5G Tokyo Bay Summit 技術セミナー
2017年5月25日

キーサイト・テクノロジーの５Ｇへの取り組み

Keysight Technologies
徳田　裕司
森下　幹夫

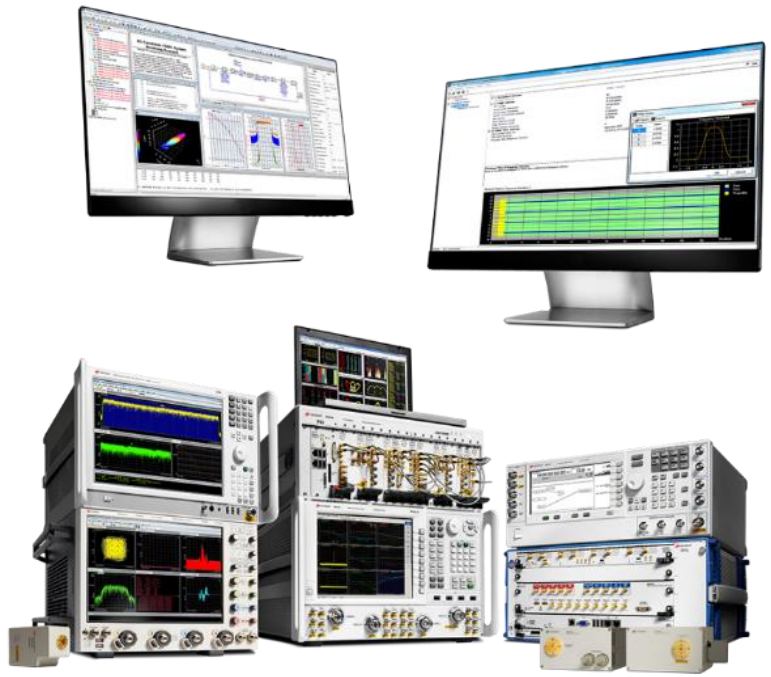
KEYSIGHT TECHNOLOGIES

Agenda

– キーサイト・テクノロジーについて

– 5Gに関連した各社との取り組み

– 測定ソリューション紹介



KEYSIGHT TECHNOLOGIES

Keysight Technologies について

1939: ウィリアム・ヒューレットとデビット・パッカードが
「ヒューレット・パッカード社」を創業

1963: HPと横河電機株式会社の合弁で
「横河・ヒューレット・パッカード株式会社(YHP)」を設立

1995: 「日本ヒューレット・パッカード株式会社」へ社名変更

1999: ヒューレット・パッカードからの会社分割により
「アジレント・テクノロジー株式会社」を設立
(計測機器、化学分析機器、医療機器、電子部品)

2014: ライフサイエンス事業を営む「アジレント・テクノロジー株式会社」と
電子計測機器事業を営む「キーサイト・テクノロジー合同会社」に事業を分割

KEYSIGHT TECHNOLOGIES

5G Scenarios and Use Cases

Broad range of new services and connectivity paradigms

Amazingly Fast	Great Service In a Crowd	Best Experience Follows You	Real-Time & Reliable Communications	Ubiquitous Things Communicating

Mobile Broadband Access

- All data, all the time
- 2 billion people on social media

Massive Machine Communication

- 30 billion “things” connected
- Low cost, low energy

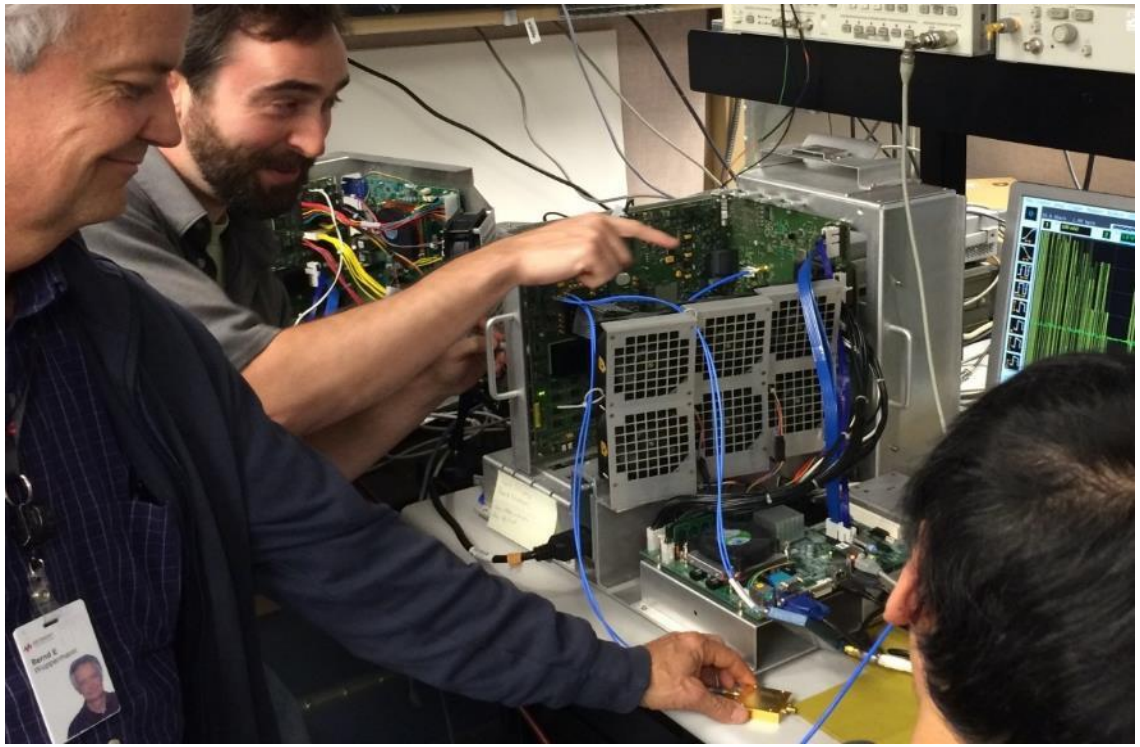
Mission-Critical Machine Communication

- Ultra high-reliability
- Ultra-low latency

KEYSIGHT TECHNOLOGIES

Keysight Labs

Centered on applied research



Keysight Labs' world class researchers include four IEEE Fellows and three Keysight Fellows

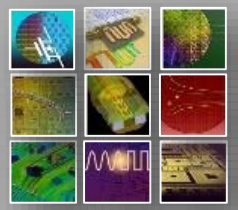
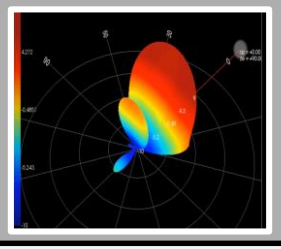
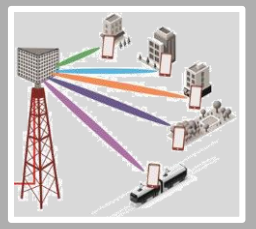
Research themes:

- ✓ Software
- ✓ Heterogeneous computing systems
- ✓ Human-computer interaction
- ✓ Wireless
- ✓ ASICs
- ✓ DSP
- ✓ Photonics
- ✓ Imaging
- ✓ Modeling

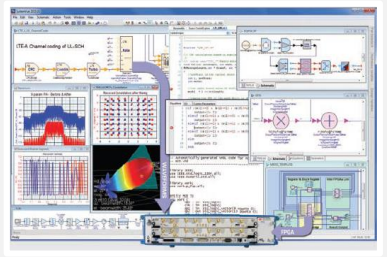
Labs' portfolio centers on applied research to create breakthroughs that enable superior measurement solutions.

KEYSIGHT TECHNOLOGIES

5G Solutions For Components, Circuits, Devices, Systems

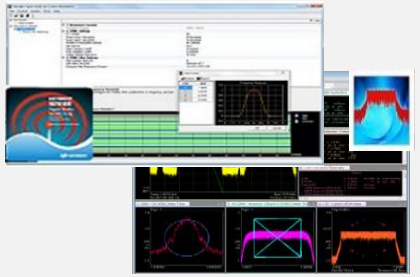





Simulate & Visualize



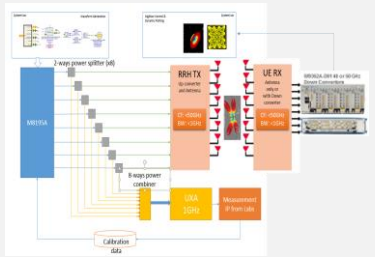
Electronic Design Automation Software

Calíbrate & Capture



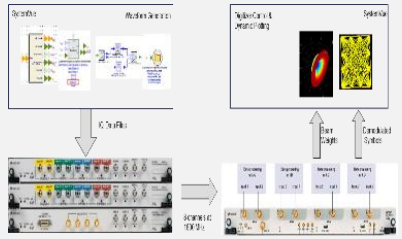
World's Fastest and Most Accurate Measurement Science

