schwarz-and-iemn-collaborate-on-6g-thz-by-bringing-together-electronic-and-phonic-technologies-press-release-detailpage_229356-1369600.html



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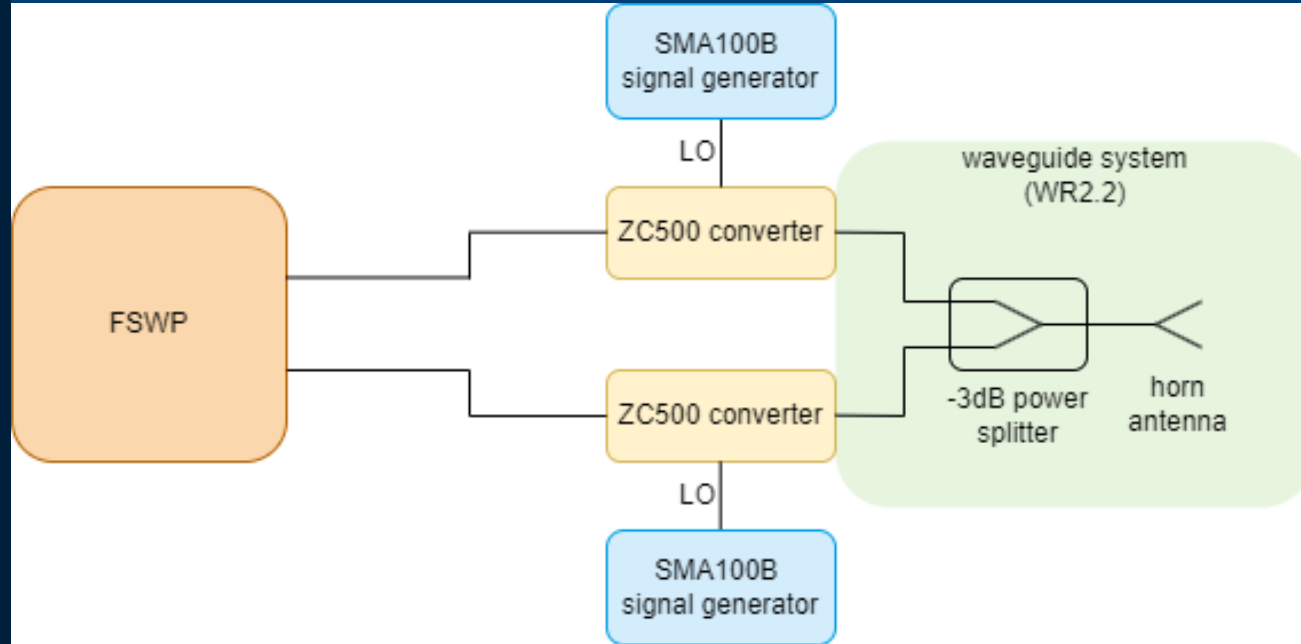
Rohde & Schwarz Korea 6/19/2024

