

Automotive Radar Module Test and Measurement.

Choi, Ji-Hoon

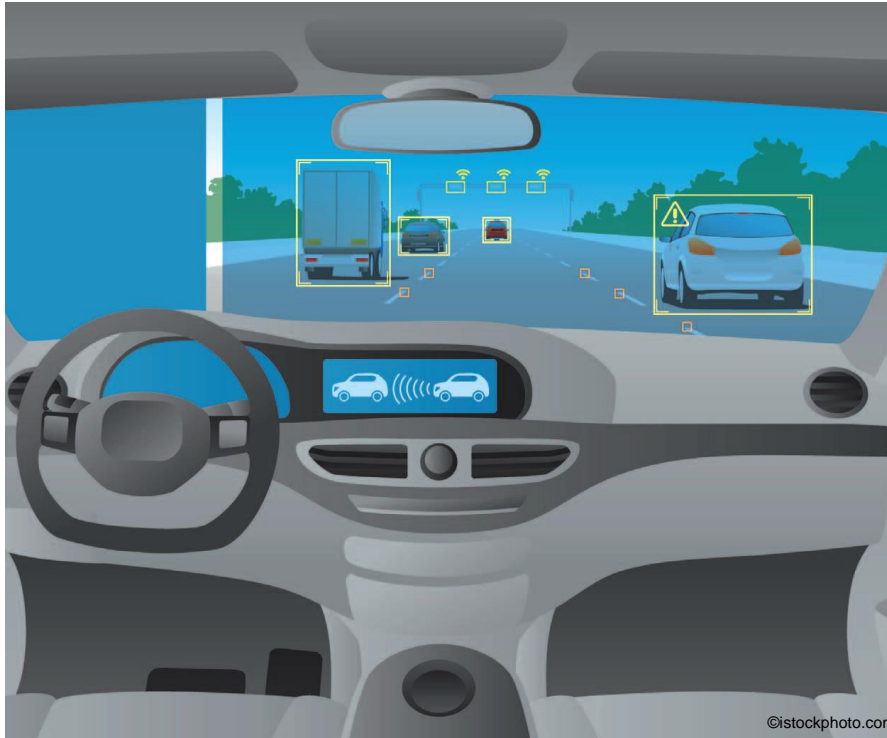


Agenda

- ADAS Technologies overview
- Automotive Radar 79GHz
- Keysight's Radar Solution
- How to Measure Radar Module
- Q&A

ADAS Technologies

- Sensors
 - Radar
 - LIDAR
 - Cameras

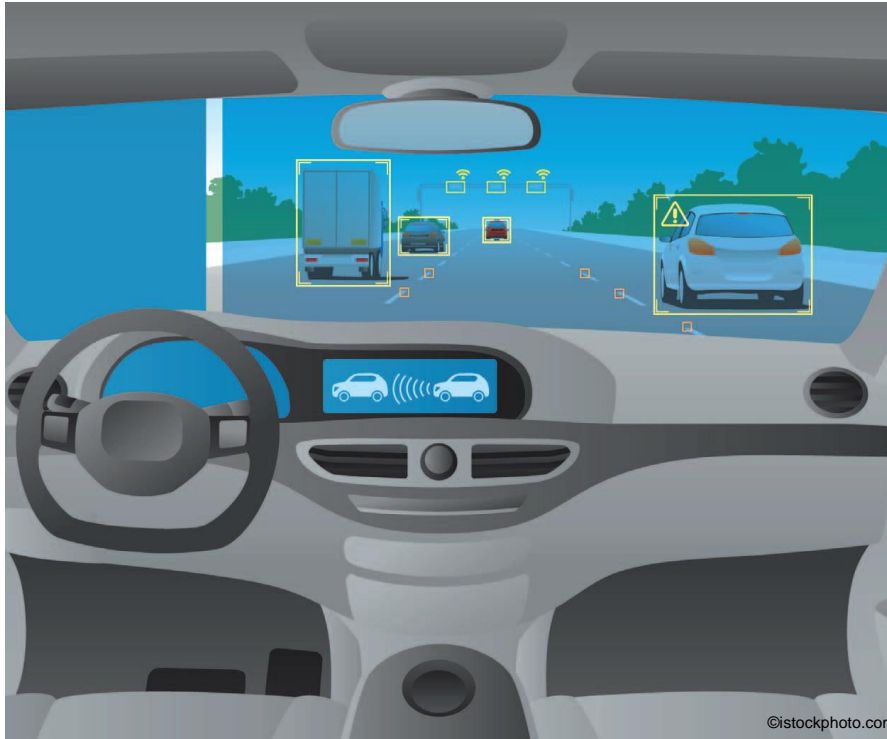


- Wireless connections
 - 2/3/4G and coming 5G
 - 802.11p WAVE / DSRC

- Automotive high speed serial buses and Car Ethernet
 - BroadR-Reach, MOST150
 - CAN/CAN FD, FlexRay, CXPI, and etc.

ADAS Technologies

- Sensors
 - Radar
 - LIDAR
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ADAS Technologies

Ultrasonic



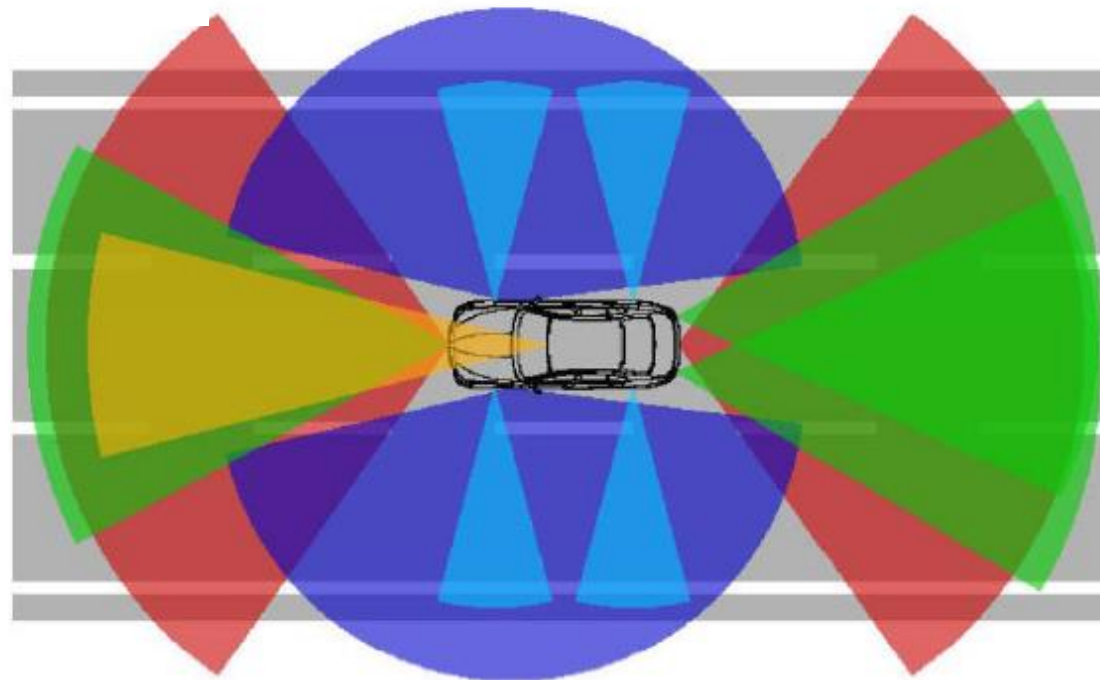
Camera



Radar



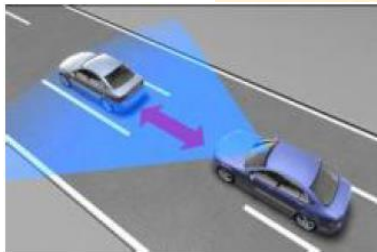
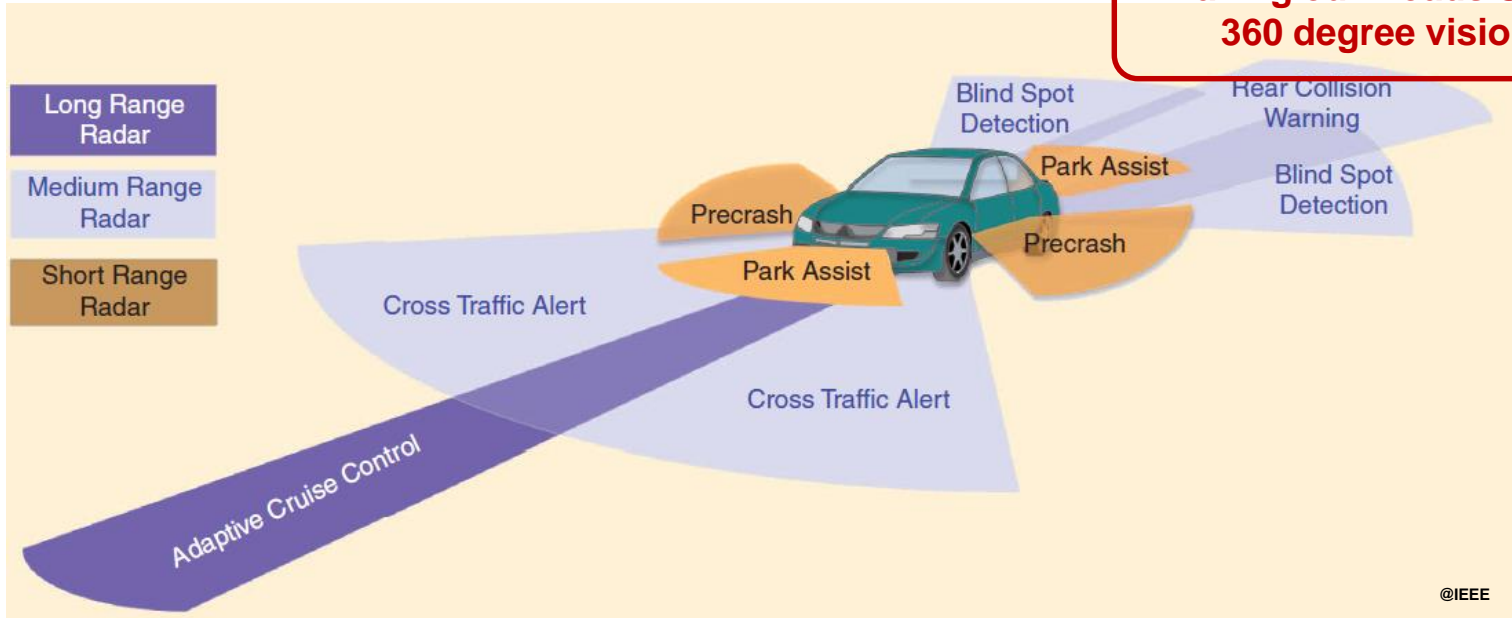
Lidar



- Four-Layer Laser scanner
- Single-Layer Laser scanner
- Radar
- Mono Camera
- Ultrasonic

Radar Application Overview

**Making our Roads Safer
360 degree vision**



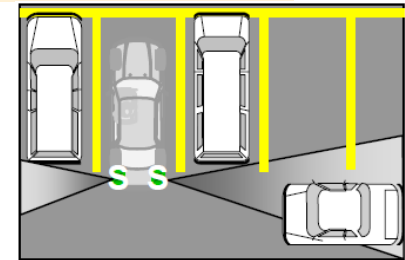
Adaptive Cruise Control (ACC)