Emulate in Real Time



Emulation, Visualization, Performance Metrics

Scale & Adapt



Software-Enabled Reference Solutions and Services

Innovating With Industry Leaders From The Entire Ecosystem

Validation: Physical Layer Through Application Layer

KEYSIGHT TECHNOLOGIES

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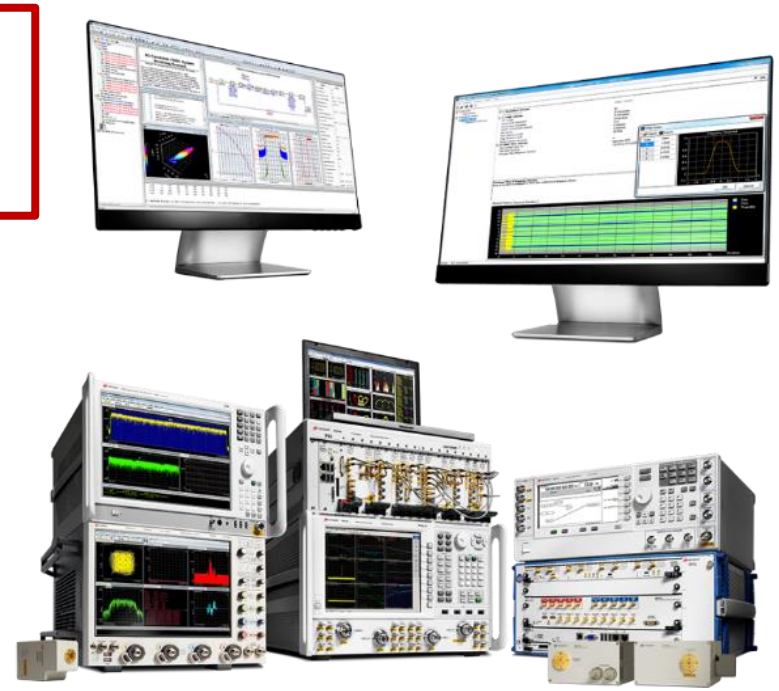


KEYSIGHT TECHNOLOGIES

NTTドコモ様 との 5G 実験協力

「60GHz 超広帯域通信における伝搬特性」

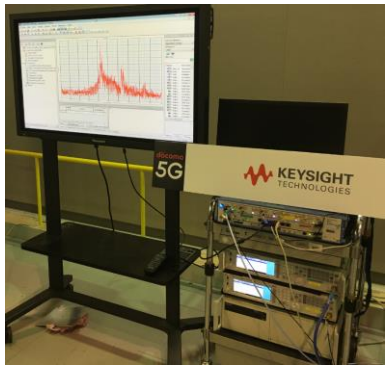
NTT docomo

- 計測外システムのご提供
- 実験局ライセンスの取得
- 伝搬特性の実験実施

－

KEYSIGHT TECHNOLOGIES

- システム設計
- 計測ソリューションの提供
- システムパーフォーマンス調整



目的

■60GHzにおける測定を実施し、高周波・広帯域信号の伝搬特性モデル（チャネルモデル）構築に向けて共同検証

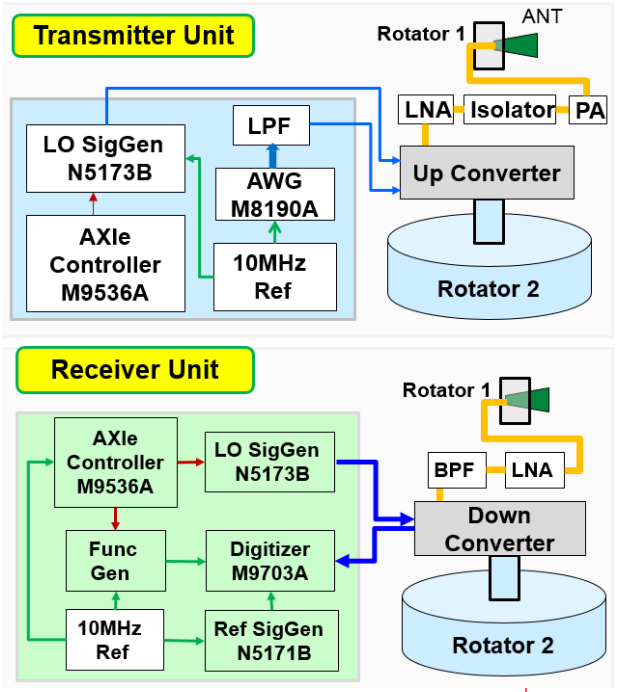
特長

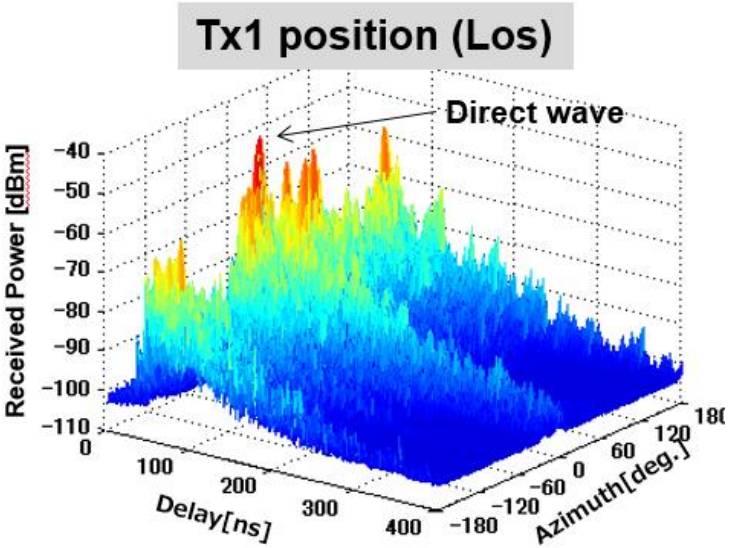
■伝搬特性として、伝搬損失、到来角プロファイル、遅延プロファイルの測定・評価

■反射や遮蔽物がある状況での特性の把握

■ミリ波帯において広帯域信号の送受信、計測、解析が可能

- 広帯域任意波形発生器
- アップダウンコンバータ
- アンテナ
- 広帯域デジタル・レシーバ
- 解析用ソフトウェア



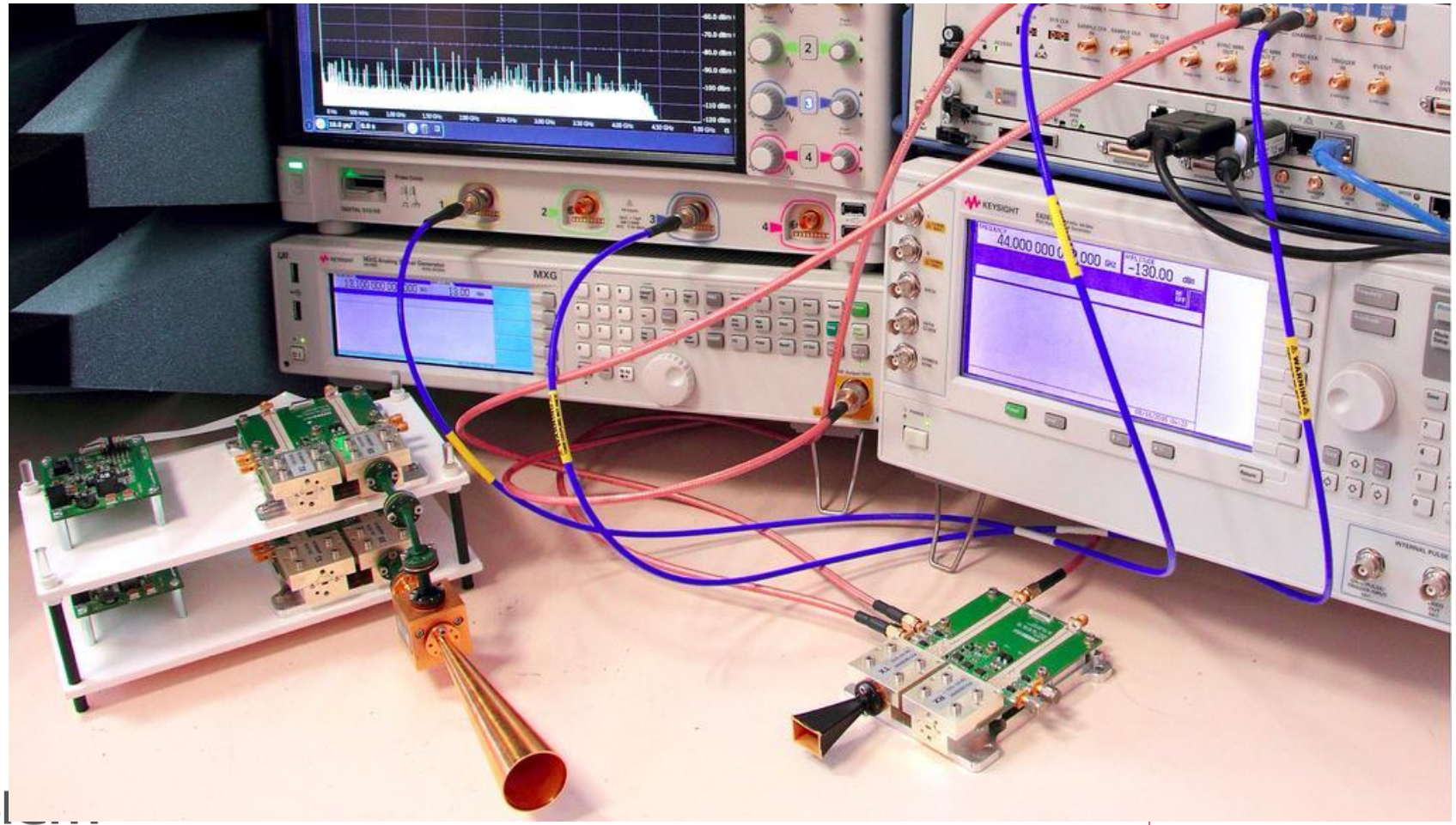


KEYSIGHT TECHNOLOGIES

Keysight 60 GHz channel sounder with 2 GHz Real-time bandwidth at University of Bristol in mmMAGIC Project