PHASE NOISE MEASUREMENT USING CROSS-CORRELATION

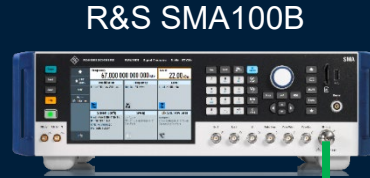


CROSS CORRELATION METHOD UP TO 500GHZ

Schematic Setup



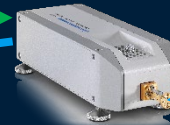
PHASE NOISE ANALYZER WITH FREQUENCY CONVERTERS



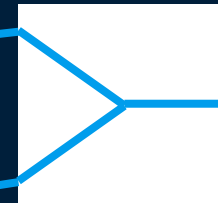
LO



R&S ZC500

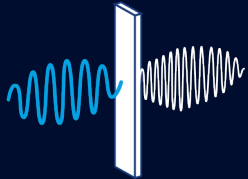


R&S ZC500



Splitter

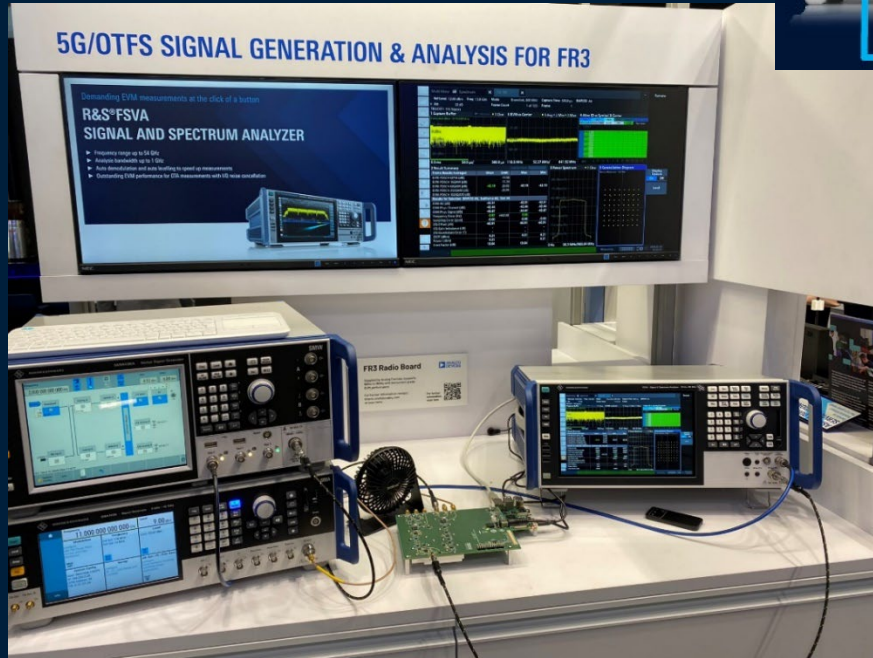
THz communication,
and “FR3”



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THZ COMMUNICATION AND “FR3”