Blind Spot Monitoring



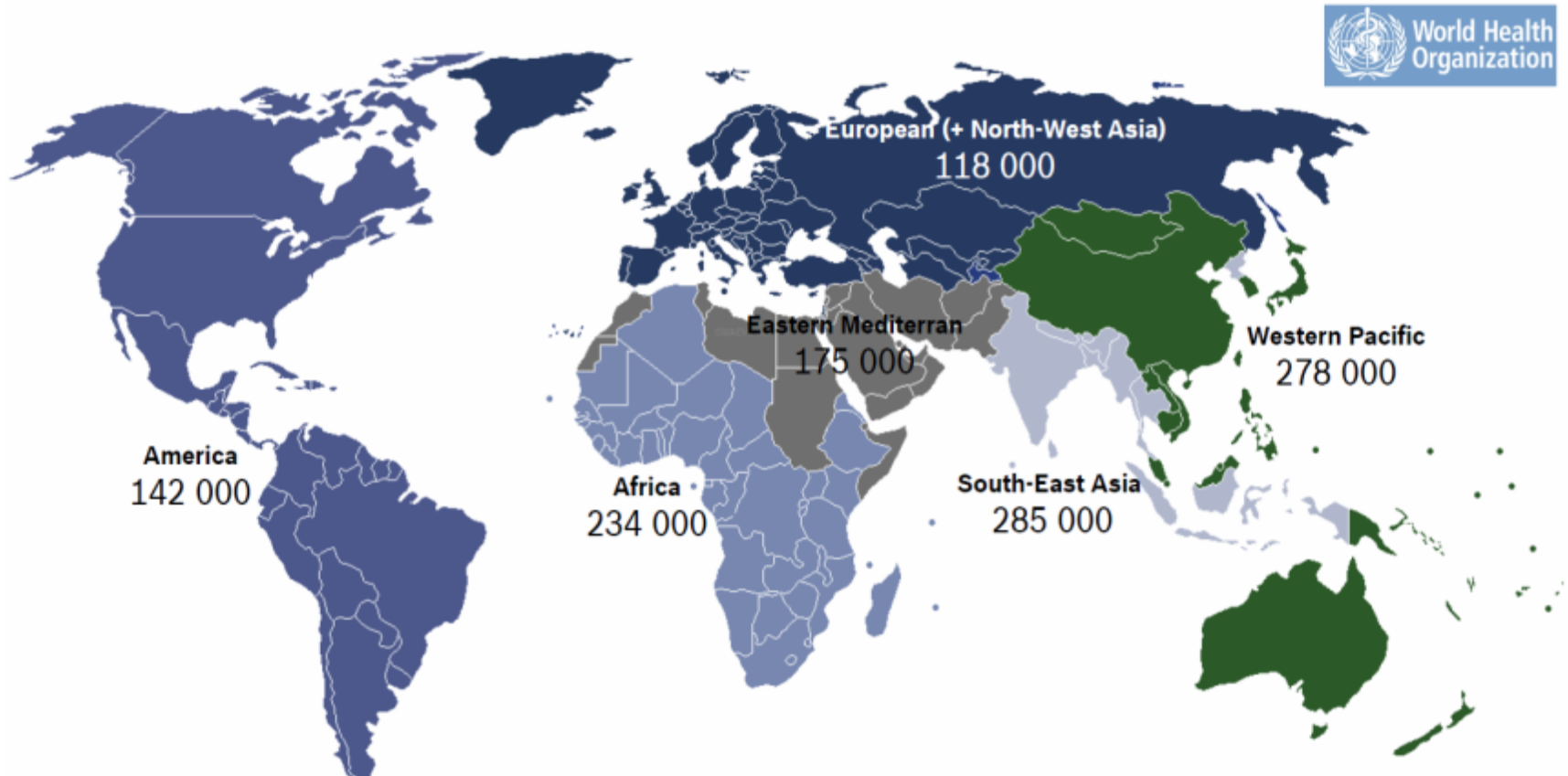
Lane Change Assist



Rear traffic crossing alert

Automotive Radar – Government Motivation

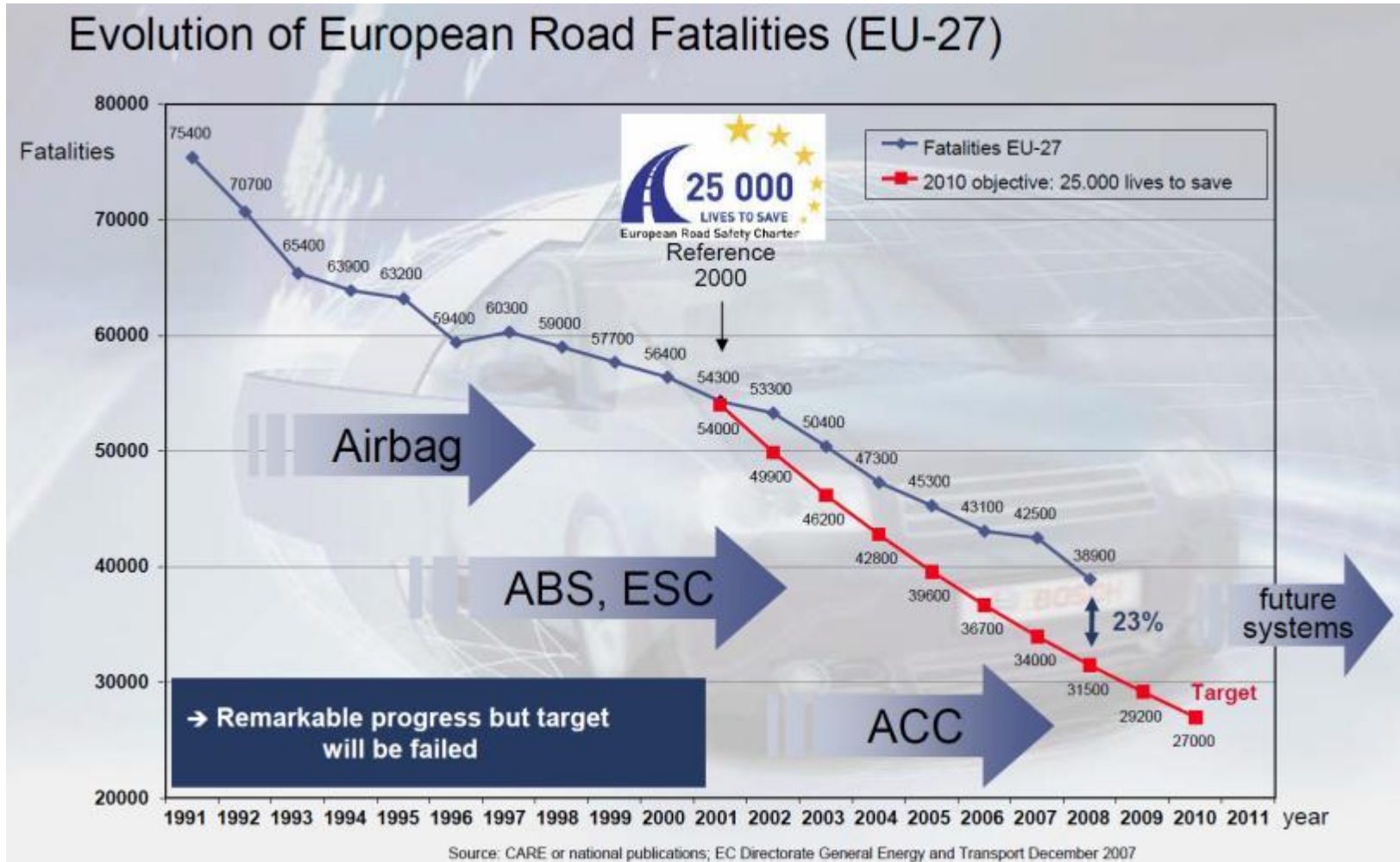
Road traffic deaths by WHO region



Worldwide approximately 1.23 million fatalities per year

source: global status report on road safety, WHO 2009

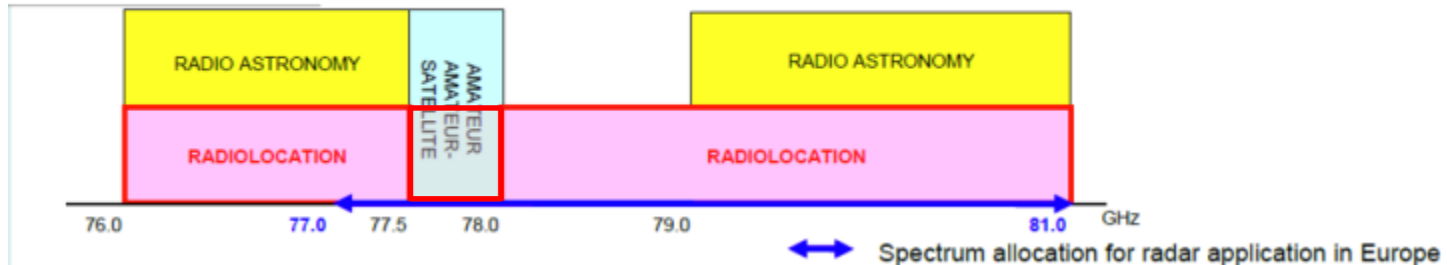
Automotive Radar – Government Motivation



Automotive Radar – Regulatory

76 – 81 GHz band primary users from ITU-R

Primary spectrum allocations in the 76-81GHz band



77 – 81 GHz band allocated to “Radiolocation Service” on a Co-Primary basis

- The device must operate/ behave **as a Radar**
- Wherever applicable, the device **must be licensed under the Radar rules**
- It cannot operate as an unlicensed short-range device per ITU-R definition
 - Except US, where FCC permits unlicensed vehicular radar SRD within 76 - 77 GHz band

ITU-R propose to allocate 77.5 – 78 GHz region to “Radiolocation Service” on a Co-Primary basis to support “**global frequency harmonisation**” and appropriate international protection status for automotive SRR, essential for safety application needs.

ITU-R Technical Studies ongoing for completion prior to WRC-15

- Report at WRC-15 on compatibility studies with other Co-Primary band users:
 - Radioastronomy, Space Sciences, Amateur Radio

Automotive Radar – Regulatory

77 – 81 GHz band global availability status

24 GHz NB (12.7dBm, 200 MHz → 50m range*, 75cm resolution)



24 GHz UWB (-41.3dBm/MHz, 2.5GHz → 15m range*, 6cm resolution)



77 GHz NB (50dBm, 1000 MHz → 200m range*, 15cm resolution)

79 GHz (-9dBm/MHz, 4GHz → 30m range*, 4cm resolution)



Recommended by ITU-R M1452 for forward looking applications

$$\Delta R_{\min} > \frac{c}{2B}$$

Estimated value with 1 sqm RCS

Recommended by ITU-R M1452 for short range radar



Move by 2018

Automotive Radar – 24GHz → 79GHz Transition

Why move from 24GHz SRR to 79GHz SRR ?

- Smaller wavelength at 79GHz ($\lambda = 3.8\text{mm}$) compared with 24GHz ($\lambda = 12.5\text{mm}$) leads to improved spatial and angular resolution
- Smaller wavelength (λ) leads to smaller Antenna's and smaller Sensor Modules
- From 2018, the 24GHz will be limited to 200MHz BW (Europe), 250MHz BW (Japan) ISM band only, **79GHz will have 4GHz BW available**
 - *More bandwidth supports improved spatial resolution applications*
 - *More bandwidth supports improved interference mitigation (hopping)*
- Rapid signal attenuation at 79GHz good for interference mitigation reasons (~30m max for SRR, ~100m max for MRR)
- Maximum allowed Tx Power limit is higher at **79GHz (-3 dBm/MHz mean e.i.r.p)** compared with **24GHz (-41.3 dBm/MHz mean e.i.r.p)**

Recent statement from CSA 79GHz Project in Nov 2012 regards cost

- “79GHz is cost comparable with 24GHz and will gain at the same time higher performance”

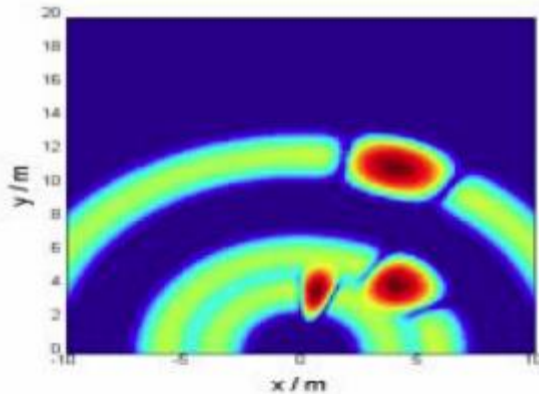
Automotive Radar – 24GHz → 79GHz Transition

79 GHz Functions & Technology



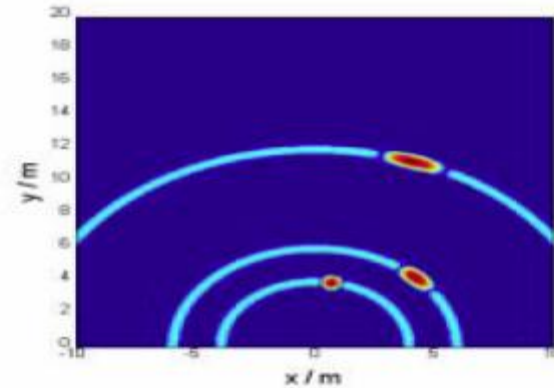
Target separation capability

B = 250 MHz



Typ. Long Range Radar Bandwidth

B = 1500 MHz



Typ. High Resolution Radar Bandwidth

Chassis Systems Control

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BOSCH

Automotive Radar – 24GHz → 79GHz Transition

79 GHz Functions & Technology

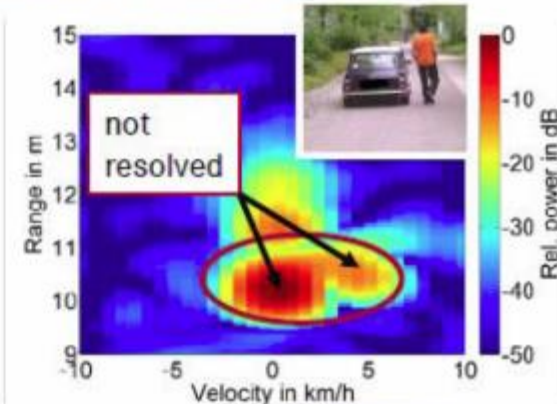


Bandwidth Influence on Range-Velocity Processing

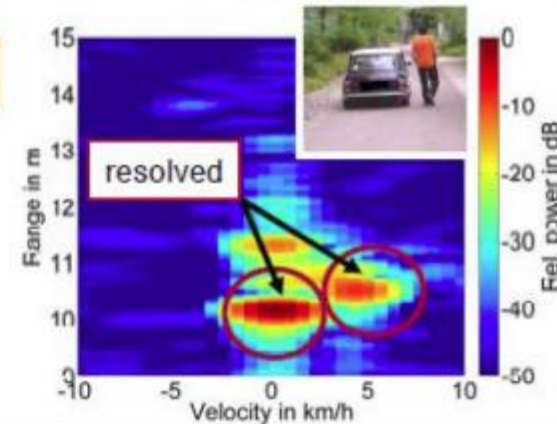
Measurement Setup

- Carrier frequency: 79 GHz
- Polarization: vertical
- Amount of chirps: 32
- Chirp duration: 144 μ s (@B=1.35GHz)
- Ramp rep. interval: 160 μ s
- Velocity resolution: 1.36 km/h
- Max. range: 49.9m
- Max. velocity: ± 21.69 km/h

B_{net} : 0.5 GHz



1.35 GHz



→ Increased bandwidth resolves pedestrian and car.

Source: Daimler AG

Chassis Systems Control

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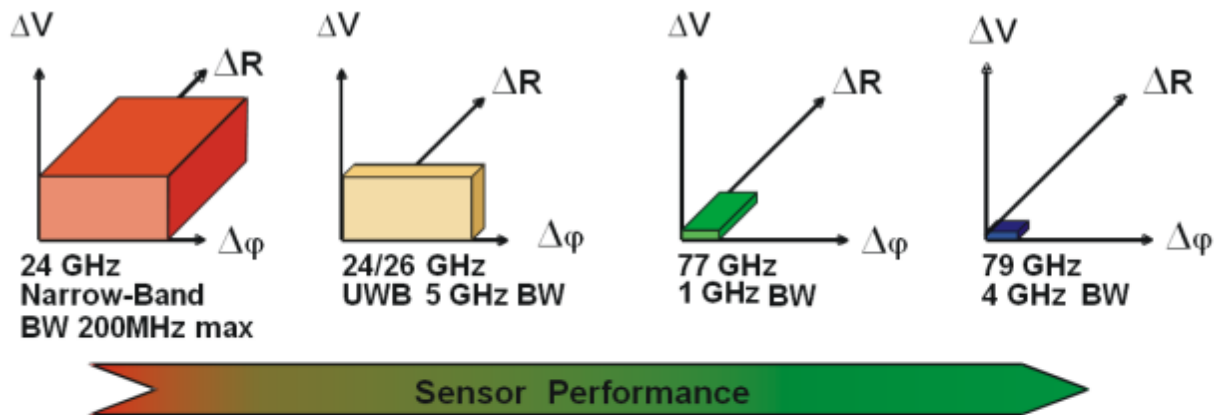


BOSCH

Automotive Radar – 24GHz → 79GHz Transition

Comparison of sensor performance showing key parameters

Range resolution, Angular resolution, Doppler resolution



Legend:

ΔV : Velocity Axis

→ Doppler resolution of object distance is RF frequency dependant
Higher RF frequency enables better Doppler resolution

$\Delta \phi$: Angle Axis

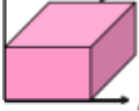
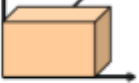



→ For a given aperture, the resolution increases with frequency.
Angular resolution depends on antenna aperture.

ΔR : Range Axis

The smaller the cubic the better the radar performance !

Automotive Radar – 24GHz → 79GHz Transition

Table 7.1: Radar performance overview and evolution of systems (automotive and non-automotive allocations)

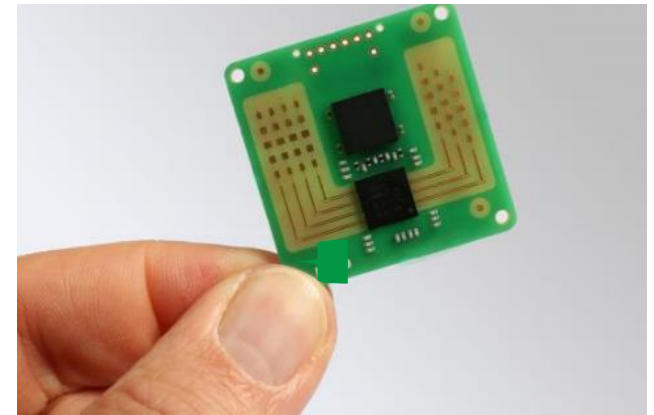
| Frequency range (see note 1) | Narrowband 24 GHz | 24 GHz/26 GHz UWB | 76 GHz | 79 GHz | 122 GHz ISM |
|---|---|---|---|---|---|
| Sensor performance for proposed applications (summary of all three parameters / resolutions) (see notes 2, 3 and 4) | 0 | + | ++ | +++ | +++ |
| ΔV : Velocity Axis $\Delta \phi$: Angle Axis ΔR : Range Axis |  |  |  |  |  |
| Bandwidth | 200 MHz | > 2 GHz | 1 GHz | 4 GHz | 1 GHz |
| Regulated output power | ++ | 0 | ++ | + | |
| Radar Cross Section influence (cooperative contribution) | + | + | ++ | ++ | +++ |
| Technology available | ++ | ++ | ++ | ++ | + technology 0 for sensor realization |
| NOTE 1: Other frequency ranges below 24 GHz were not taken into account, because of possible/reachable sensor performance for the proposed applications. NOTE 2: The smaller the cubic, the better the radar performance. NOTE 3: Doppler resolution of object distance is RF frequency dependent, Higher RF frequency enables better Doppler resolution. NOTE 4: For a given aperture, the resolution increases with frequency. Angular resolution is directly related to antenna aperture. | | | | | |

Automotive Radar Chipset

Second-generation long-range radar



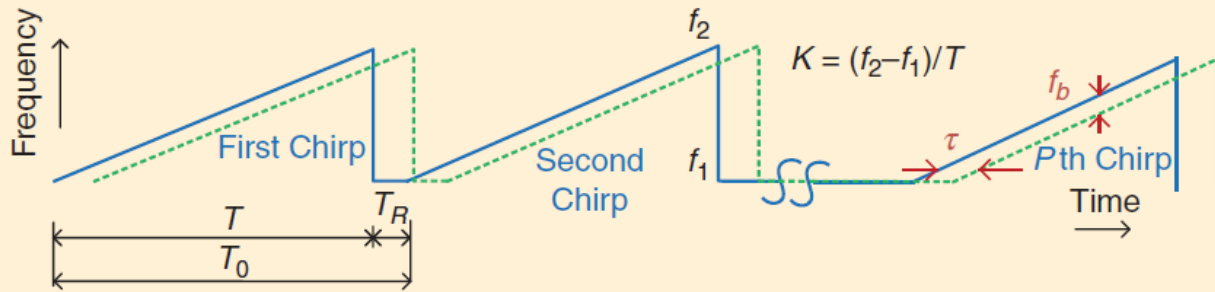
Third-generation long-range radar



6cm x 6cm
cmos RFIC

Radar Theory

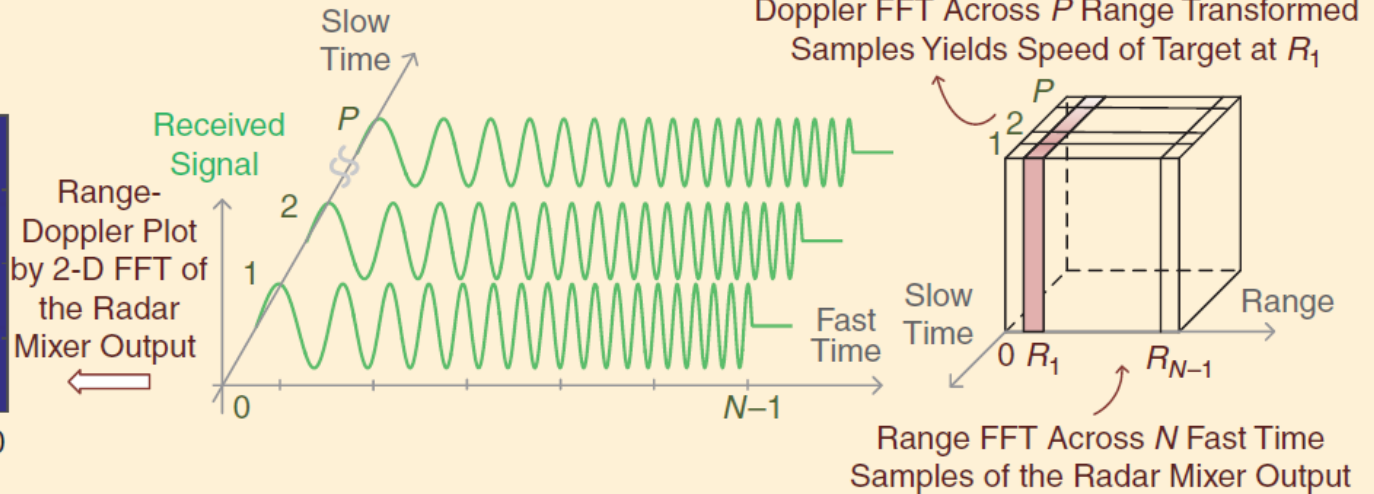
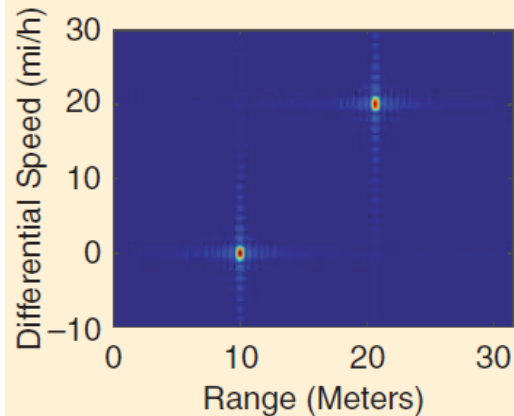
FMCW Radar