mmMAGIC

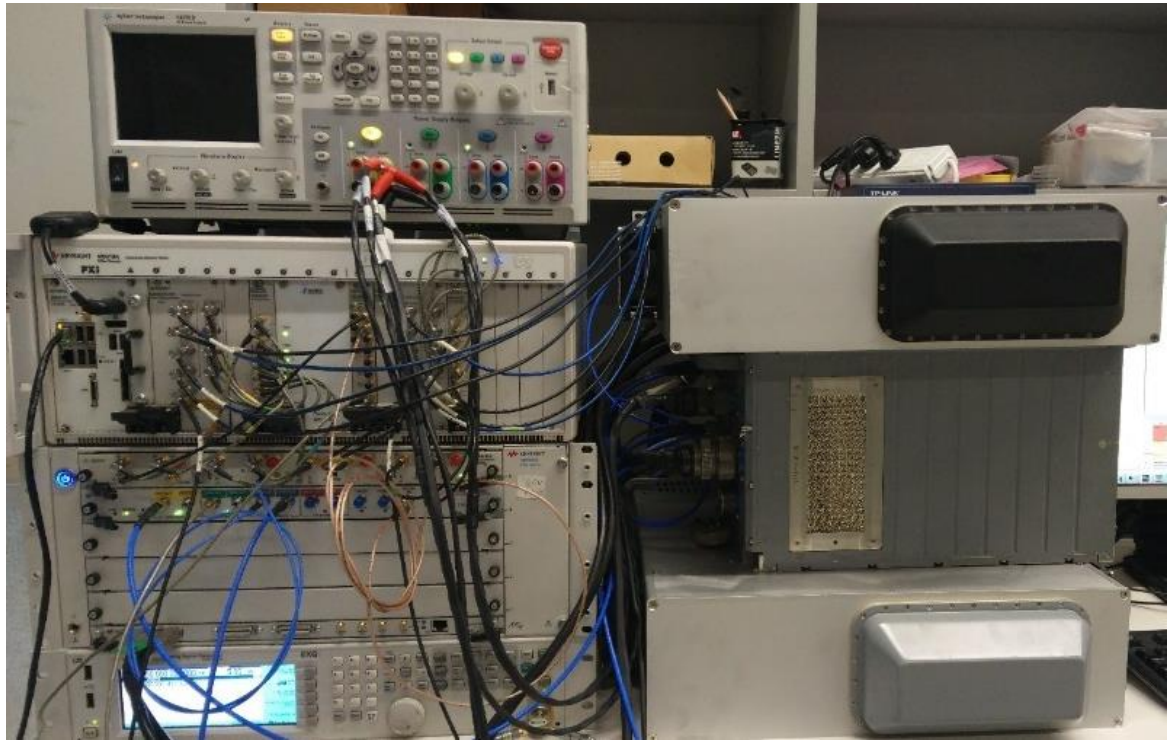
University of BRISTOL



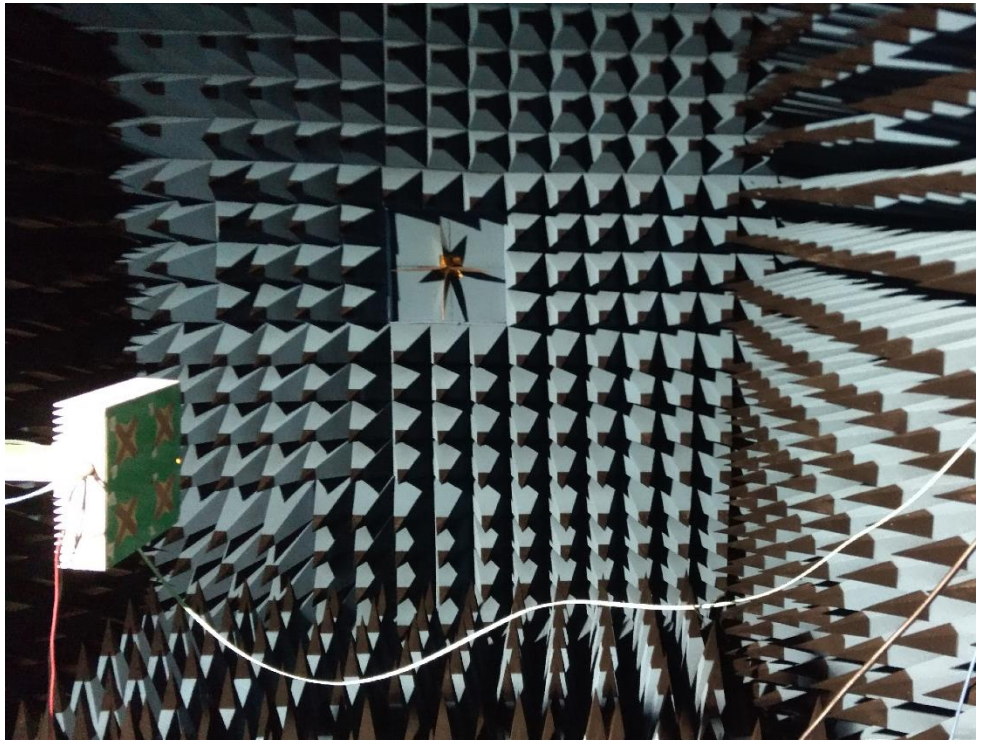
KEYSIGHT TECHNOLOGIES

5G Collaborations

Massive MIMO Prototype System and OTA Test Research

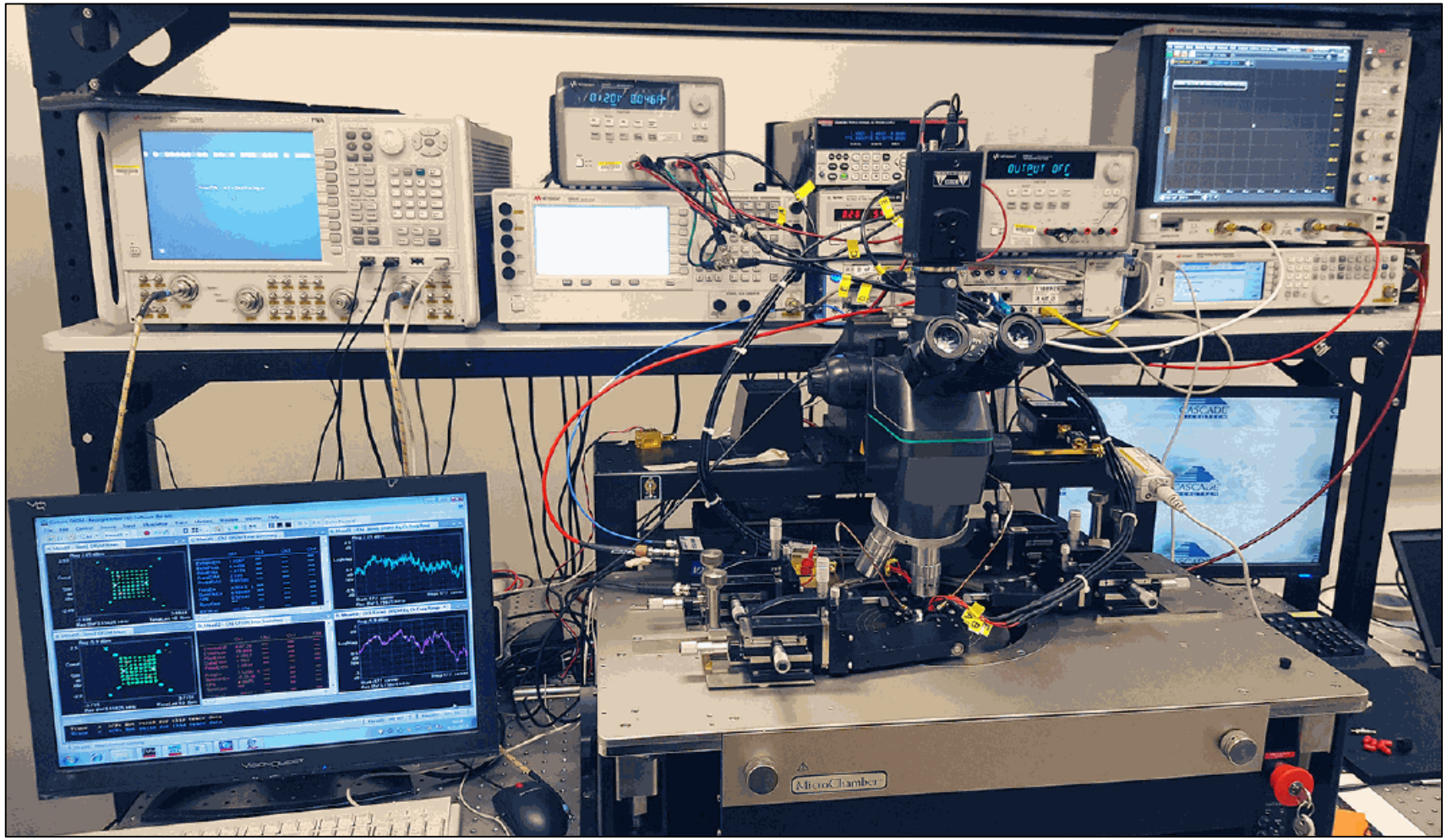


Massive MIMO real-time beamforming prototype with Aselsan



Massive MIMO OTA test collaboration with CMCC

Flexible mmWave Testbed Setup at Skyworks for DPD @mmWave



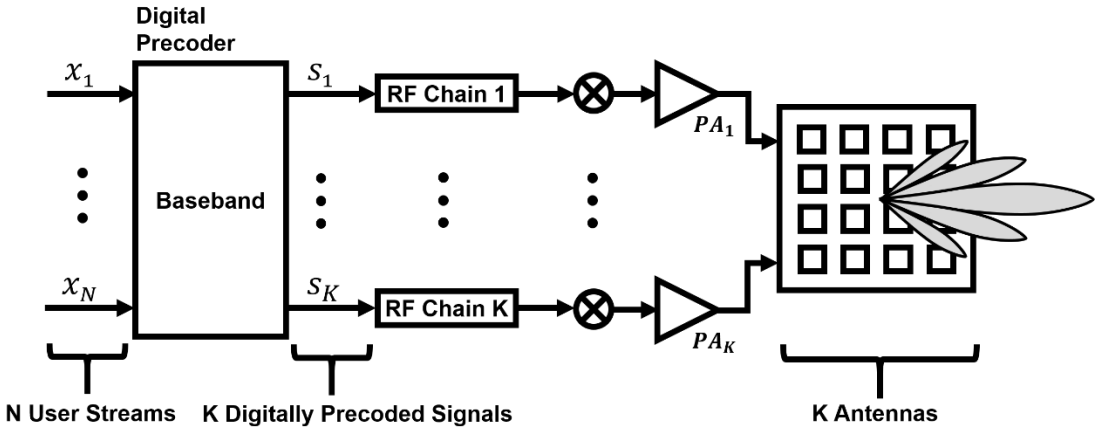
- ✓ Wideband mmWave Testbed with SystemVue for DPD
- ✓ 2-4 dB improvement in ACP
- ✓ 1-2 % improvement in EVM

Digital Predistortion for 5G

Problem Statement

– Frequency and Bandwidth:
  - Current 5G trails and standards definitions include frequency bands at 28 GHz, 39 GHz and above
  - Signal bandwidths proposed for these frequency bands range from 100 MHz to greater than 2 GHz
  - DPD requires modulation and measurement bandwidths 3-5 times the signal bandwidth

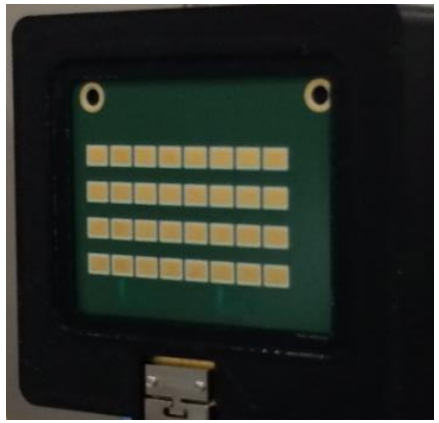
– Multi-channel:
  - mmWave systems will utilize multi-antenna systems with power amplifiers spaced at distances less than 1 wavelength
  - Interaction between amplifiers is a new area to be researched



Demonstration Phased Array

University of California at San Diego

UC San Diego



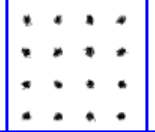