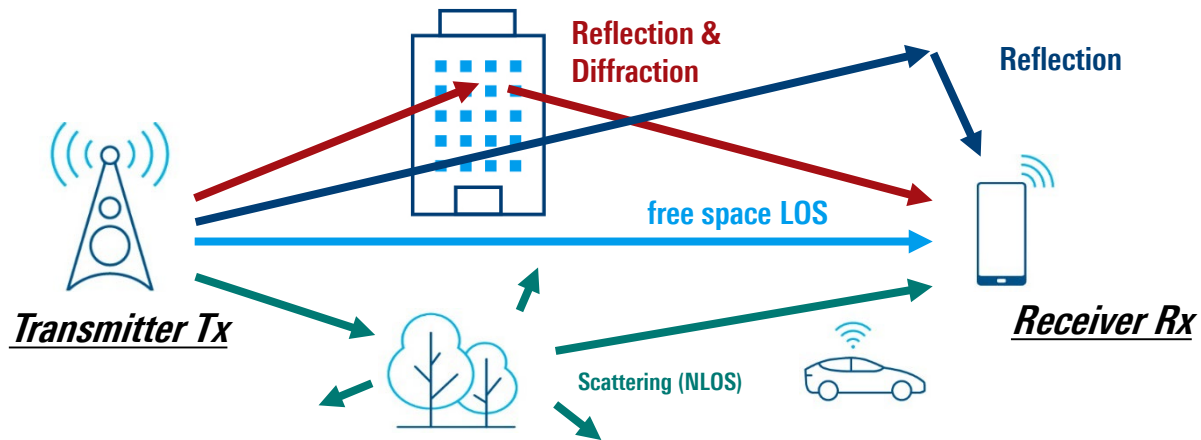
TOWARD 6G NEW SPECTRUM FR3



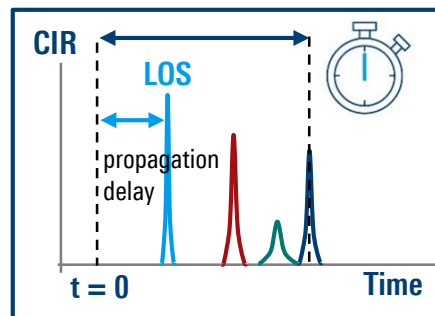
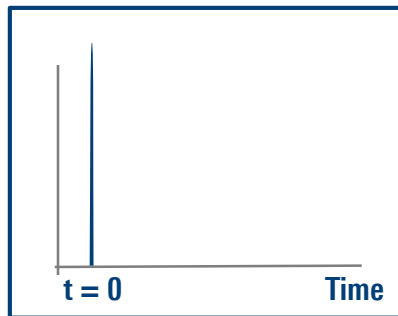
- ITU 2023 / FCC / WRC-23 Study items: 14.8 to 15.35 GHz, 1 2.2 to 13.25 GHz, **7.125-8.4 GHz**
[IMT-2030, 6G 후보 주파수 대역 : 네이버 블로그 \(naver.com\)](#)
[차세대 이동통신 6G로 가는 길 - Part ... : 네이버블로그 \(naver.com\)](#)
- Candidate BW: Max. 400MHz(expectation)
- Candidate Signal: OTFS*(Orthogonal Time Frequency Space)
- MWC2024 demo:
 - ADI reference transceiver board
 - 550 MHz BW, 60 kHz SCS, -42dB EVM (w/o I/Q NC)
 - <-45dB EVM w/ I/Q NC applied

* [한국전자파학회논문지 \(The Journal of Korean Institute of Electromagnetic Engineering and Science\) \(jkiees.org\)](#)

TOWARD 6G NEW SPECTRUM – CHANNEL MEAS.