(a)



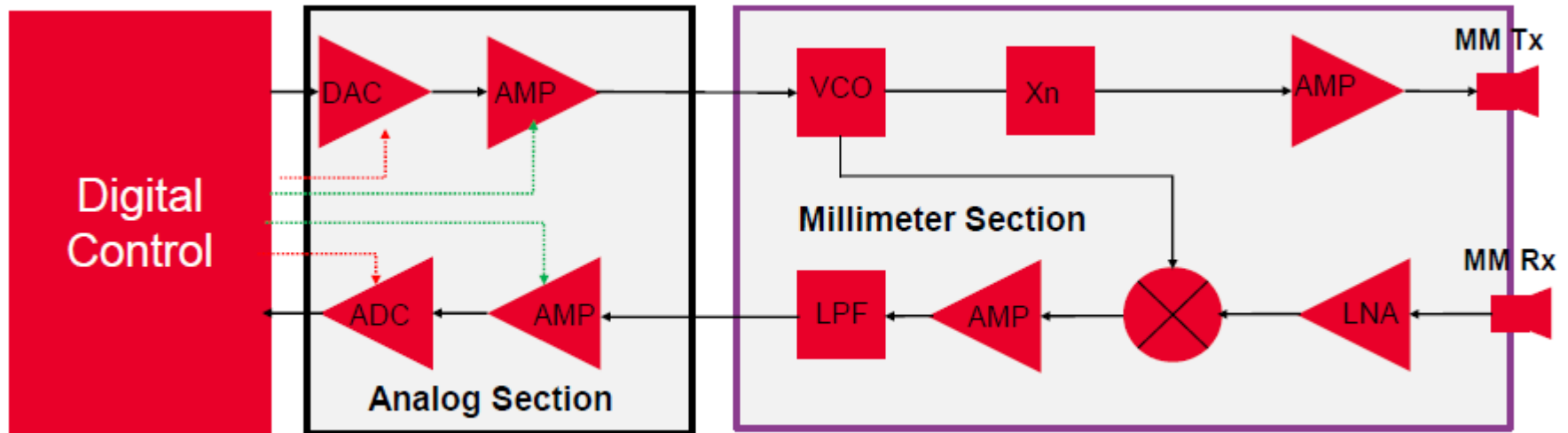
(b)



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How to Test Radar Module

FMCW Radar



Typical FMCW Automotive Radar Module Design

How to Test

Millimeter Wave Frequency ?

- 76~77GHz(1GHz)
- 77~81GHz(4GHz)

How to Verify Each Section

- Digital (Oscilloscope)
- VCO, PLL Phase noise(SA)
- Tx,Rx(SG,SA)

How to Test Radar Module

Test Challenges – Millimeter Wave and Analog Section

- **Frequencies** – include 24GHz , plus 77GHz and 79GHz mmW.
- **Bandwidth** – from 100MHz up to 4 GHz BW at mmW.
- **Power** – need to validate both wanted power levels plus unwanted emissions against ETSI conformance specifications (e.g. *ETSI EN 302 264 for 79GHz*).
- **Increased Levels of Integration** integrated amplifier and antenna structure
- **Reduction in cost** move to Si Ge components for the front end

How to Test Radar Module

Test Challenges – Digital Control Section

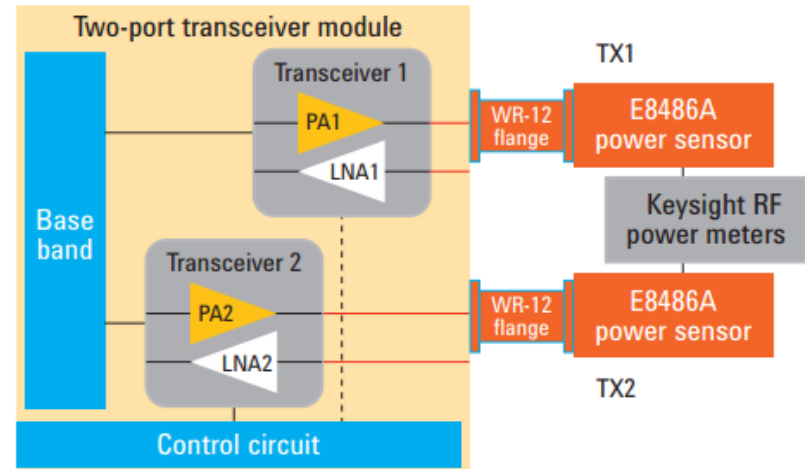
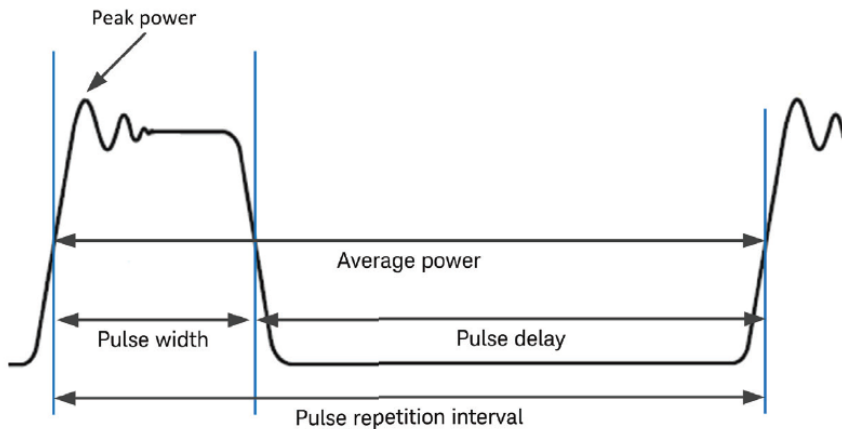
- **Modulation & Phase Noise** – both need to be verified to ensure sensor provides required range, velocity and target identification/separation performance.
- **Protocol** – ensure communication bus compliance to CAN, CAN-FD, FlexRay, Ethernet (BroadR-Reach) standards
- **Complex real-world environment** scenarios, includes multiple moving targets, multi-scattering RCS, unwanted clutter and interference.

Automotive Radar – Power Measurement

- Method with an average power meter

- Measurement time shall be sufficiently long to cover the EUT cycle time
- Use rms Meter

$$Peak\ Power = \frac{Measured\ Mean\ Power}{Power\ Duty\ Cycle}$$



Automotive Radar – Power Measurement

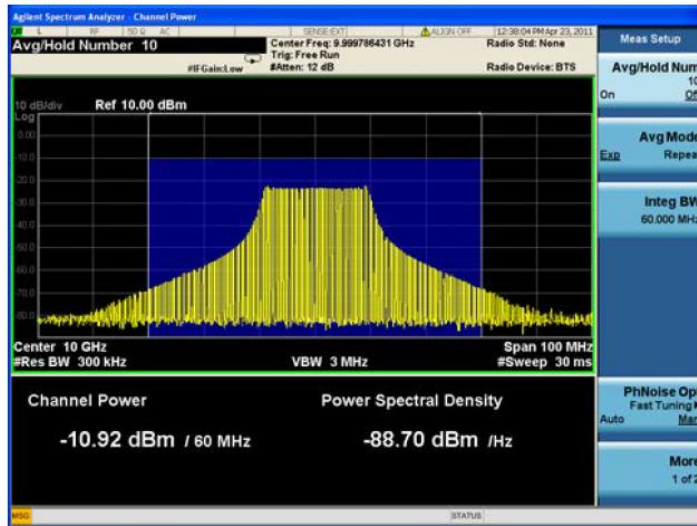
| | Average power meter | Peak power meter |
|-------------------------------------|---------------------|------------------|
| Frequency range | 110 GHz | 40 GHz |
| Bandwidth | Broadband average | Narrow |
| System rise time | Slow | Fast |
| Pulse parameter analysis capability | No | Yes |
| Power range | ~96 dB | ~55 dB |
| Dynamic range | High | Low |

Trading off flatness for responsiveness and bandwidth

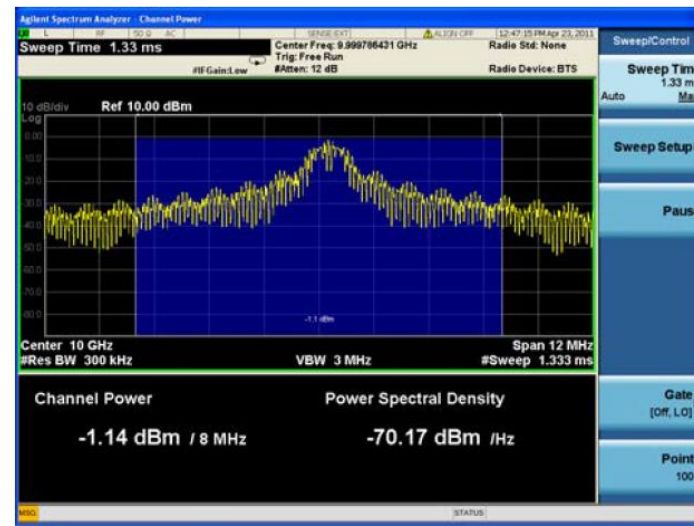


Automotive Radar – Power Measurement Method with a spectrum Analyzer

- Start frequency: lower than the lower edge of the operating frequency range
- Stop frequency: higher than the upper edge of the operating frequency range
- Resolution bandwidth: **1 MHz**
- Video bandwidth: **VBW \geq RBW**
- Detector mode: **RMS**
- Display mode: **clear write**
- Averaging time: larger than one EUT cycle time
- Sweep time: averaging time \times number of sweep points



Chirped radar

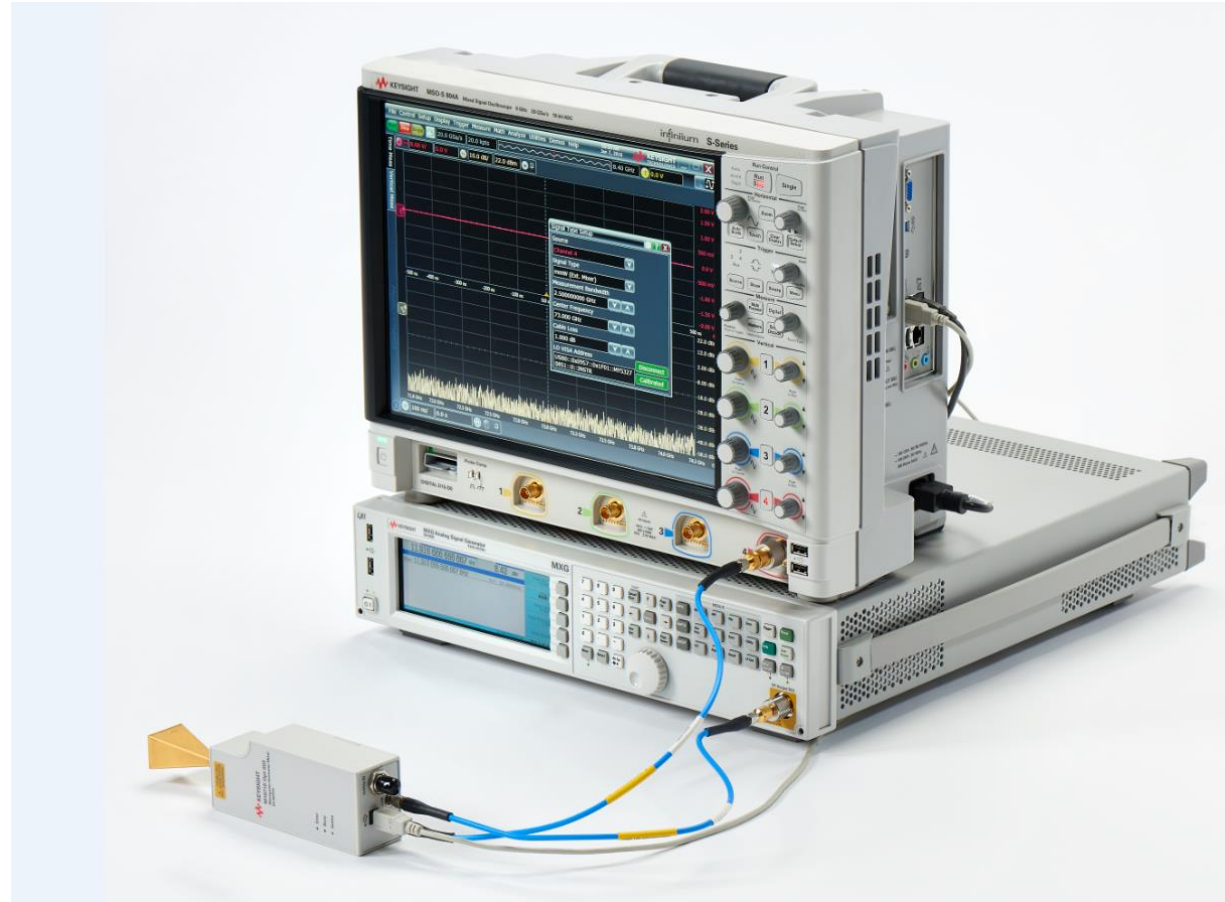


7-bit Barker code

Automotive Radar – Signal Analysis

FMCW Radar Tx Test <2GHz BW

- RF output from N5183B signal generator to LO/IF input of M1971E smart mixer
- Aux output from M1971E Mixer to channel 1 input of S-series oscilloscope
- USB from M1971E smart mixer to S-series oscilloscope
- USB from N5183B to S-series oscilloscope