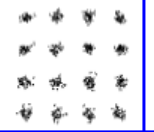
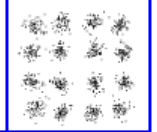
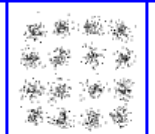
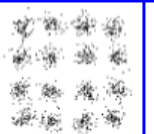
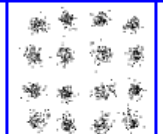
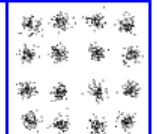
	5 m / +50° H-plane		300 m / 0° scan	
16-QAM				
Data rate EVM	2 Gbps 3.74%	4 Gbps 6.68%	400 Mbps 5.9%	1.6 Gbps 10.9%
Scan angle	+50° H-plane	-50° H-plane	+20° E-plane	-20° E-plane
16-QAM 300 m 1 Gbps				
EVM	12.1%	11.7%	10.3%	9.6%

Fig. 9. Measured constellations at different data rates and scan angles with 16-QAM for 5 m and 300 m links.

LINK BUDGET FOR 300 M 5G LINK USING 32-ELEMENT PHASED-ARRAYS

Frequency / Wavelength	29 GHz / 10.3 mm
Transmit Power, Pt	17 dBm at 5 dB Backoff
Transmit Antenna Gain, Gt	19 dB
Receive Antenna Gain, Gr	19 dB
Absorptive Loss in Atmosphere	0.3 dB/km
Receive Bandwidth	400 MHz
System Noise Figure	7.5 dB
Range / Space Loss Factor	300 m / -111 dB
Receive Power, Pr	-56 dBm
Receiver Noise	-81 dBm
Receiver SNR at normal incidence	25 dB
Receiver SNR at ±50° in H-plane	20 dB

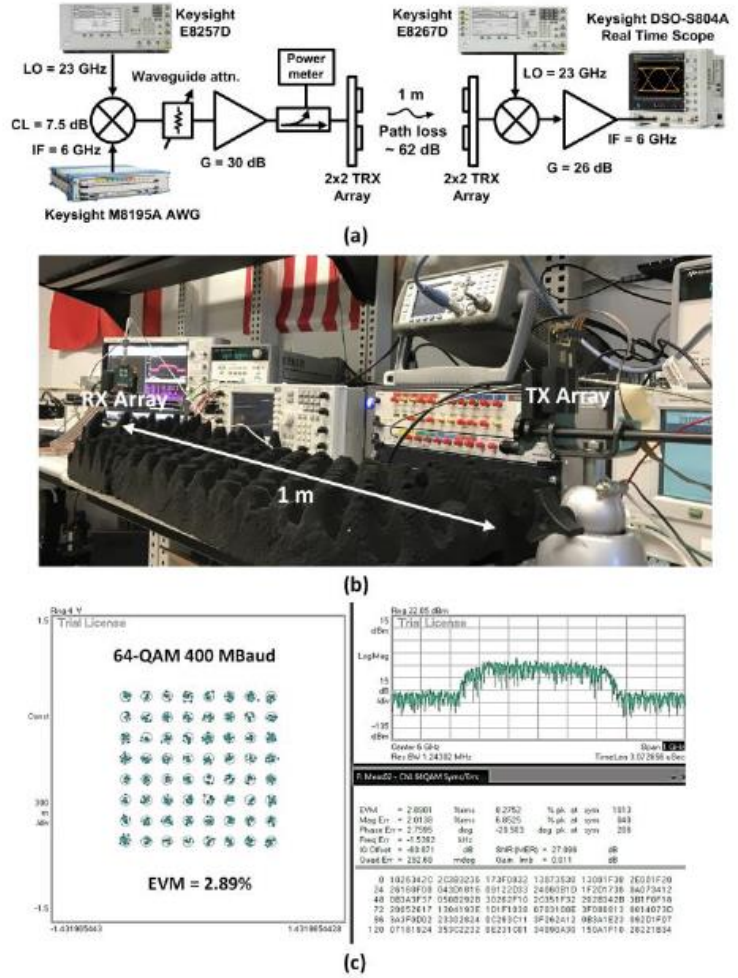


Fig. 6. (a) Measurement setup for communication link at 1 m distance, (b) photograph of setup, (c) measured constellation with 64-QAM 400 MBaud data rate at 8 dB backoff (2.4 Gbps).