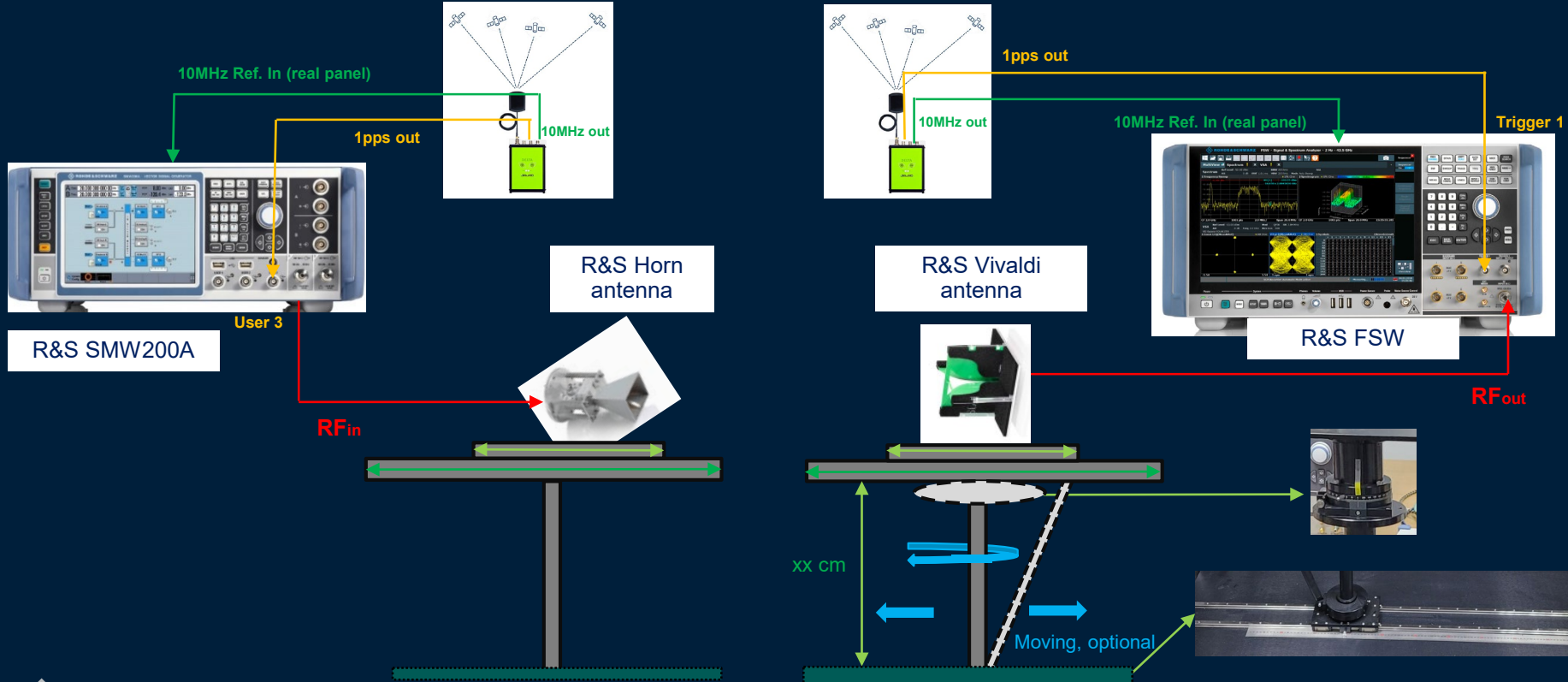
Transmitter
Signal



Receiver
Signal

Channel
Impulse
Response
(CIR)

TOWARD 6G NEW SPECTRUM – CHANNEL MEAS. FR3

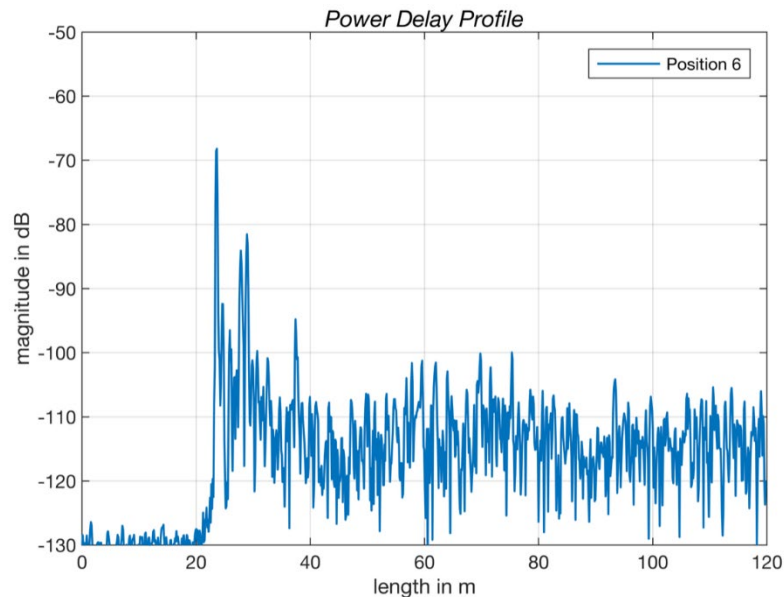


TOWARD 6G CHANNEL MEASUREMENTS FR3 (13-15 GHz) WITH DOA

FR3 14 GHz center frequency, 2 GHz BW (Tx at elevator)



Power delay profile CIR 14 GHz (LOS and multipath)