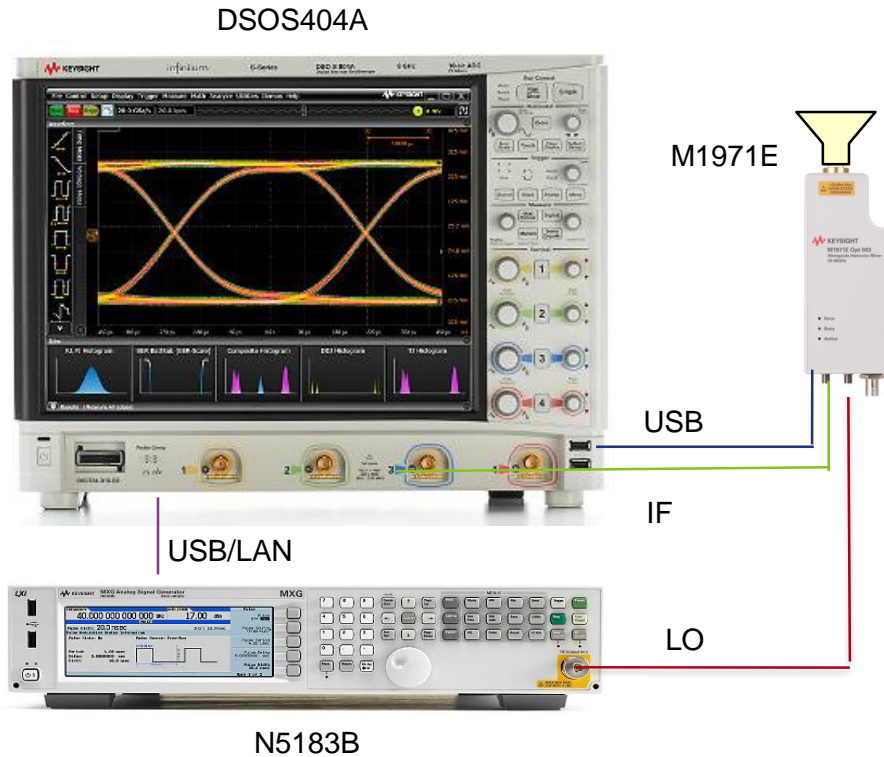


Automotive Radar – Signal Analysis

FMCW Radar Tx Test <2GHz BW

- Signals exists between 55/60-90 GHz
- Signal bandwidth up to 2.5 GHz

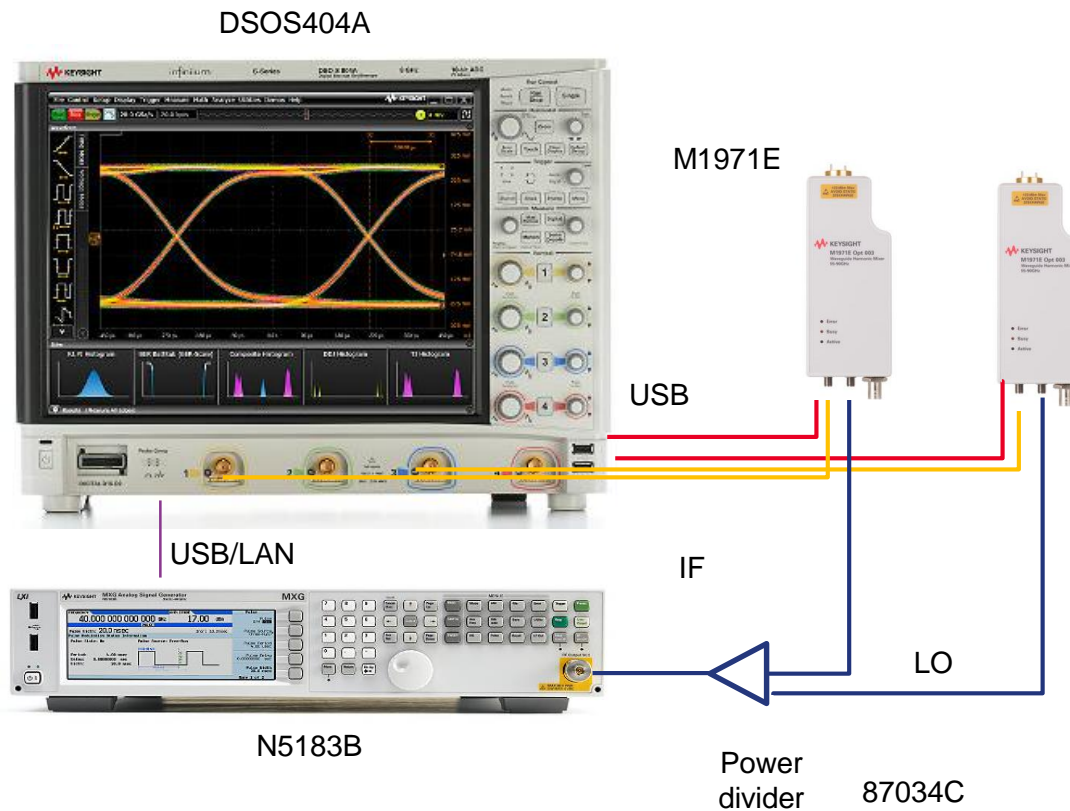
- DSOS404A
 - 4 GHz scope
 - w/ option 100
- N5183B-513
 - 13 GHz analog sig gen
 - w/ option 513, UNY
- M1971E
 - 55/60-90 GHz mixer
- 89601B VSA
 - w/ options 200,300,BHP
- **N8838A**
 - **Mixer support**



Automotive Radar – Signal Analysis

FMCW Radar Tx Test <2GHz BW

– Dual Channel Configuration



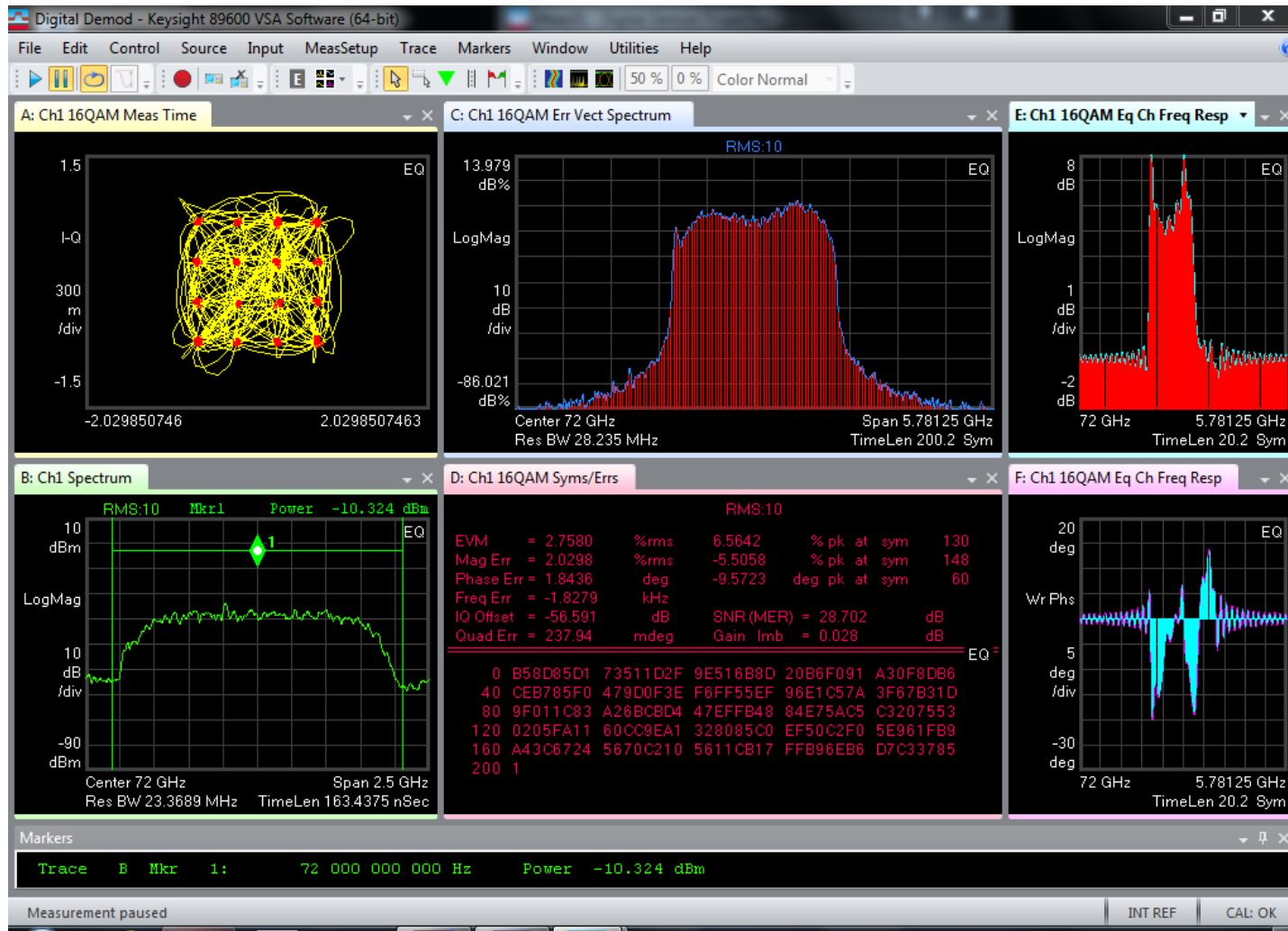
Automotive Radar – Signal Analysis

Infiniium FFT



Automotive Radar – Signal Analysis

Demodulation



Automotive Radar – Signal Analysis

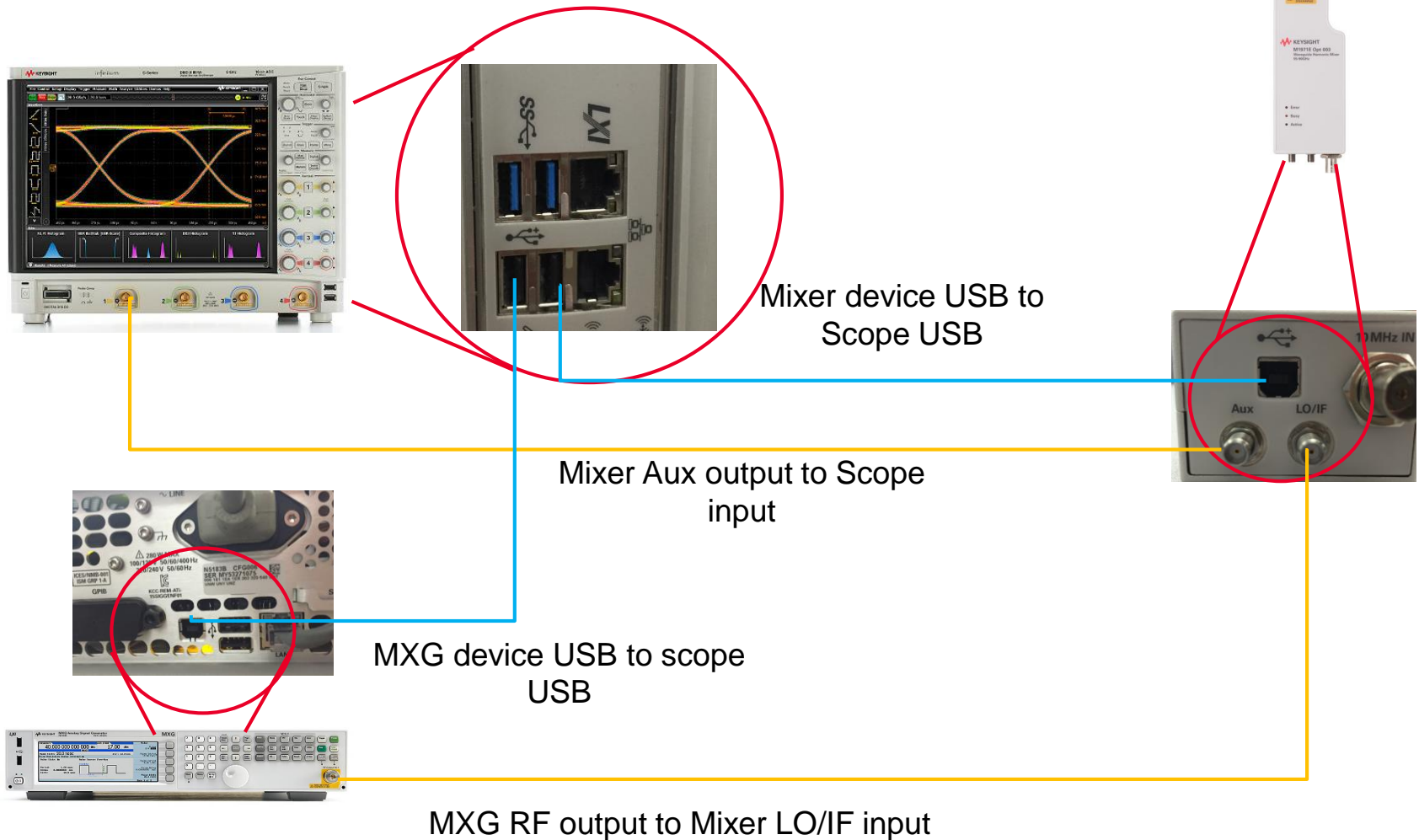
FMCW Radar



Automotive Radar – Signal Analysis

FMCW Radar Tx Test <2GHz BW

– Hardware connections



Automotive Radar – Signal Analysis

FMCW Radar Tx Test <2GHz BW

- This menu become available when the user has a license for the N8838A external mixer assistant software option
- With the option enabled, the user must have a M1971E smart mixer **SN >=MY56130101** connected to the oscilloscope for the mmW (ext. mixer) signal type to be selectable.
- Supported scopes
 - DSOS/MSOS404,604,804
 - No raptor, GREX ,V, Q,Z or Infinivision
- Supported signal generators
 - N5183B-513,520,532,540
- Supported smart mixers
 - M1971E only
 - Must be newer hardware, SN break TBD.



Automotive Radar – Signal Analysis

FMCW Radar Tx Test <2GHz BW

Source: Selects the scopes channel to be used, 2 channels supported (max) channels 1&3 (recommended) or 2&4 can be used simultaneously

Signal Type: mmW (Ext. Mixer) this is the N8838A feature

Measurement Bandwidth: sets the span of the FFT display, user adjustable up to 2.5 GHz,

Center Frequency: sets the center frequency of the FFT display. After connection/calibration, changing the center frequency will also automatically tune the signal generator (LO) to the correct frequency



Automotive Radar – Signal Analysis

FMCW Radar Tx Test <2GHz BW

Cable loss: user settable to compensate for the IF cable loss from the mixer to the input channel of the scope. 0-6dB. If cable has more than 6dB of loss, use a better cable.

LO VISA address: user input field, the VISA address of the N5183B must be input to this field before the “connect” button is pressed. Recommended to use USB connection from scope to signal generator (LO)