Key Performance Characteristics:

- 3 GHz Instantaneous Bandwidth
- 1.6 Gb/s at 300 m demonstrated*
- 1.0 Gb/s at +/- 50 degree E Plane*
- Supports up to 256 QAM for 6 Gb/s*

❖ IC Fabrication Provided by TowerJazz

* Results without FEC or Equalization

KEYSIGHT TECHNOLOGIES

MWC2017
Press Release

GSMA MOBILE WORLD CONGRESS BARCELONA 27 FEB - 2 MAR 2017

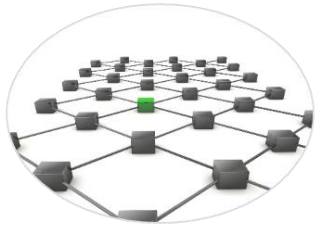
1. Keysight Technologies Works with Huawei on Phase II of China 5G Technology R&D Trial

   Using its UXA N9040B signal analyzer and 89601B VSA signal analysis software, Keysight has conducted the first integration tests with Huawei's 5G prototype base station. The tests cover numerology, frame structure, and new waveform in the 5G new radio (5G NR).

2. Keysight Technologies, Samsung Electronics Announce 5G Collaboration

   The initial focus of the partnership is on Verizon 5GTF specifications (www.5gtf.org). Future collaboration will include 3GPP NR.

TRIANGLE: End-to-End Testing Ecosystem



Transport
- Deployment scenarios
- Carrier-grade SDN
- SLA/B2B services

Services
- Business Integrations
- Dynamic QoS
- Integrated vs CDN

Mobile App
- Live in-the-wild
- Connected behavior
- Device coverage

EPC
- Deployment configurations
- Network conditions
- Subscription levels

Device
- Power consumption
- Compliancy
- Chipset Performance

RAN
- New Waveforms
- RAN configuration
- Deployment scenarios

5G

KEYSIGHT TECHNOLOGIES

Quamotion Make your app shine

UCL

RedZinc

AT4 WIRELESS a DEKRA company

ma

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 688712

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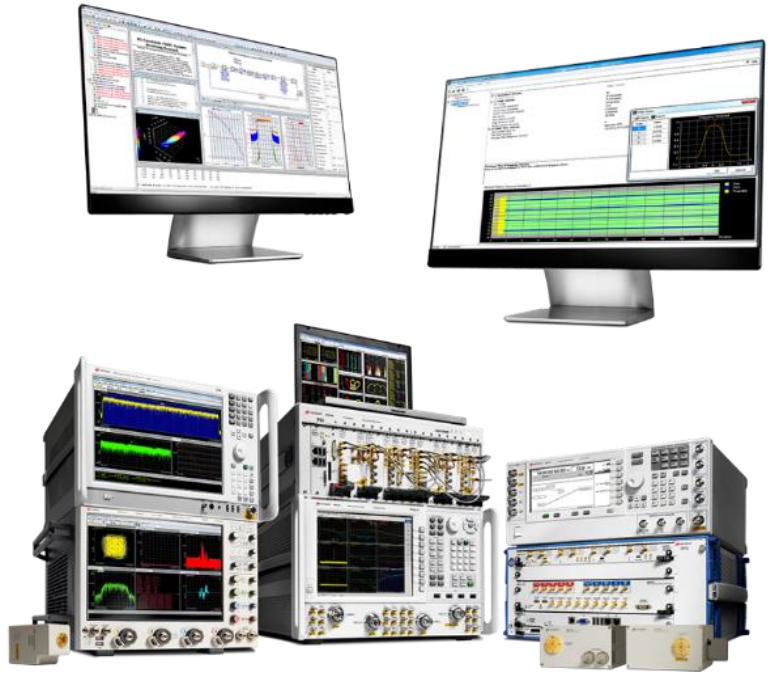
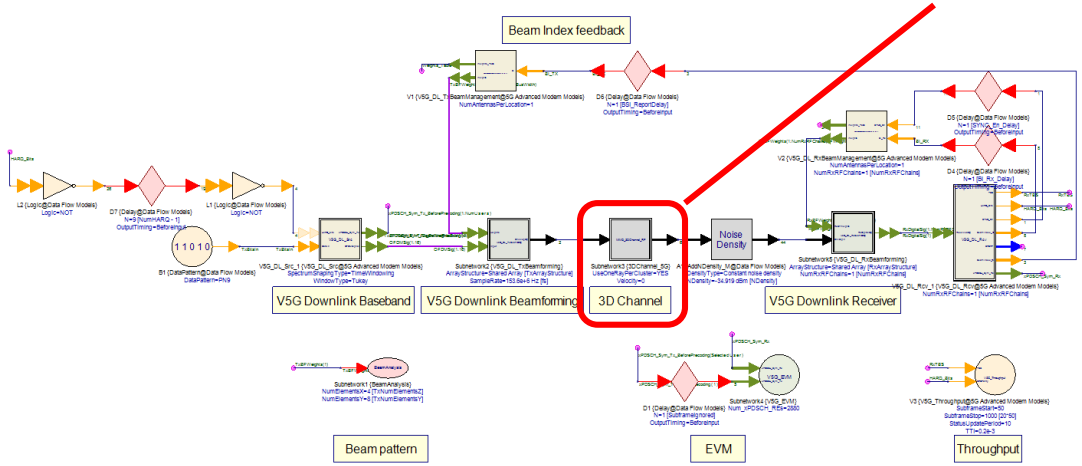
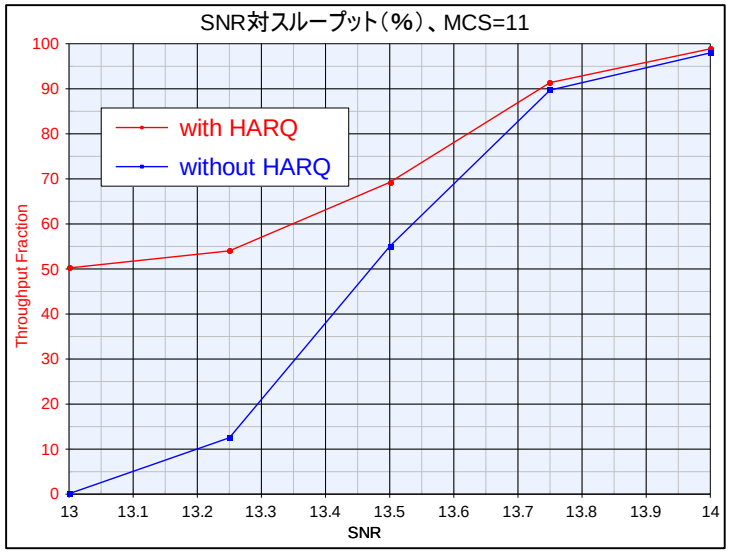


KEYSIGHT TECHNOLOGIES

SystemVueによるシステムシミュレーション

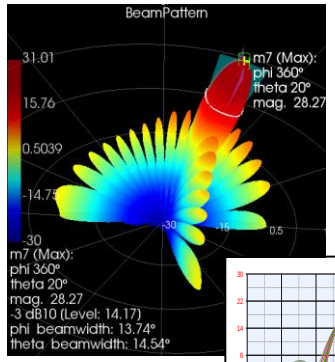
偏波も考慮される
新しいChannel Model

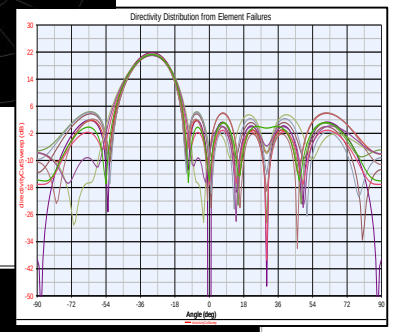


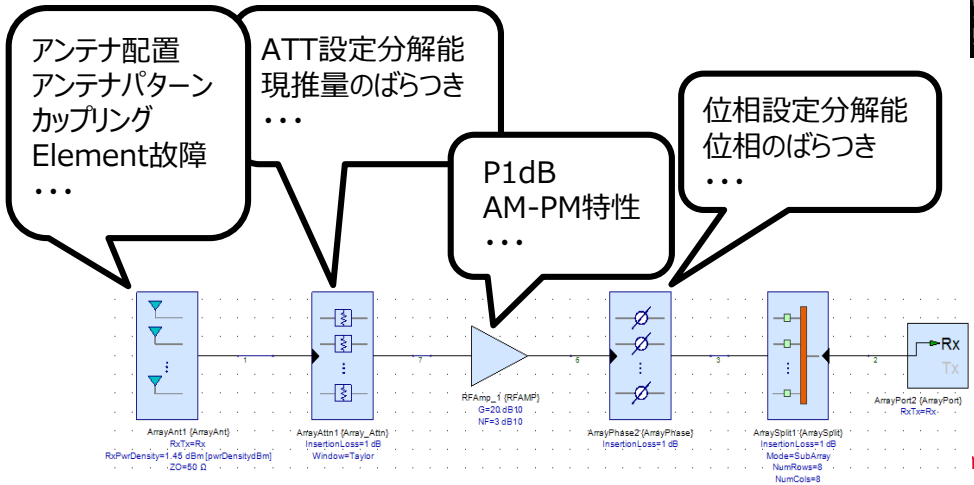


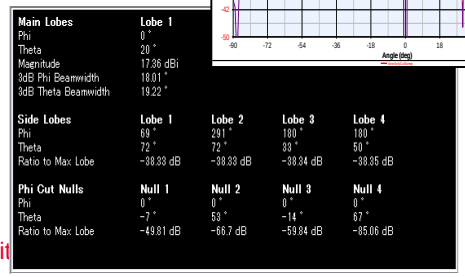
Verizon Pre-5G DLスループット解析の例

3GPPのミリ波チャネルモデルを用いたスループット解析
W1906 “5Gライブラリ”