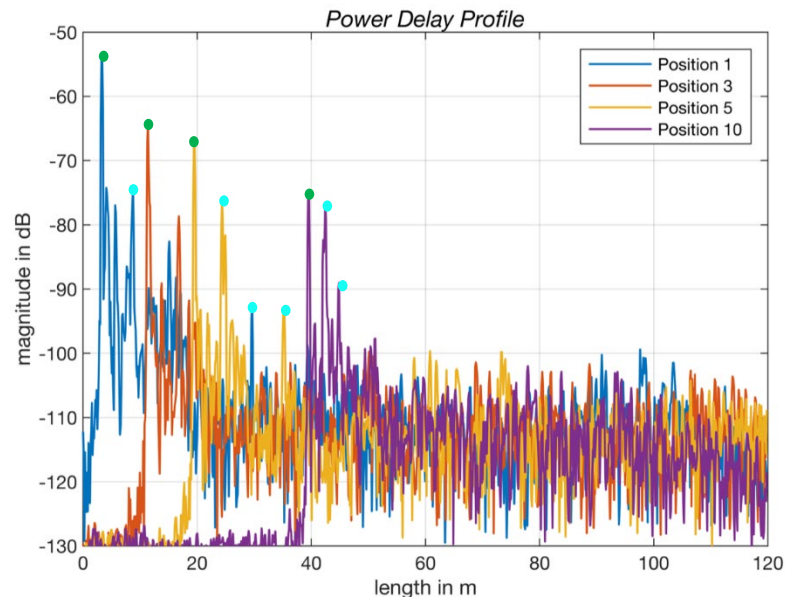


TOWARD 6G CHANNEL MEASUREMENTS FR3 (13-15 GHz) WITH DOA

FR3 14 GHz center frequency, 2 GHz BW (Tx at elevator)



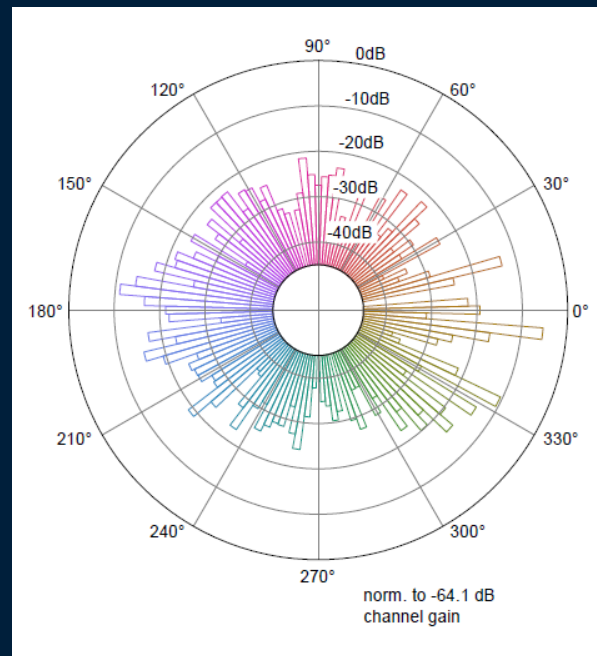
Power delay profile CIR 14 GHz at various distances