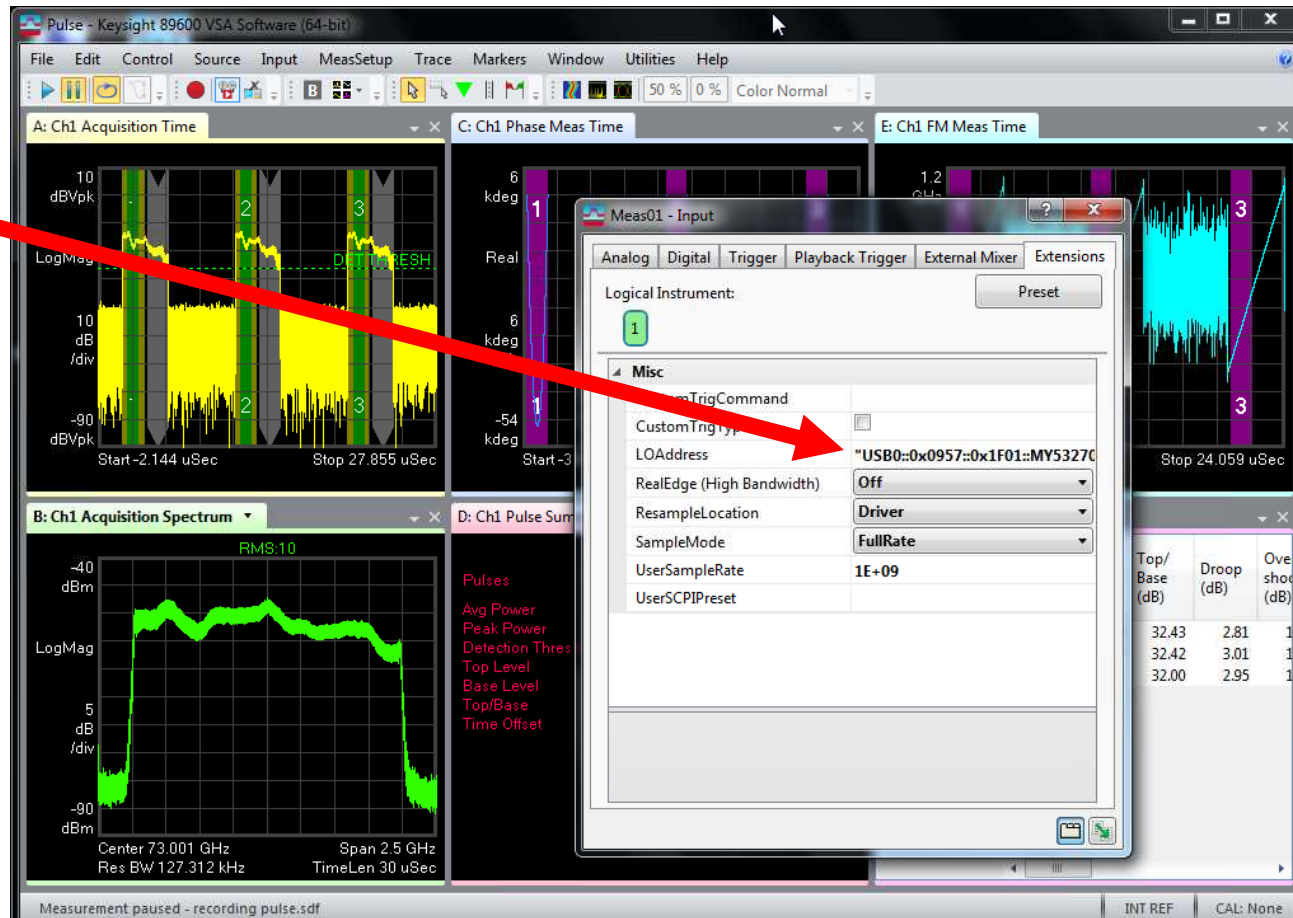


Automotive Radar – Signal Analysis

FMCW Radar Tx Test <2GHz BW

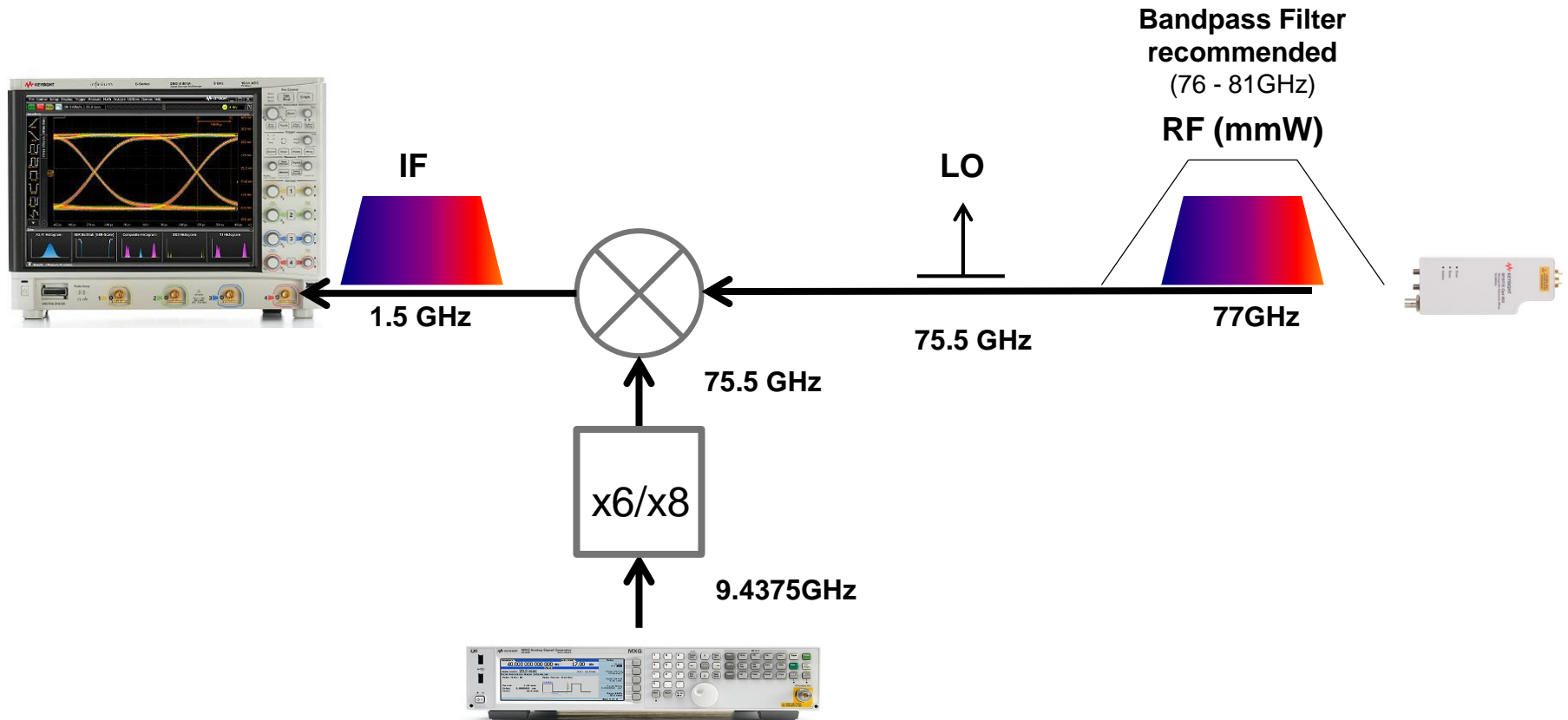
When using VSA:

- The LO address input field is in the Input>Extensions menu
- Similar to the Infiniium operation, make sure to input the N5183B USB VISA address before setting up the measurement.
- NOTE: you may have to enter the VISA address in quotes(i.e. “USB0::0x...”)



Automotive Radar – Signal Analysis

FMCW Radar Tx Test <2GHz BW

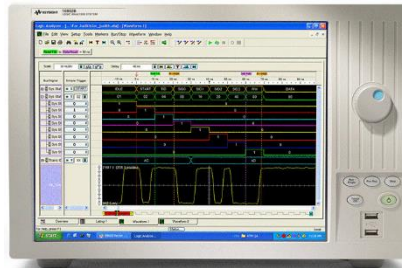


Keysight Vector Signal Analyzers

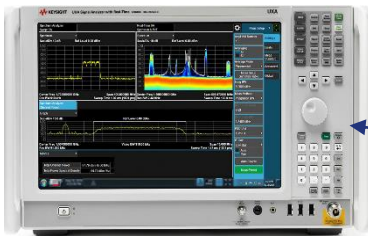
16900 Series Logic Analyzer

PXI/AXI Module VSA & Digitizers

PSA/ESA Spectrum analyzer



X-Series Signal Analyzers



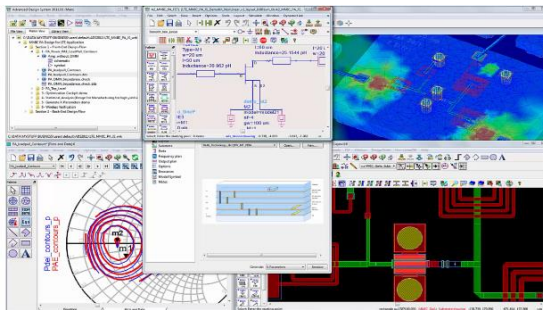
Infiniium Series Oscilloscopes



89601B
VSA Software



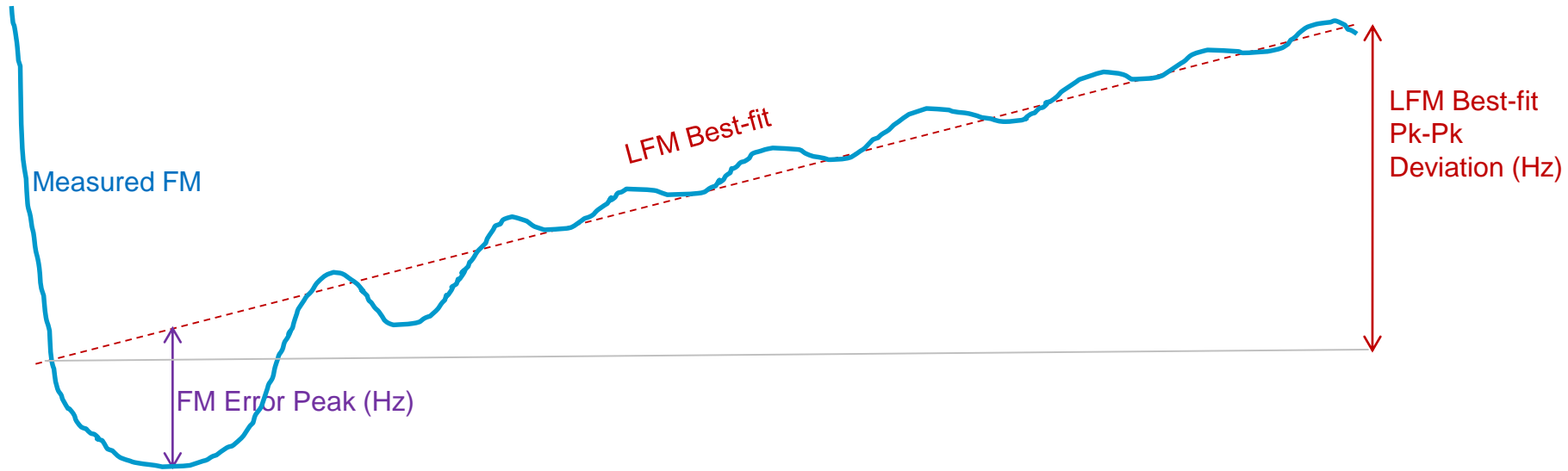
Keysight ADS or SystemVue



Even more?

Automotive Radar – Signal Analysis

FM Linearity – Integral Non-Linearity (%)



$$\text{FM Error Peak (Hz)} = \max(\text{Measured FM} - \text{LFM Best-fit})$$

$$\text{INL Best-fit (\%)} = [\text{FM Error Peak (Hz)} / \text{LFM Best-fit Pk-Pk Deviation (Hz)}] * 100$$

Automotive Radar – Signal Analysis

FMCW Radar Analysis - 89600 VSA Solution

Solution Description:



The new *FMCW Radar Analysis* solution provides:

1. *Synchronization to FMCW multi-chirp LFM radar sensor signals, enabling automated FM Linearity performance measurements.*
2. *Trace results of synchronized Frequency (FM, FM Slope), Phase and Power modulation performance and errors.*
3. *Tabular Result Metrics (per Linear FM region)*
4. *Accumulated Statistical results*
5. *Accumulated Trend and Histogram results.*
6. *Supports both live signal acquisitions plus record & post-process playback.*
7. *BW Scalable - supports X-Series SA, Scopes and Modular Digitizers*

Automotive Radar – Signal Analysis

Spectrum

Time

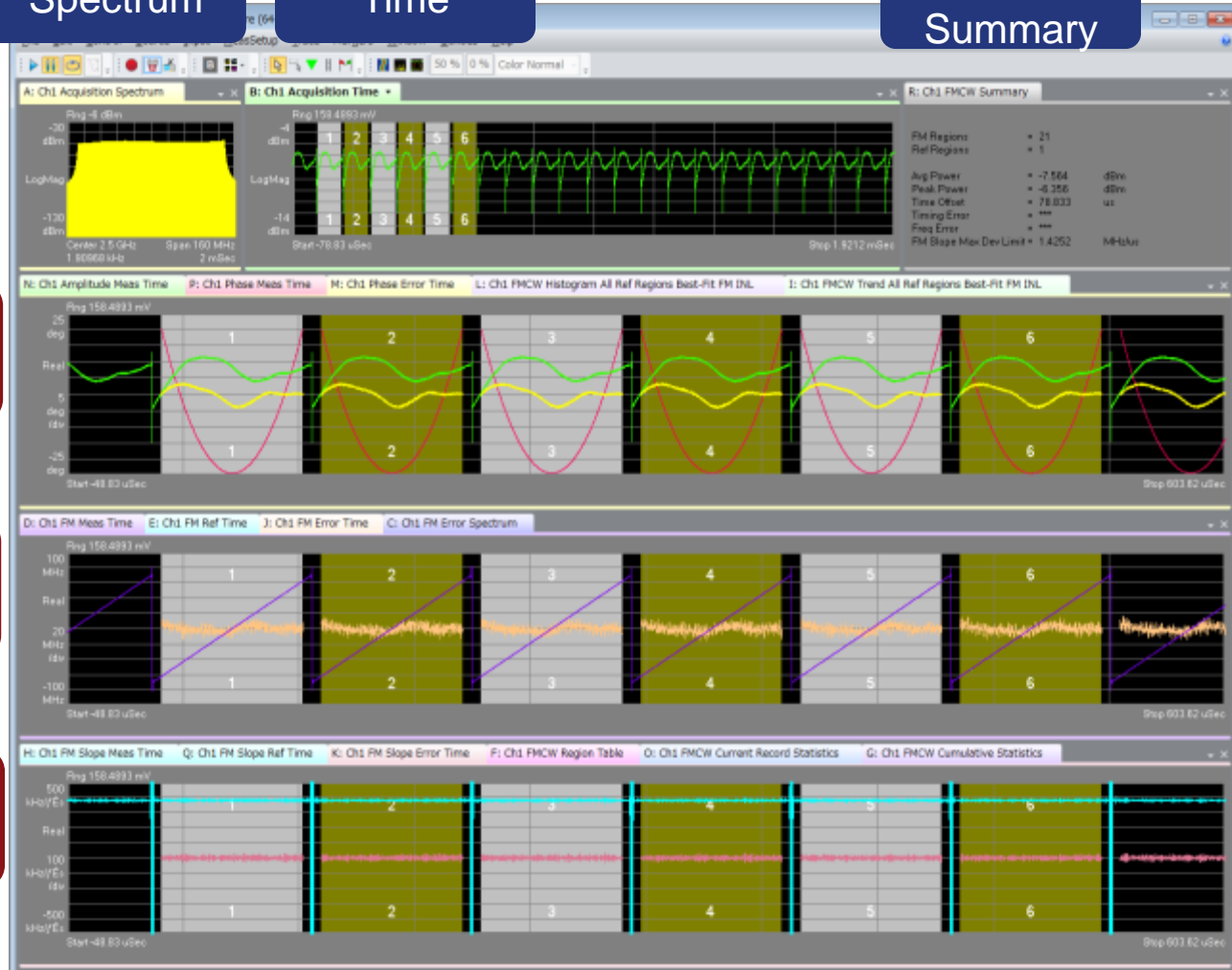
FMCW
Summary

Overlay time traces

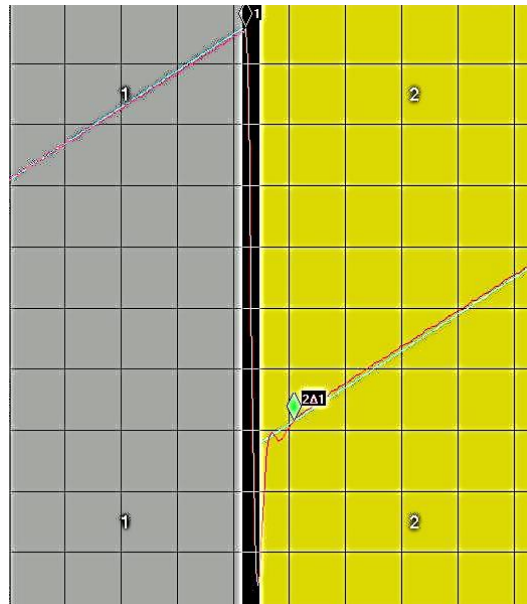
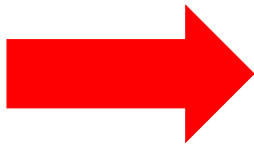
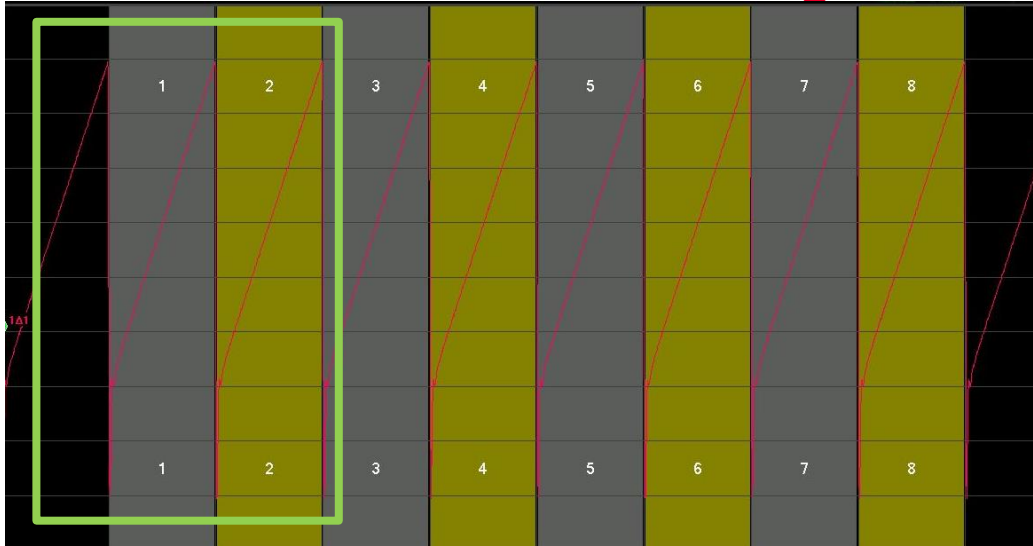
Amplitude Measured,
Reference, Error