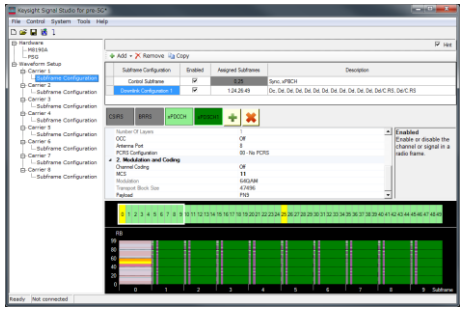




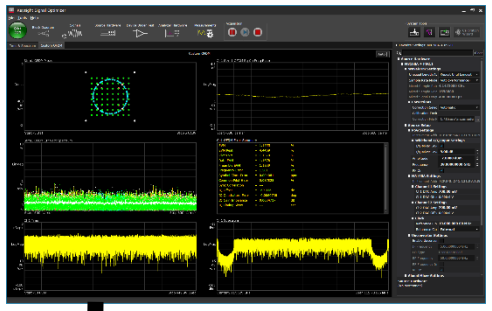
フェーズドアレイを簡単に検証
W1720 “Phased Array Beamforming Kit”

28GHz帯におけるPre-5G信号発生と変調解析

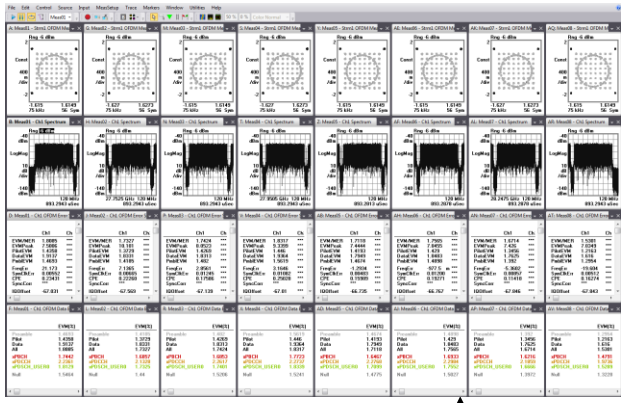
N7630C Signal Studio
for Pre-5G
(Pre-5G信号の波形生成)



K3101A
Signal Optimizer
(特性補正及び波形転送)



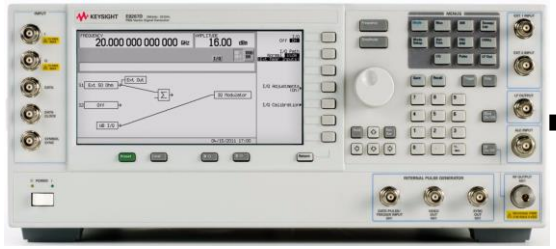
89601B-BHF VSAソフトウェア
(Custom OFDM解析オプション)
(Pre-5G信号の変調解析)



M8190A 広帯域任意波形発生器
(12GSa/s 12bit , 8GSa/s 14bit
または 4GSa/s 14bit)

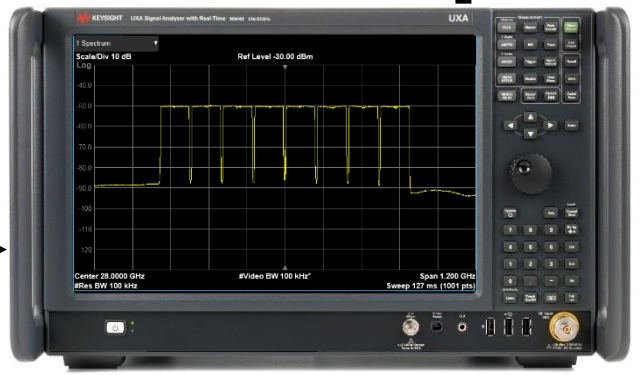
Baseband 差動IQ信号

U9391F Comb Generator
(10 MHz to 50 GHz)
K3101Aを使用してアナライザ側の
振幅位相特性補正



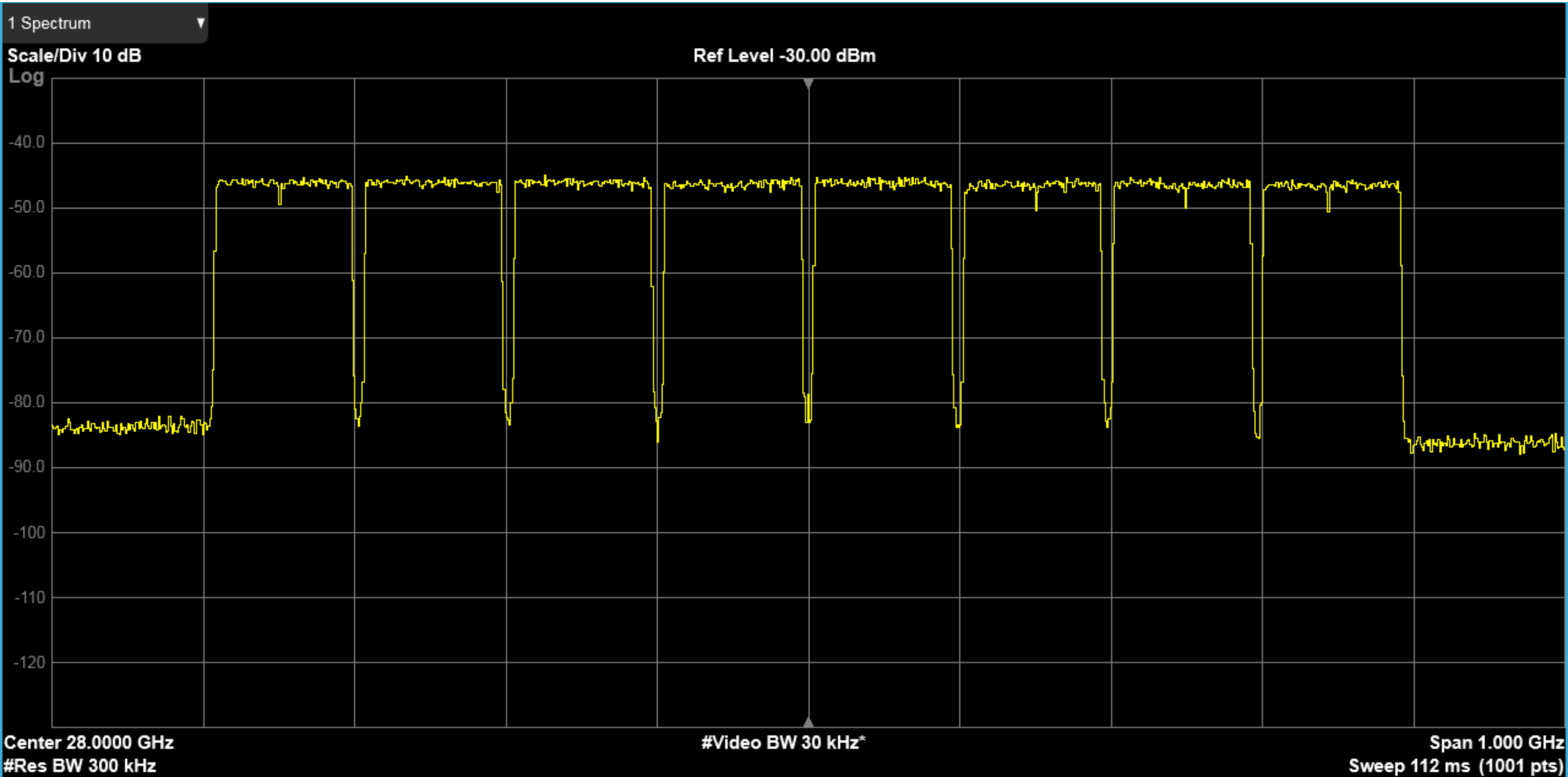
E8267D PSGベクトル信号発生器
(100kHz～44GHz, 2～4GHzの変調帯域幅)