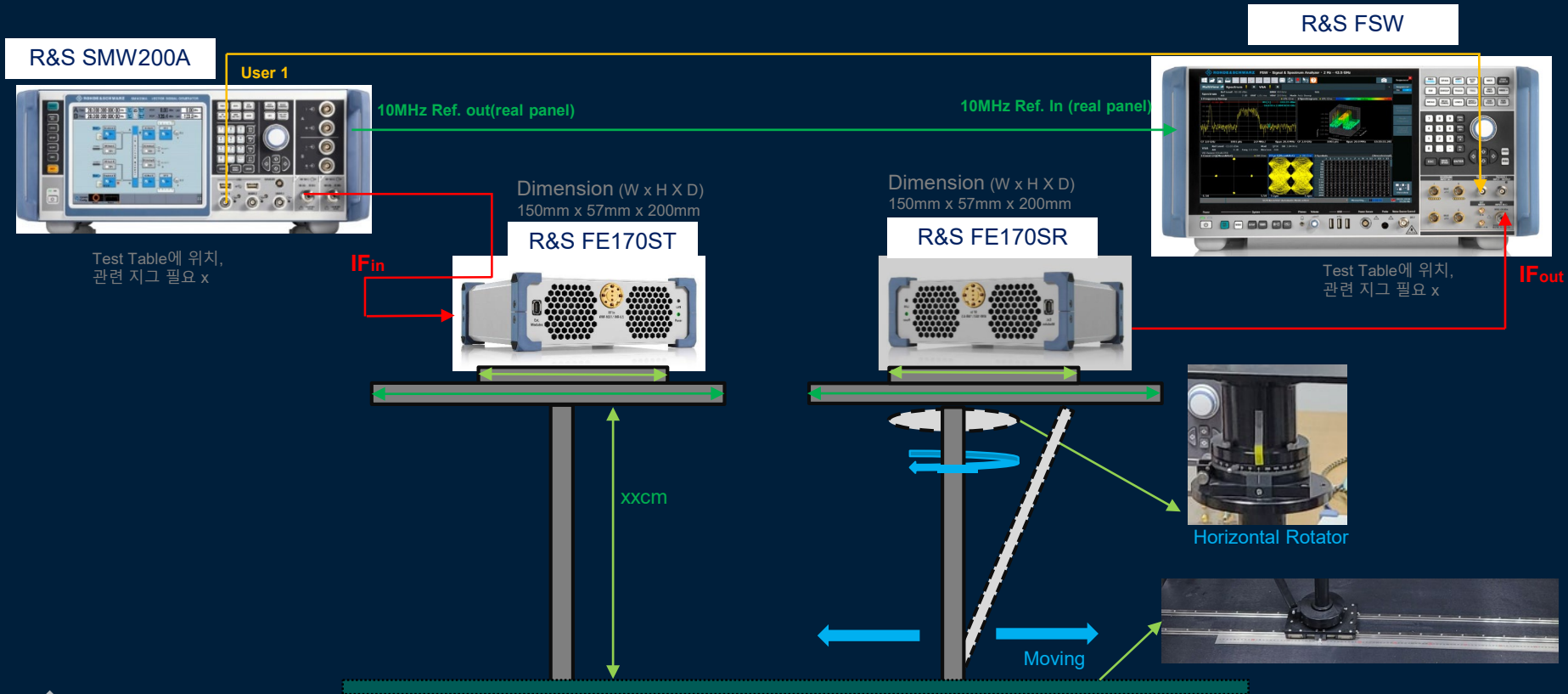
TOWARD 6G

CHANNEL MEASUREMENTS FR3 (13-15 GHz) WITH DOA

FR3 14 GHz center frequency, 2 GHz BW (Tx at elevator)



TOWARD 6G NEW SPECTRUM – CHANNEL MEAS. D-BAND



Integrated sensing
& communication

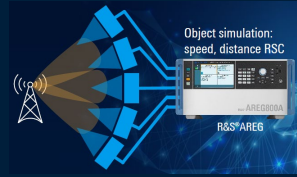


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INTEGRATED SENSING AND COMMUNICATION (ISAC)

TOWARD 6G

ISAC (INTEGRATED SENSING AND COMMUNICATION) 24- 44G



KOMSENS-6G

Perzeptive Kommunikationsnetzwerke mit integrierter Funk-Sensoren für die 6. Generation des Mobilfunks



Partners include:

- Nokia
- Ericsson
- Bosch
- DT
- Fraunhofer
- KIT
- RWTH Aachen
- ...

SPONSORED BY THE



Perzeptive und sensorische Kommunikationsnetze ermöglichen viele nützliche An-
wendungen im automatisierten Fahren oder in der Telemedizin.



Won GTI award for best proof-of-concept for Joint
Communication and Sensing at Mobile World Congress
Barcelona 2023

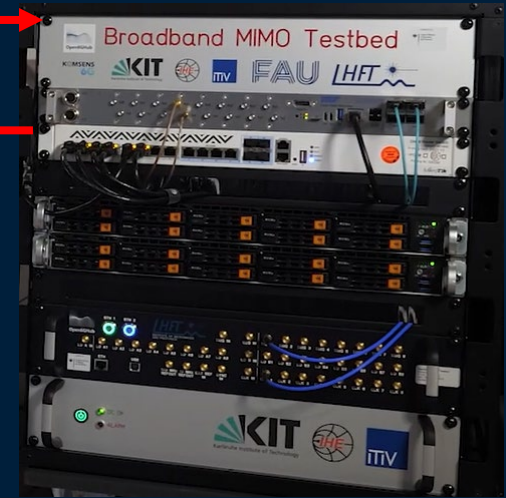
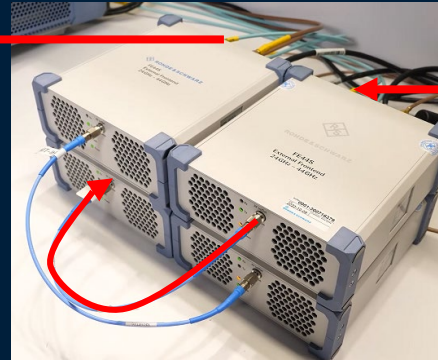