FM Measured,
Reference, Error

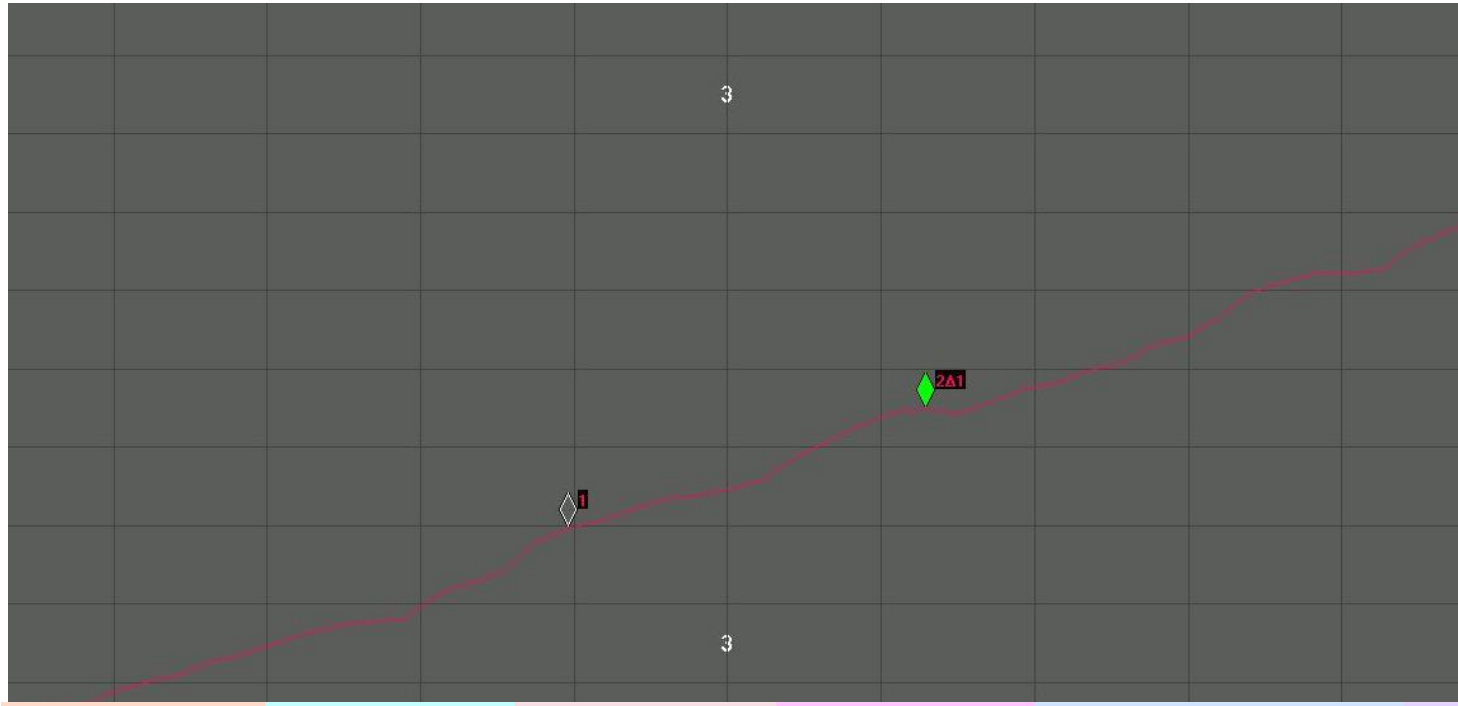
FM Slope Measured,
Reference, Error



Automotive Radar – Signal Analysis



Automotive Radar – Signal Analysis



| Region | Ref Region | Power Mean (dBm) | Power Pk-Pk Dev (dB) | Time Start (sec) | Time Length (sec) | Best-Fit FM Mean (Hz) | Best-Fit FM Pk-Pk Dev (Hz) | Best-Fit FM Slope (Hz/μs) | Best-Fit FM INL (%) | Phase Error RMS (deg) | Phase Error Peak (deg) | FM Error RMS (Hz) | FM Error Peak (Hz) | FM Slope RMS (Hz/μs) | FM Slope Error Peak (Hz/μs) |
|--------|------------|------------------|----------------------|------------------|-------------------|-----------------------|----------------------------|---------------------------|---------------------|-----------------------|------------------------|-------------------|--------------------|----------------------|-----------------------------|
| 1 | 1 | -7.28 | 2.20 | 1.50854 μ | 45.1538 μ | -1.236408 k | 126.4316 M | 2.80002 M | 0.003 | 2.031 | -3.928 | 1.4453 k | 3.864 k | 9.20628 k | 29.5598 k |
| 2 | 2 | -7.70 | 2.48 | 17.4463 μ | 45.2637 μ | 21.67596 k | 126.7374 M | -2.79998 M | 0.003 | 1.847 | -3.673 | 1.36425 k | 4.32619 k | 8.79123 k | 27.5403 k |
| 3 | 1 | -7.28 | 2.21 | 12.494 μ | 45.1538 μ | -42.25621 k | 126.4316 M | 2.80002 M | 0.003 | 2.033 | -4.038 | 1.54392 k | 4.352 k | 10.0233 k | 29.1948 k |
| 4 | 2 | -7.70 | 2.48 | 167.432 μ | 45.2637 μ | 62.71763 k | 126.7374 M | -2.79998 M | 0.003 | 1.801 | -3.742 | 1.44266 k | -4.004 k | 9.12796 k | -25.9883 k |
| 5 | 1 | -7.28 | 2.21 | 22.485 μ | 45.2637 μ | 87.6249 k | 126.7391 M | 2.80002 M | 0.003 | 2.061 | -4.11 | 1.53241 k | 4.136 k | 9.34965 k | -31.9518 k |
| 6 | 2 | -7.69 | 2.47 | 177.533 μ | 45.1538 μ | -67.17443 k | 126.4298 M | -2.79998 M | 0.003 | 1.822 | -3.68 | 1.44314 k | 3.6245 k | 9.8791 k | -29.0225 k |
| 7 | 1 | -7.29 | 2.23 | 32.471 μ | 45.2637 μ | 46.60539 k | 126.7392 M | 2.80002 M | 0.003 | 2.032 | -4.028 | 1.50574 k | 3.812 k | 10.5353 k | -41.2435 k |
| 8 | 2 | -7.69 | 2.48 | 87.518 μ | 45.1538 μ | -26.15471 k | 126.4298 M | -2.79998 M | 0.004 | 1.832 | -3.753 | 1.47357 k | -4.528 k | 9.25755 k | 31.4153 k |
| 9 | 1 | -7.29 | 2.23 | 142.456 μ | 45.2637 μ | 5.595471 k | 126.7392 M | 2.80002 M | 0.003 | 2.065 | -4.07 | 1.49068 k | -3.88767 k | 10.2288 k | 31.628 k |
| 10 | 2 | -7.69 | 2.47 | 197.504 μ | 45.1538 μ | 14.85325 k | 126.4298 M | -2.79998 M | 0.003 | 1.836 | -3.726 | 1.47759 k | -4.048 k | 9.98287 k | 31.9568 k |

Automotive Radar – Signal Analysis – Phase Noise

FMCW Radar Tx Test

E5052B Signal Source Analyzer

Key Features:

1. Phase Noise and AM Noise

- Simple, fast and accurate
- Uses cross-correlation (noise-cancelling) technique along with heterodyne digital discriminator

2. Frequency / Phase / Power Transients

- Dual heterodyne and divided path analysis
- Narrowband path (up to 80MHz BW)
- Wideband path (up to **4.8GHz** BW, band dependent, up to 500 MHz BW when using E5053A input port)

Measure Phase Noise directly at mmW using:

- E5052B SSA + E5053A Microwave

Downconverter

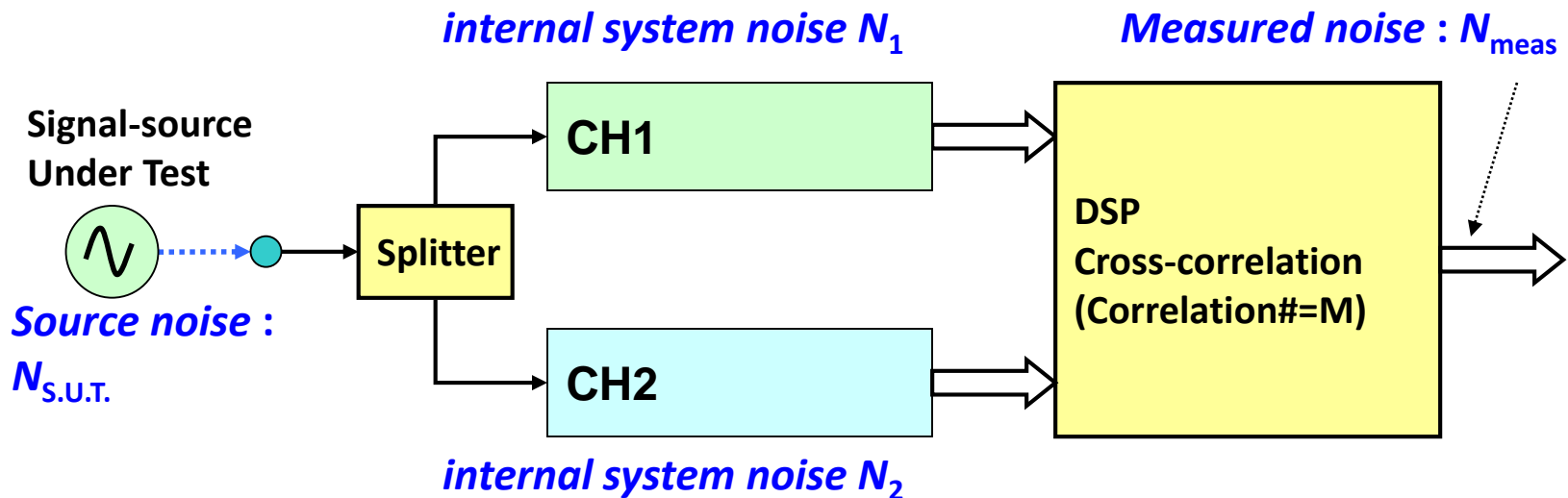
...plus 11970W 75 to 110 GHz Harmonic Mixers



Automotive Radar – Signal Analysis – Phase Noise

FMCW Radar Tx Test

Two-channel Cross-Correlation Technique



$$N_{meas} = N_{S.U.T.} + (N_1 + N_2) / \sqrt{M} \quad \text{Assuming } N_1 \text{ and } N_2 \text{ are uncorrelated.}$$

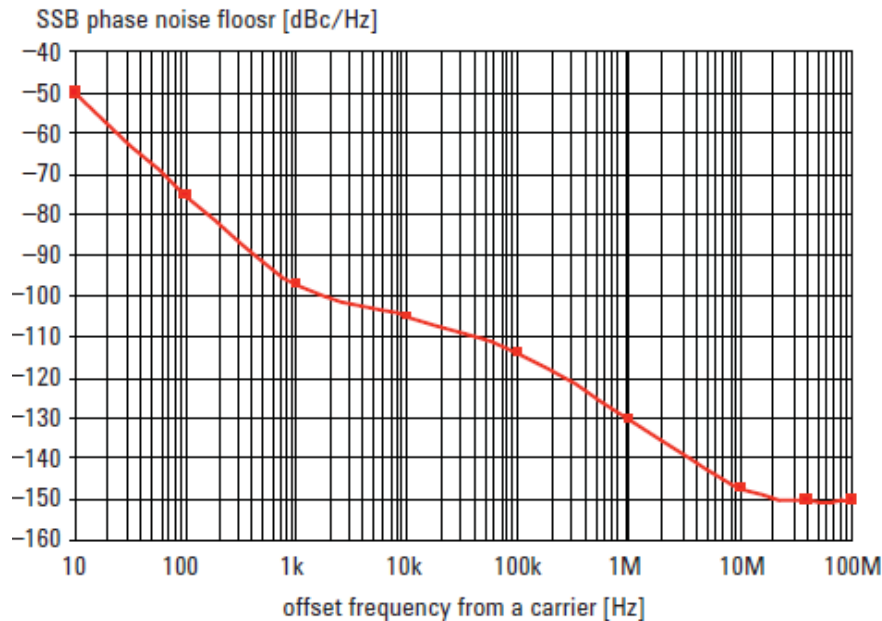
| | | | | |
|----------------------------------|------|-------|-------|--------|
| M (number of correlation) | 10 | 100 | 1,000 | 10,000 |
| Noise reduction on $(N_1 + N_2)$ | -5dB | -10dB | -15dB | -20dB |

Automotive Radar – Signal Analysis – Phase Noise

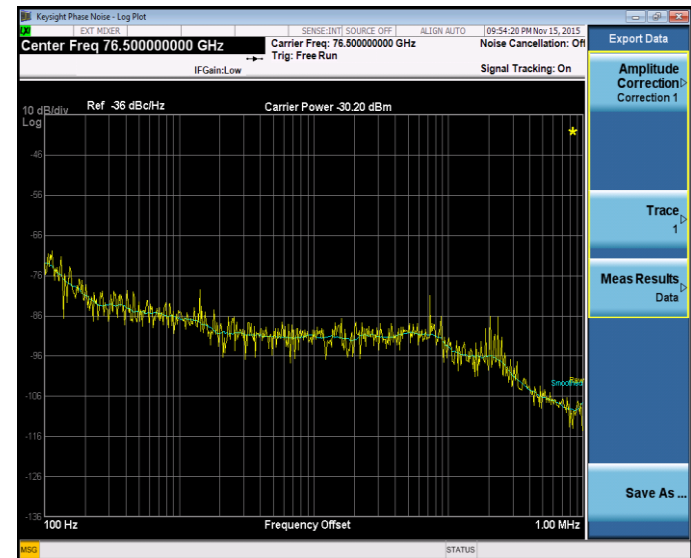
FMCW Radar Tx Test

E5052B Signal Source Analyzer

Phase Noise Floor at 77 GHz (for example)



N9020A Signal Analyzer with M1971E Mixer



Automotive Radar – Regulatory

77 – 81 GHz band global availability status

24 GHz NB (12.7dBm, 200 MHz → 50m range*, 75cm resolution)



24 GHz UWB (-41.3dBm/MHz, 2.5GHz → 15m range*, 6cm resolution)



77 GHz NB (50dBm, 1000 MHz → 200m range*, 15cm resolution)

79 GHz (-9dBm/MHz, 4GHz → 30m range*, 4cm resolution)



Recommended by ITU-R M1452 for forward looking applications

$$\Delta R_{\min} > \frac{c}{2B}$$

Estimated value with 1 sqm RCS

Recommended by ITU-R M1452 for short range radar



Move by 2018

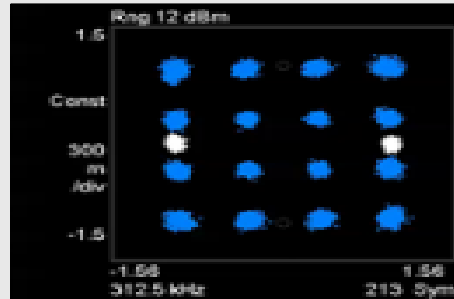
How to measurement 4GHz Band Width

Difficulties to test mmWave signal

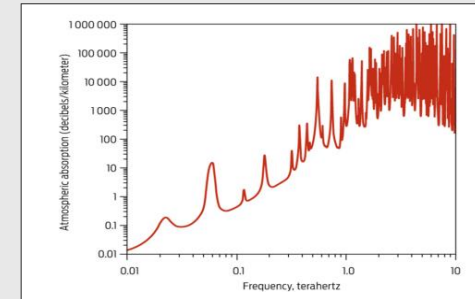
Small Dimensions and Complex Test Setups



Challenging Ultra Wideband mmWave Measurements



Small Signal Strength



The New N9041B UXA Signal Analyzer, 110 GHz

“See the Whole Picture” to 110 GHz

1st

3 Hz - 110 GHz
Continuous sweeps

1st

-150 dBm/Hz DANL
up to 110 GHz

1st

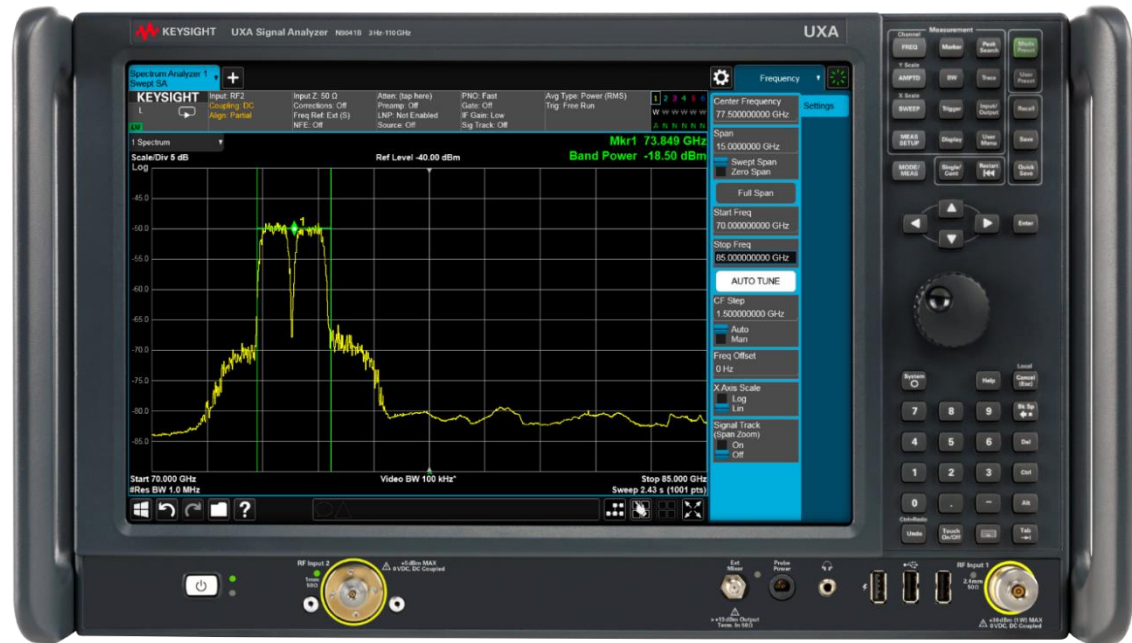
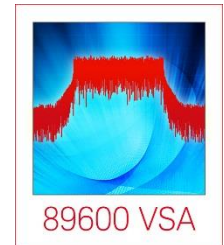
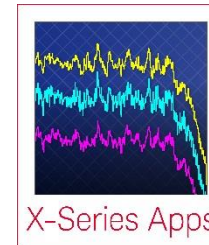
Dual input rugged
2.4 mm and 1 mm
connector