DUT
など



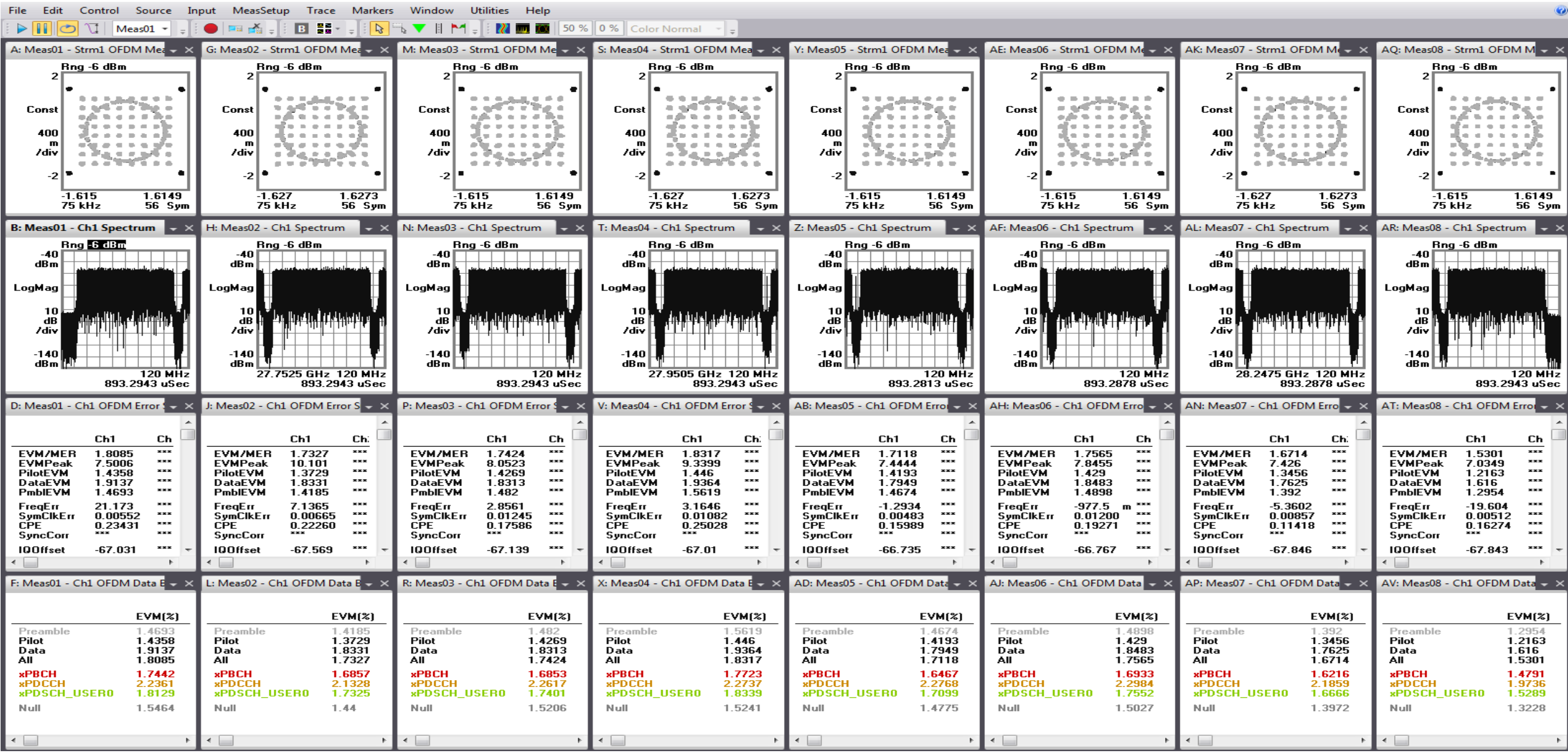
N9040B UXAシグナルアナライザ
3Hz～50GHz, 1GHz解析帯域幅(内蔵)

Pre-5G信号の8 Carrier同時出力例



89601B-BHF VSAソフトウェア(Custom OFDM)

Pre-5G信号の8 Carrier同時変調解析例



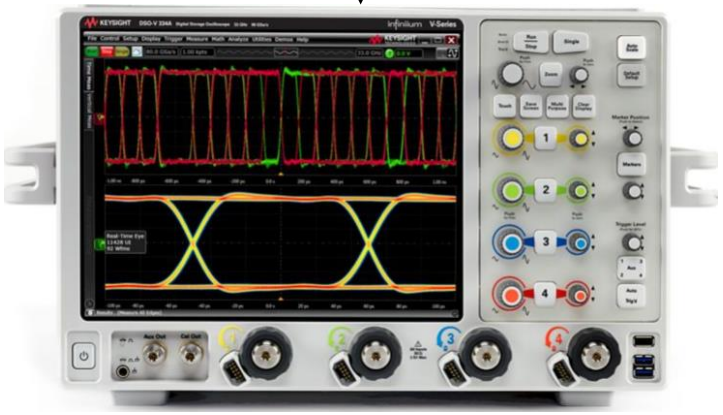
28GHz電波伝搬解析 (Channel Sounding)

I,Q

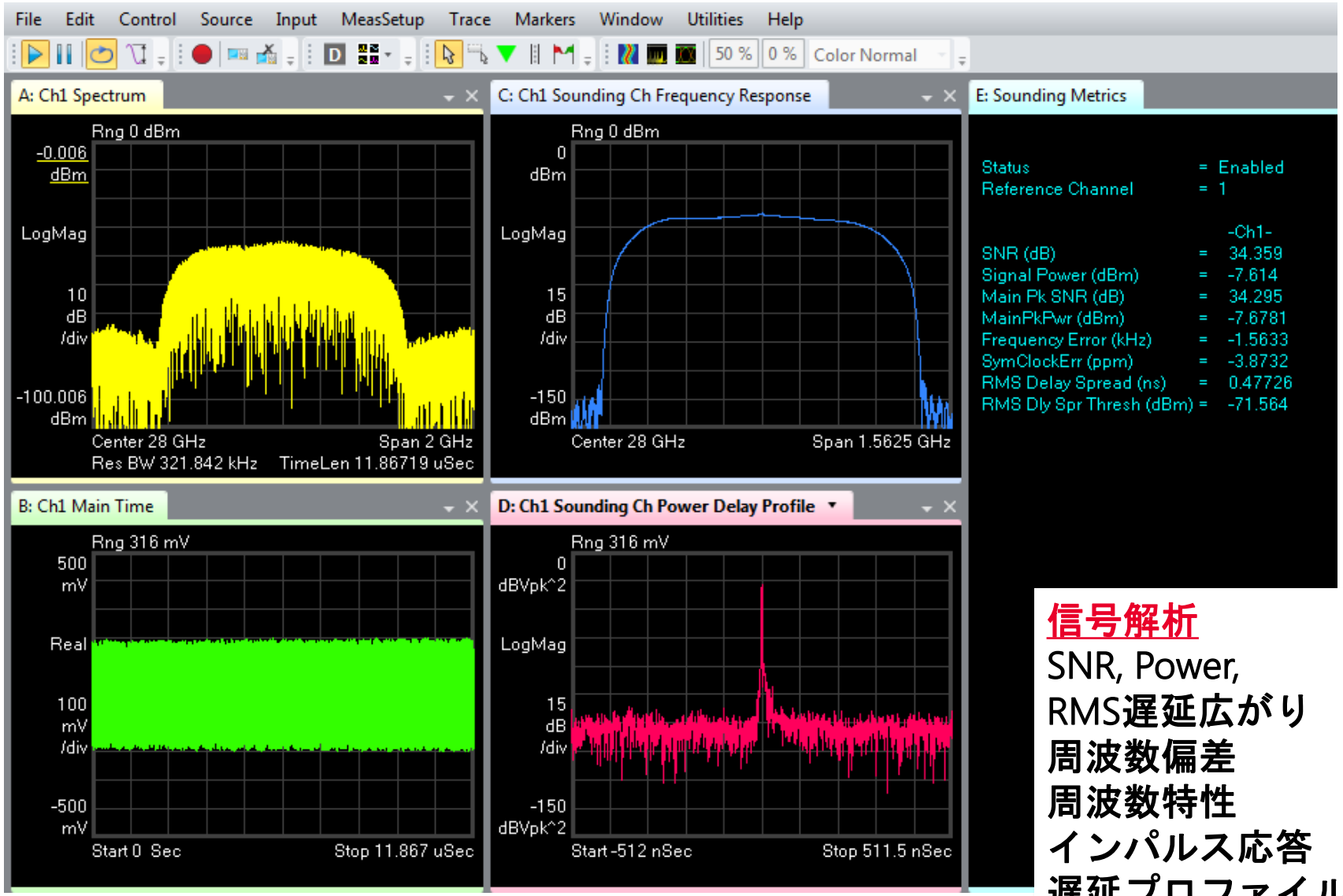
M8190A

E8267D:

28GHzなど



DSAV334A

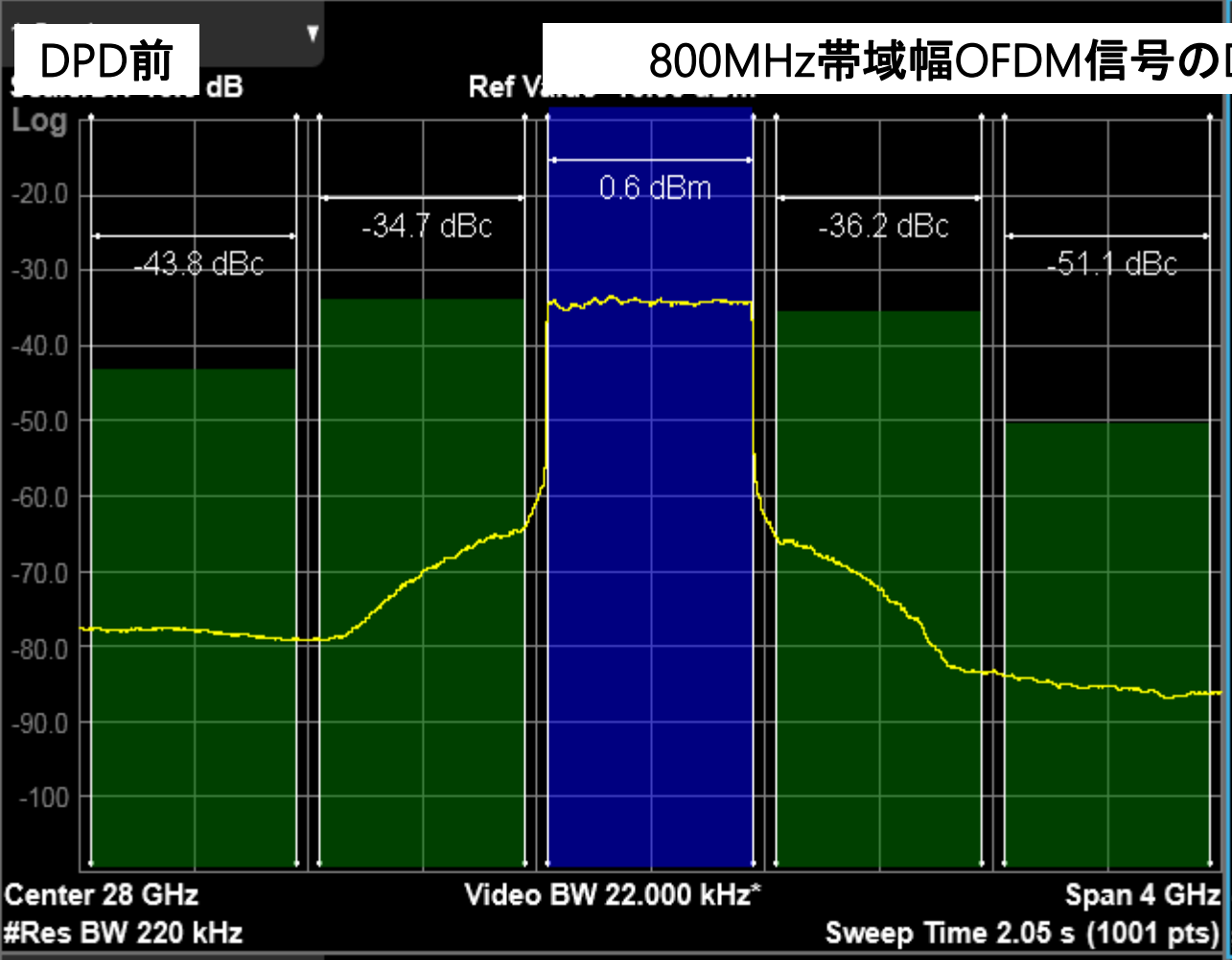


信号解析

SNR, Power,
RMS遅延広がり
周波数偏差
周波数特性
インパルス応答
遅延プロファイル

800MHz帯域幅OFDM信号のDPD(Digital Pre-Distortion)実験例

DPD前

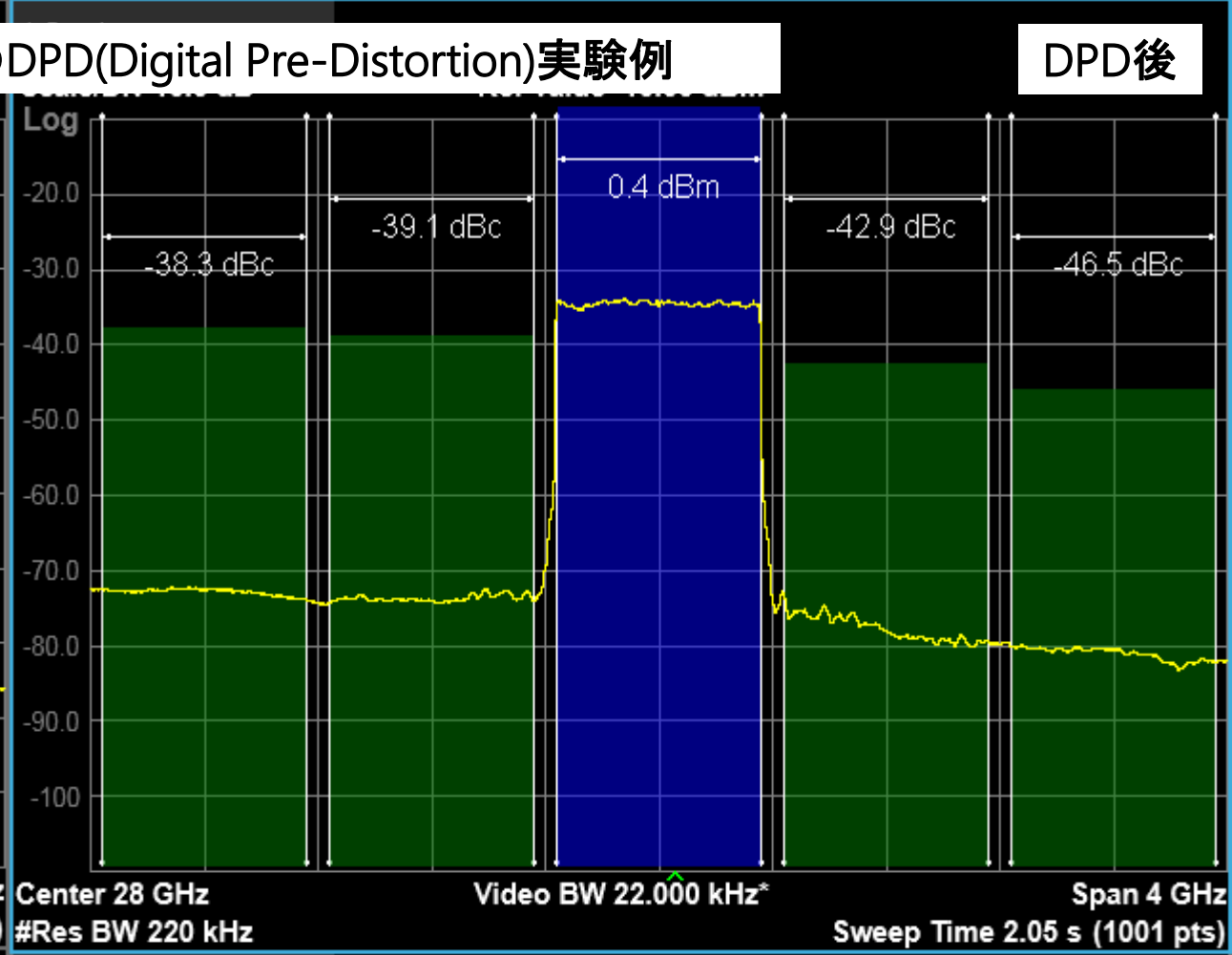


2 Metrics

Total Car Pwr	0.621 dBm/720.0 MHz
Total PSD	---

			Lower				Upper		
			ACP		Ref Carrier		ACP		F
	Offs Freq	Integ BW	dBc	dBm	dBm	Car #	dBc	dBm	dI
A	800.0 MHz	720.0 MHz	-34.66	-34.04	0.621	1	-36.23	-35.61	0.
B	1.600 GHz	720.0 MHz	-43.84	-43.22	0.621	1	-51.10	-50.48	0.

DPD後



2 Metrics

Total Car Pwr	0.367 dBm/720.0 MHz
Total PSD	---

			Lower				Upper		
			ACP		Ref Carrier		ACP		F
	Offs Freq	Integ BW	dBc	dBm	dBm	Car #	dBc	dBm	dI
A	800.0 MHz	720.0 MHz	-39.12	-38.75	0.367	1	-42.86	-42.50	0.
B	1.600 GHz	720.0 MHz	-38.26	-37.89	0.367	1	-46.45	-46.08	0.

FieldFox ハンドヘルドRFアナライザ

高耐久性
軽量(3 kg)
バッテリ動作

対応バンド
- WR-12 (60-90 GHz)
- WR-15 (50-75 GHz)
- WR-10 (75-110 GHz)

9kHz～50GHzのスペクトラム・アナライザ+ネットワーク・アナライザ+信号源+パワーメータを１台に凝縮

更に外部ミキサを使用することで最大110GHzまでの信号解析が可能に

KEYSIGHT TECHNOLOGIES