[1. KOMSENS-6G](#)

[2. Rohde & Schwarz ISAC Solution](#)

[3. MWC 2024 ISAC](#)

TOWARD 6G ISAC (INTEGRATED SENSING AND COMMUNICATION) 24- 44G



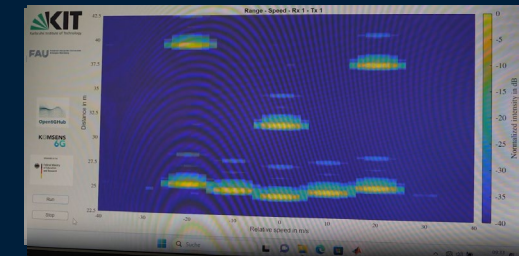
Channel 1
A1

Radars Power

Measurement Setup

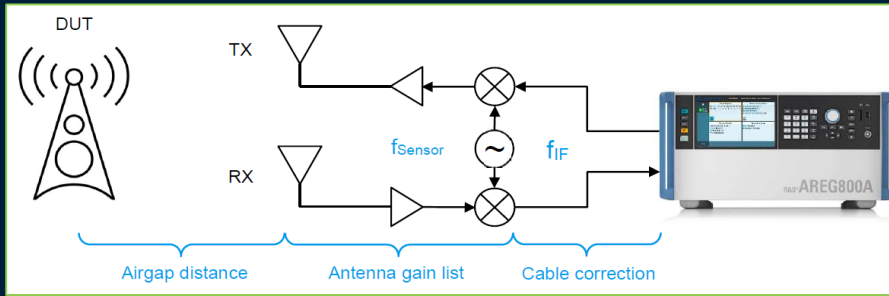
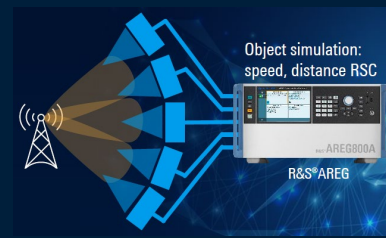
Objects

Object	State	Range (m)	Attenuation (db)	Doppler Speed (m/s)	Horizontal Angle (deg)	RCS (dBm ²)
4	On	25.50	0.00	-10.000 0	0.0	-13.2
5	On	40.00	0.00	20.000 0	0.0	-5.4
6	On	40.00	0.00	-20.000 0	0.0	-5.4
7	On	32.00	0.00	0.000 0	0.0	-9.3
8	On	26.00	0.00	-20.000 0	0.0	-12.9



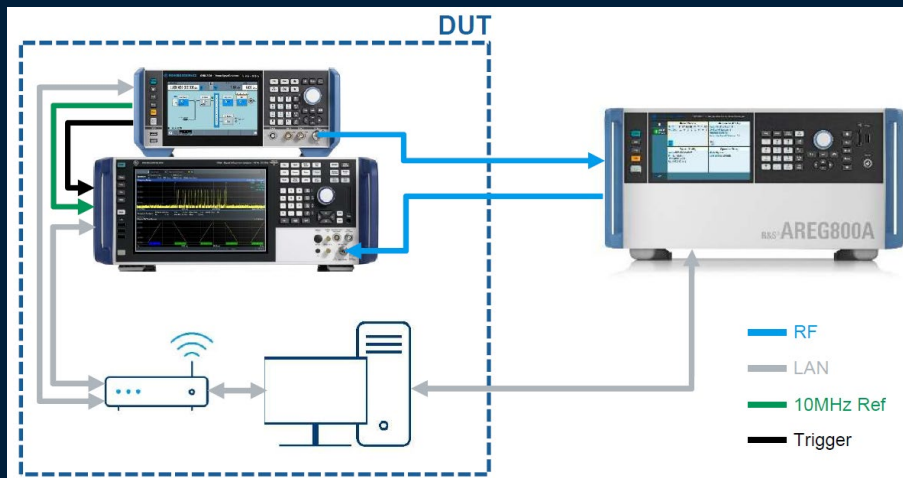
TOWARD 6G

ISAC (INTEGRATED SENSING AND COMMUNICATION) ALL-FREQ



AREG800A new features

- Customized Frontend 지원, up to **5GHz BW (0.7 to 5.7GHz)**
- AREG8-K528 (5GHz BW), AREG8-K553 (Frontend Control)