1st

Up to 1 GHz
internal BW

1st

5 GHz BW (with
external oscilloscope)



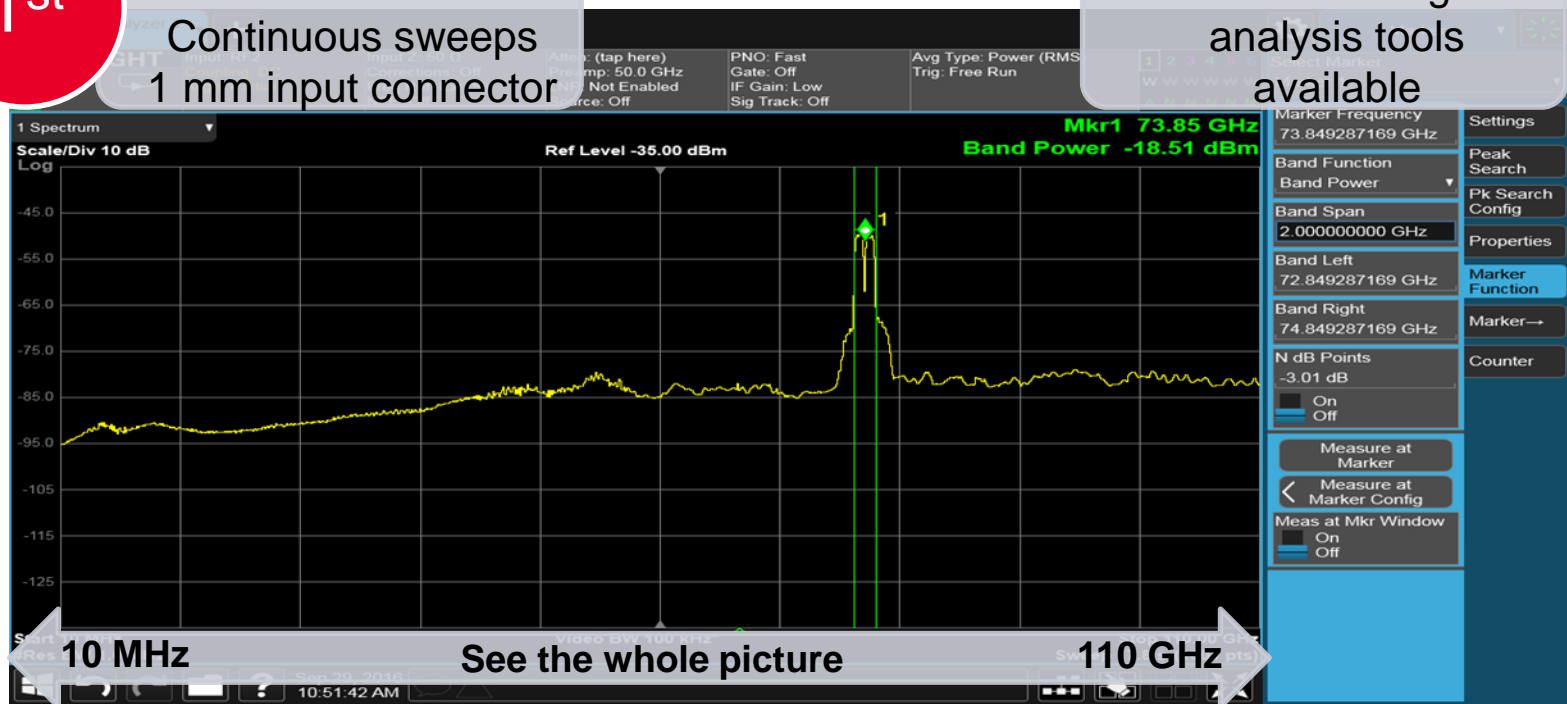
World's First 3 Hz to 110 GHz Continuous Sweeps

Complexity solved – No complicated external mixers

1st

3 Hz - 110 GHz
Continuous sweeps
1 mm input connector

Full suite of signal
analysis tools
available



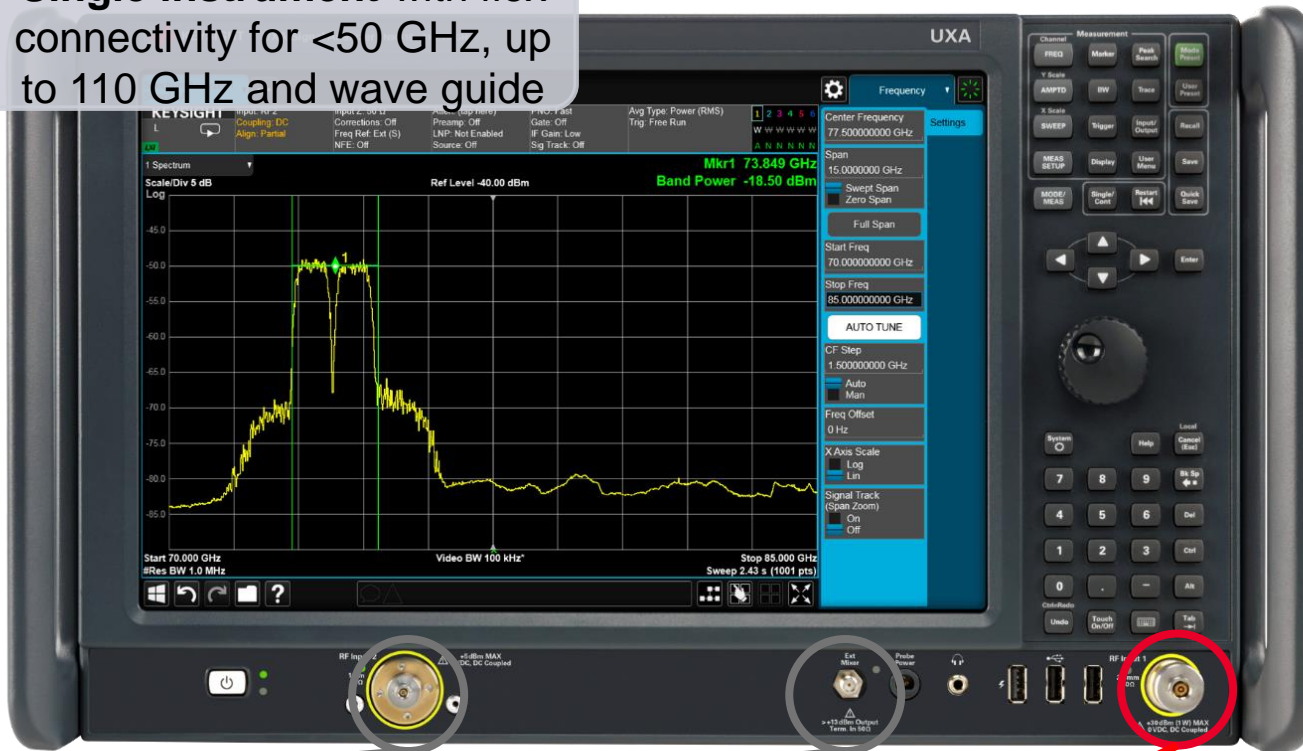
90 GHz option available for export controlled countries

World's First 3 Hz to 110 GHz Continuous Sweeps

Fragility solved – **2nd rugged 2.4 mm** connector < 50 GHz

1st

Single instrument with flex connectivity for <50 GHz, up to 110 GHz and wave guide



RF Input 2
1.0 mm connector
3 Hz – 110 GHz

EXM supports
M1971 V/E/W waveguide
“smart” harmonic mixers

RF Input 1
2.4mm connector
3 Hz – 50 GHz

Best Dynamic Range at 110 GHz

Solved – Measure small signals in presence of high power

1st

-150 dBm/Hz DANL
up to 110 GHz



Superb DANL without preamp = Best SEM dynamic range

Unmatched BW at 110 GHz

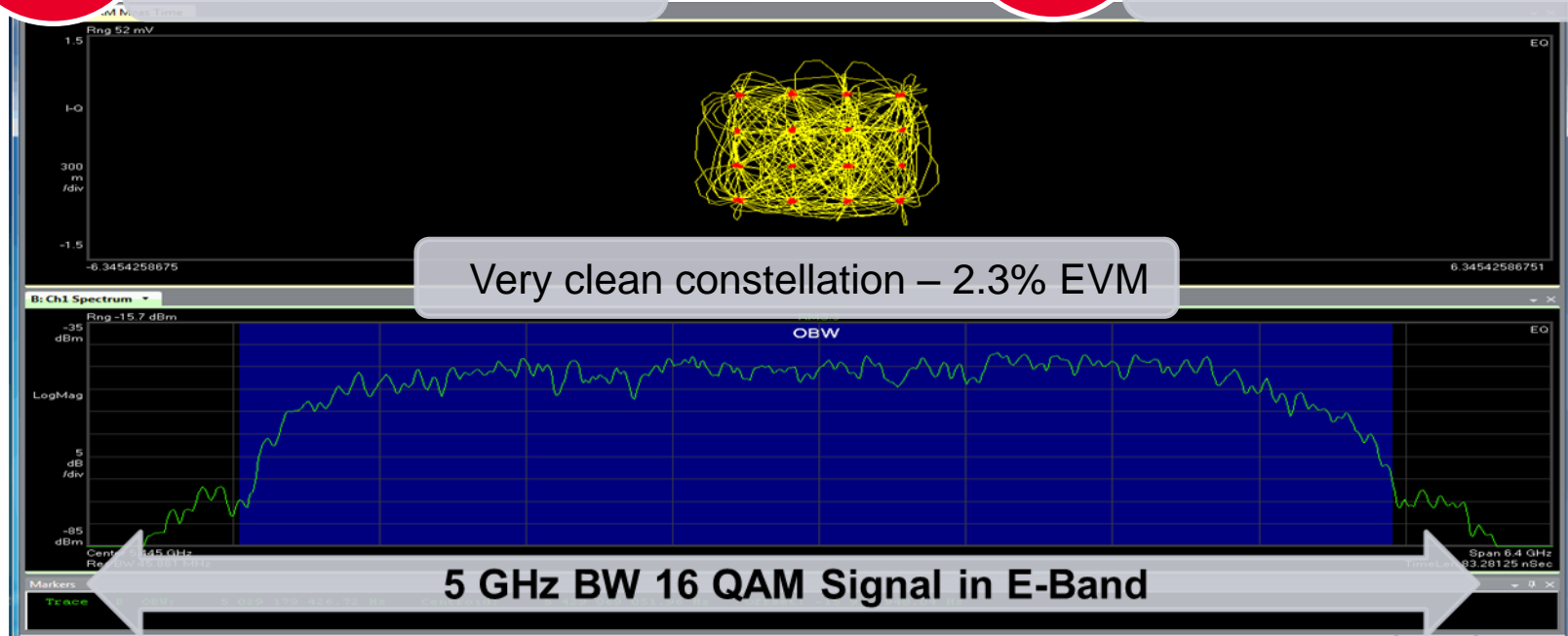
Solved – Challenging ultra wide BW measurements

1st

5 GHz BW (Opt CRW)
(to external oscilloscope)

1st

1 GHz internal BW

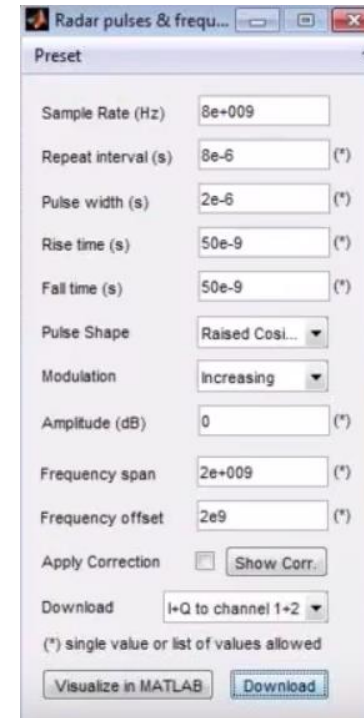
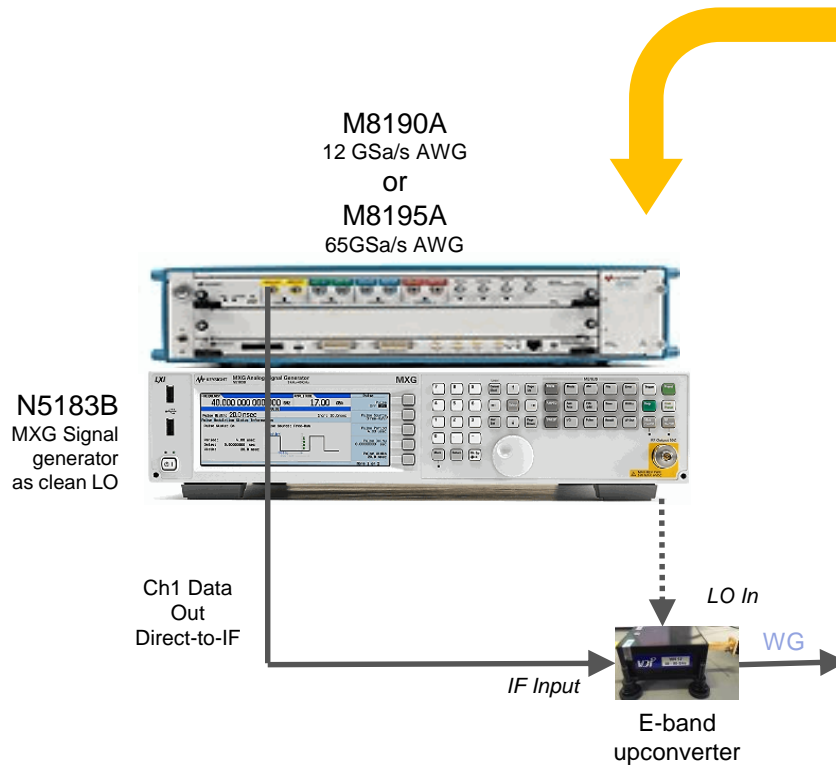


Option CRW: Wideband IF Output (rear panel)