		Channel 1				
		A1				
		Object	State	Range (m)	Attenuation (dB)	Doppler Speed (km/h)
SCPI		1	On	30.00	0.00	112.000

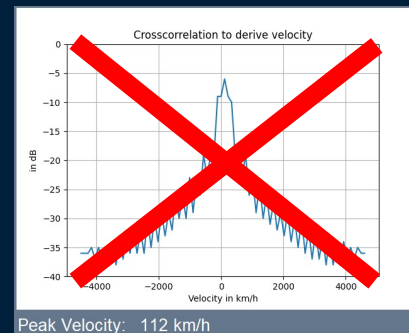
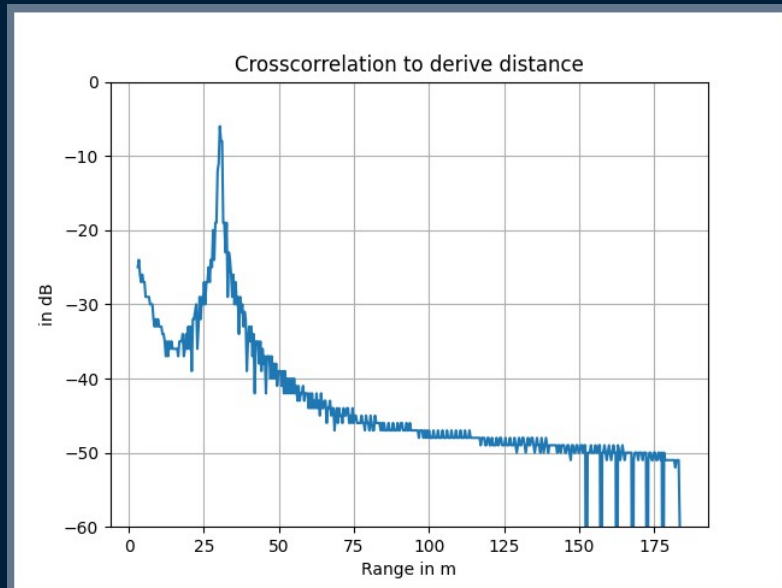
ISAC Demonstration

- DUT: Tx - VSG, Rx - VSA
- Waveform: NR + FMCW
- AREG: Target Simulator

TOWARD 6G

ISAC (INTEGRATED SENSING AND COMMUNICATION) ALL-FREQ

Channel 1		A1			
Object	State	Range (m)	Attenuation (dB)	Doppler Speed (km/h)	
SCPI	1	On	30.00	0.00	112.000



2 Result Summary

Frame Results Averaged	Mean	Limit	Max	Min
EVM PDSCH QPSK (%)		18.50		
EVM PDSCH 16QAM (%)		13.50		
EVM PDSCH 64QAM (%)	2.31	9.00	2.31	2.31
EVM PDSCH 256QAM (%)		4.50		
EVM PDSCH 1024QAM (%)		3.80		
Results for Selection BWP/SS All, Subframe All, Slot All				
EVM All (%)	2.39		2.75	2.31
EVM Phys Channel (%)	2.38		2.93	2.31
EVM Phys Signal (%)	2.45		2.55	2.28
Frequency Error (Hz)	-997.03	±252....	0.00	
Sampling Error (ppm)	0.00		0.00	0.00
I/Q Offset (dB)	-47.68		-47.68	-47.68
I/Q Gain Imbalance (dB)	-		-	-
I/Q Quadrature Error (°)	-		-	-
OSTP (dBm)	-32.53		-32.53	-32.53
Power (dBm)	-25.19		-25.19	-32.55
Crest Factor (dB)	10.48		10.48	

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THANK YOU

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