Convenient measurements of 5G, automotive and A/D signals

Automotive Radar – Signal Generation

How to Make WB Radar Signal

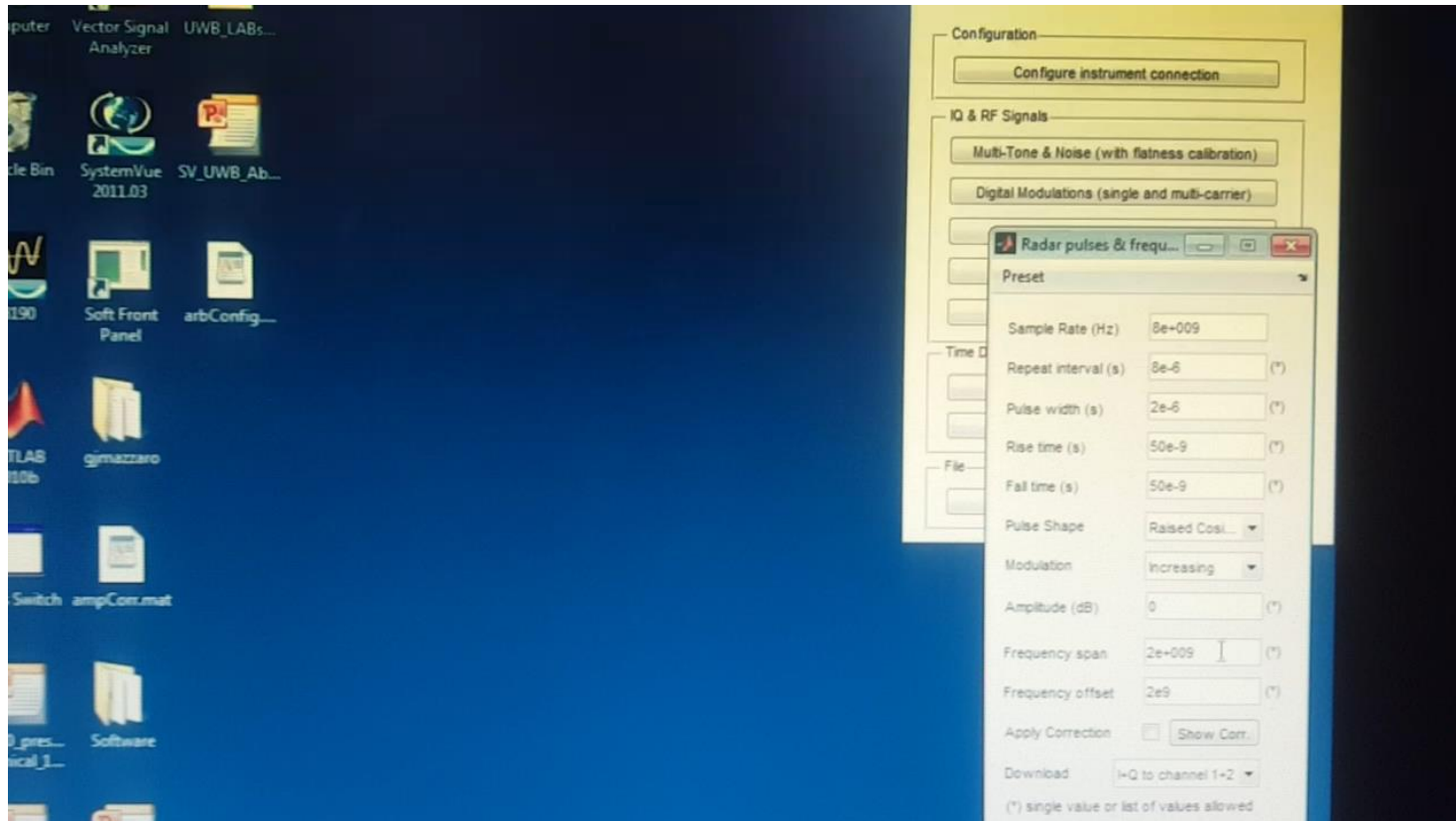


IQ Tools



Automotive Radar – Signal Generation

How to Make WB Radar Signal



Keysight Solutions 77 / 79GHz(4GHz) – Generation + Analysis

FMCW Radar Signal Generation

- ✓ Pulse Builder for Signal Studio
- ✓ SystemVue
- ✓ “iqtools” MATLAB utility

Cle
LAN

LAN

System Configuration

PSG

E8257D Analog (Low Phase noise LO)



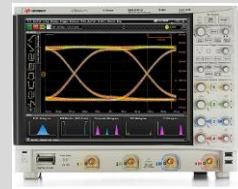
mmW Source Module

WR12SAX(60 to 90GHz, N=6, SAX option)



AXIe AWG

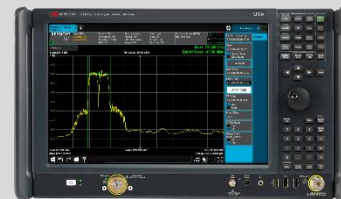
M8190A (
14bit @ 8GSa/s,
12bit @ 12GSa/s,
5GHz Analog BW)



Scope Infiniium

S-Series
DSOS804A

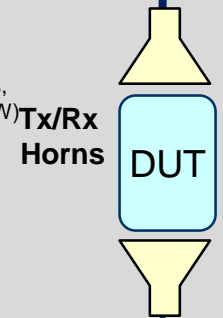
External IF (Up to 5GHz)



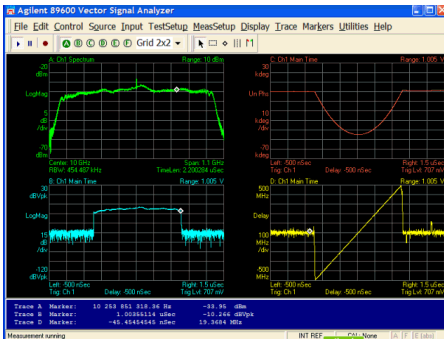
Spectrum Analyzer

UXA

N9041B up to 110GHz



89600 VSA Analysis Software



Automotive Radar Test procedures

[PCA Build]



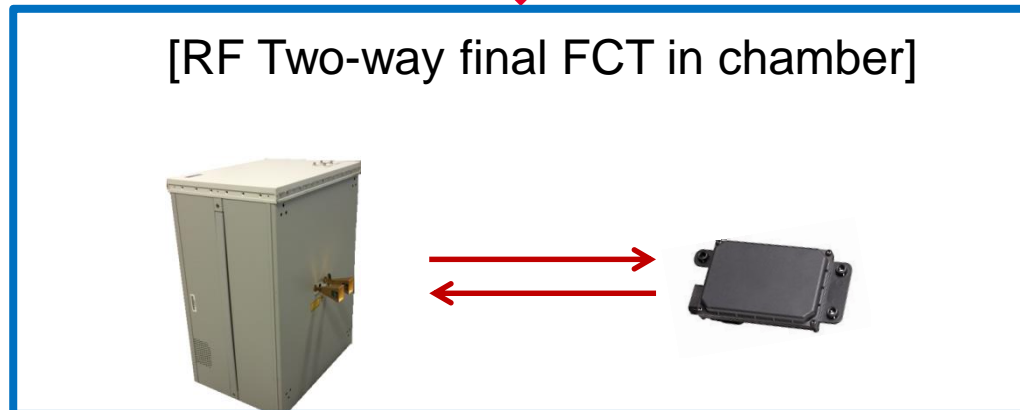
[ICT & Flash]



[RF One-way Tx/Rx FCT anechoic chamber]



[RF Two-way final FCT in chamber]



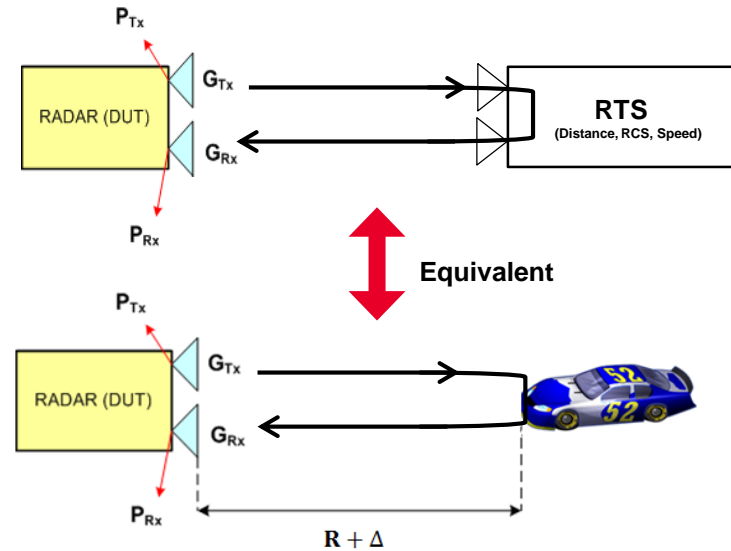
Keysight Automotive Radar Solutions

Radar Target Simulator(RTS)

Basic Functionality:

The actual UUT radar signal is




- a) Received
- b) manipulated
- c) retransmitted



| A radar target simulator will apply ... | to simulate ... |
|---|-----------------------------------|
| Time Delay | Range (Distance) |
| Doppler Frequency Shift | Radial velocity |
| Attenuation | Radar Cross section (object size) |

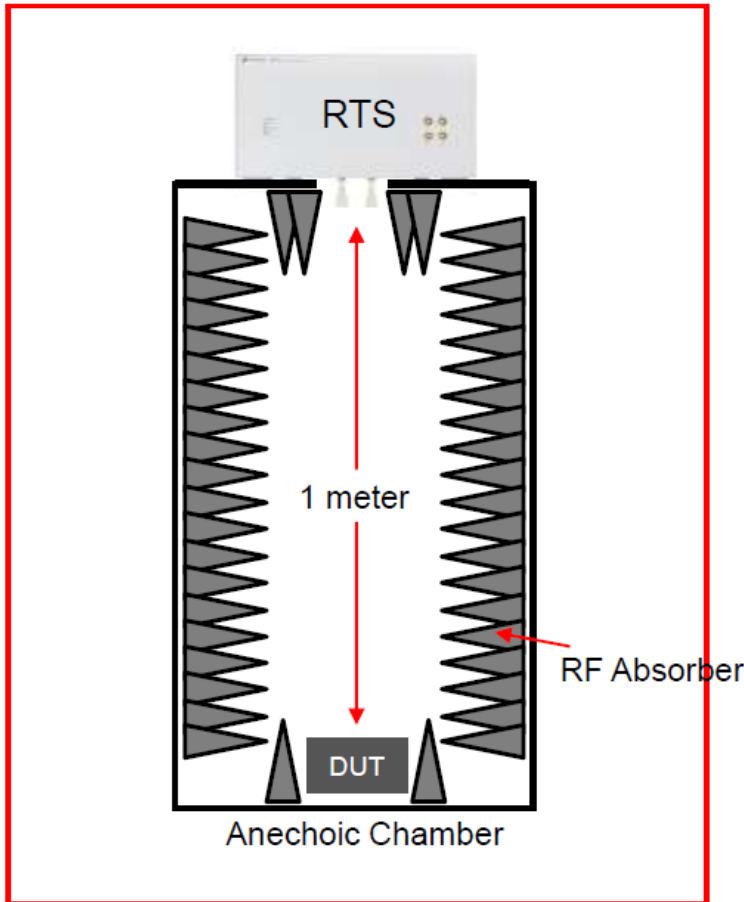
Keysight Radar Target Simulator

Scalable system configurations

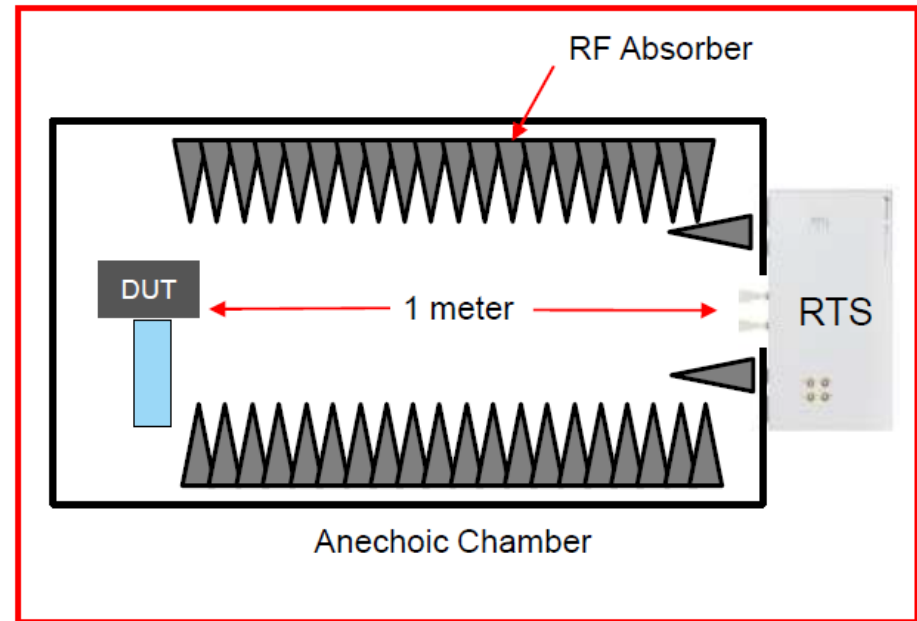
| Description | Fixed range RT S | + Full Range | + Doppler | + DUT Tx Power |
|------------------------|--|--|---|--|
| Key Features | <ul style="list-style-type: none"> • 76-77GHz • 1 or 2 Horns • 75 & 150m • 1GHz BW • Full RCS • DUT Tx simulated power | <ul style="list-style-type: none"> • 10 – 450m with 1m resolution | <ul style="list-style-type: none"> • +/- 360 Km/h with 1Km/h resolution | <ul style="list-style-type: none"> • Enable DUT Tx power measurement |
| Hardware Configuration |  <p>Base System</p> | Base system internal HW upgrade |  <p>N5183A MXG</p> |  <p>U2042XA Power Meter</p> |
| Support & Warranty | <ul style="list-style-type: none"> • 3 Years Keysight Factory warranty with calibration certificate valid for 1 year • Optional 1 or 3 years contract <ul style="list-style-type: none"> ○ Return to Keysight or onsite calibration ○ Spare onsite swap | | | |

Keysight Automotive Radar Solutions

RTS Chamber Configuration



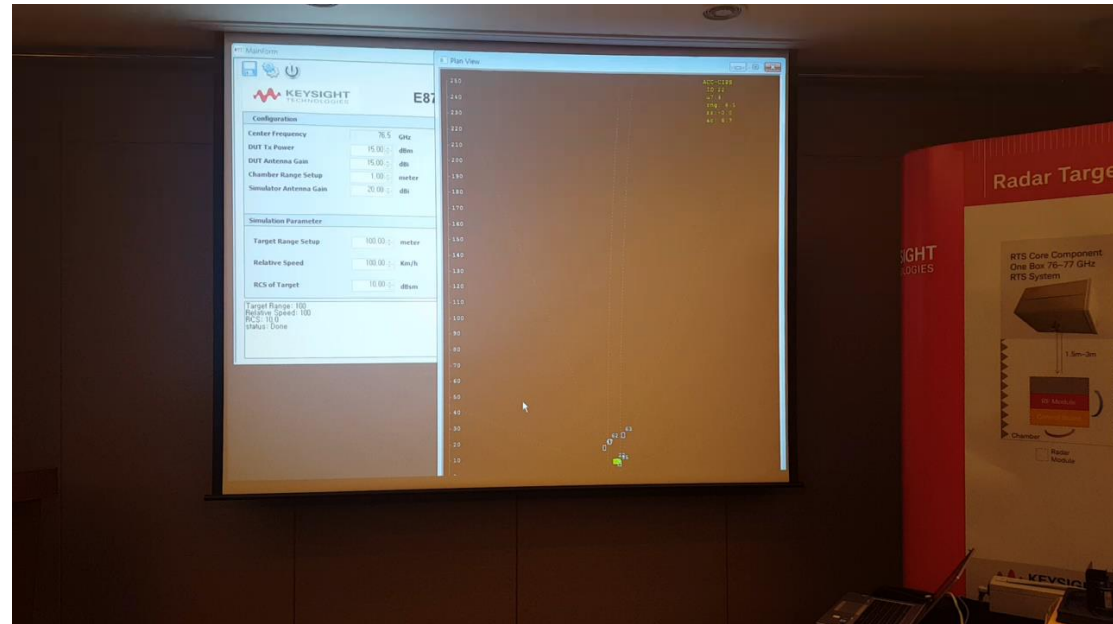
Vertical Setup



Horizontal Setup

Keysight Radar Target Simulator

RTS Test with Radar Module



Keysight Automotive Radar Solutions

RTS Specification

| | |
|-------------------------------|-------------------------------|
| Frequency Range | 76 – 77 GHz |
| Horn Antenna Configuration | Single and Dual Horns Antenna |
| Bandwidth | 1 GHz |
| Min Target Distance | 10m |
| Simulated Range | 10m to 450m with 1m step |
| Doppler Shift Range | +/- 360km/h with 0.1km/h step |
| Receive Transmit Gain Control | -63.5dB with 0.5dB step |
| Dimension (H x W x D) | 222 x 425 x 574 (mm) |

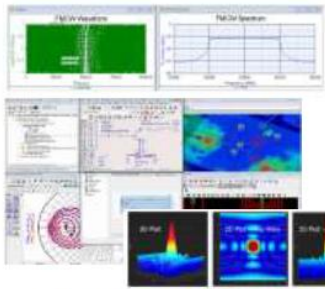


Keysight E8707A Radar
Target Simulator



Keysight Automotive Radar Solutions

FMCW Radar Test



ADS / SystemVue Simulation SW



89600 VSA SW with FMCW option



S-Series Oscilloscope



X-Series Signal Analyzer



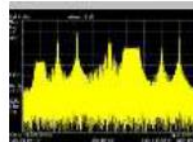
PXI Modular VSA/VSG/Digitizer /Network Analyzer



E-Band Power Sensor and Meter



E8267D PSG Vector Signal Generator



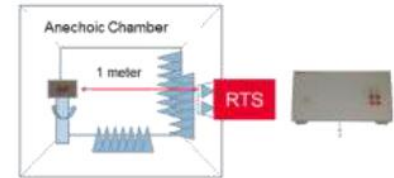
Signal Studio for Pulse Building



Signal Source Analyzer



PNA Network Analyzers Banded mmW Solution



Radar Target Simulator (RTS)

Question and Answer

