Challenges and Solutions of Advanced Automotive Radar Design and Test Lifecycle

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KEYSIGHT TECHNOLOGIES

Automotive Radar Design and Test Lifecycle Webinar

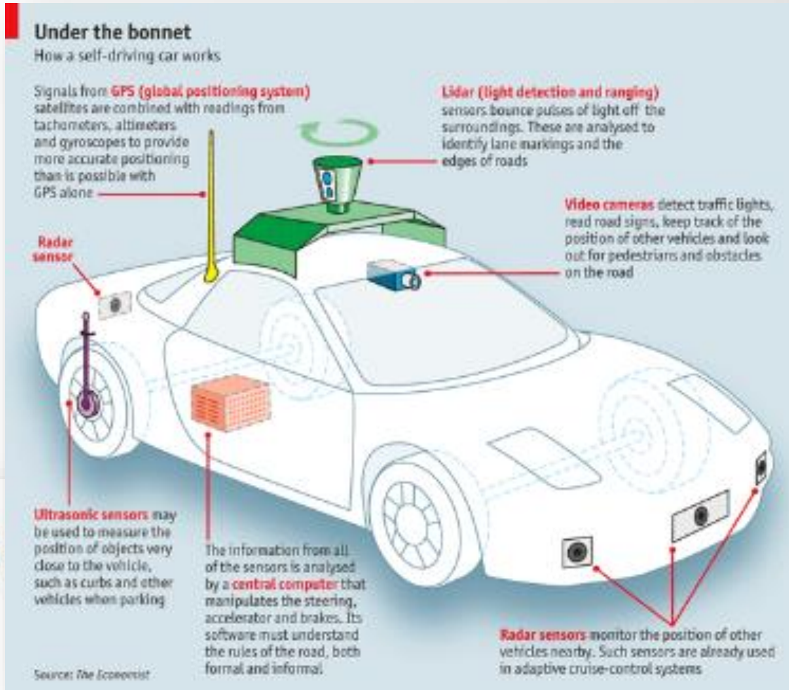
TOPICS

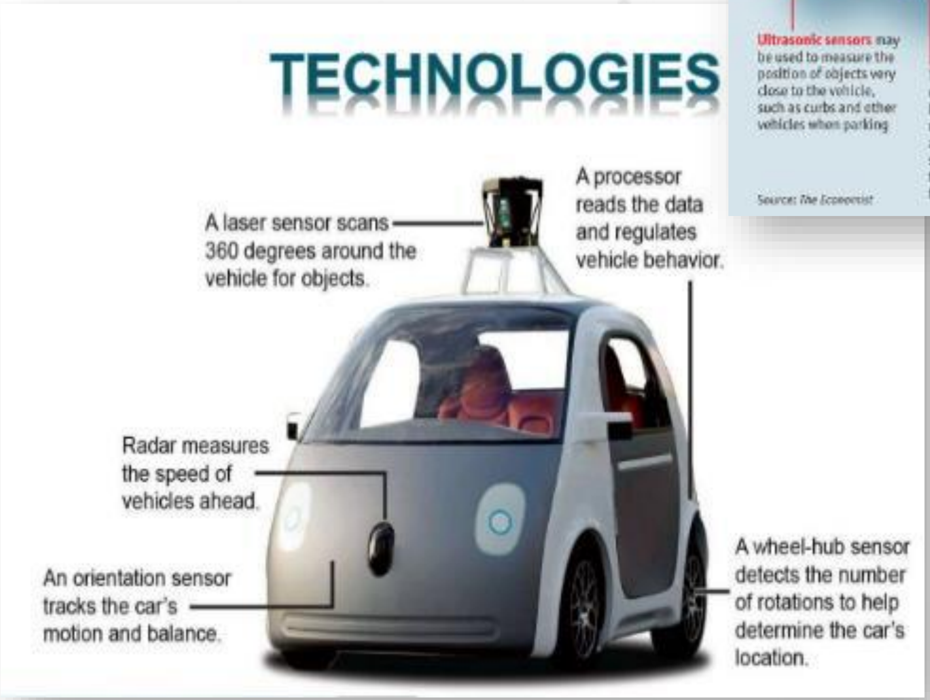
- Automotive Radar Review
- Enabling Technologies
- Design & Test Challenges / Solutions

Autonomous Driving System

ENABLING TECHNOLOGIES

- Sensors
  - Radar
  - LIDAR
  - Camera
- Wireless connections
  - 2/3/4G and coming 5G
  - 802.11p DSRC
- Automotive Ethernet
  - BroadR-Reach, 100 / 1000 BASE-T
- Navigation systems
- Processors
- Artificial Intelligence
- High Definition Mapping
- More





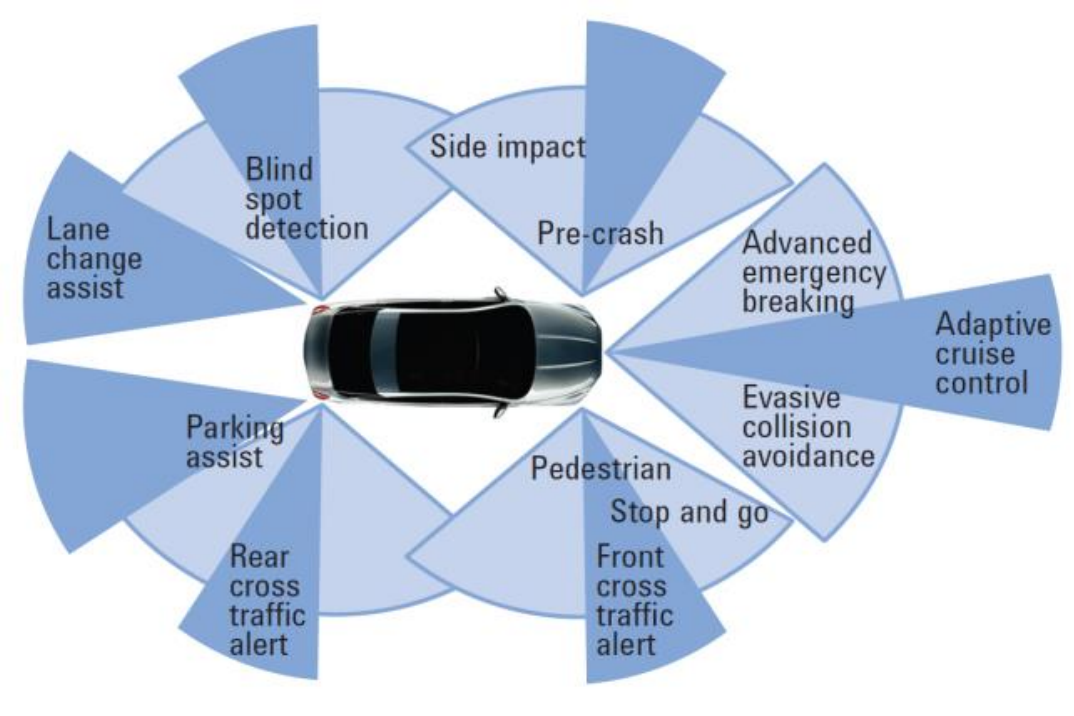
Autonomous Driving System

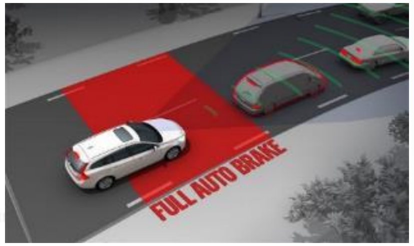
SENSORS

	RADAR	Camera	LIDAR
Used for	• Detection - distance (range) and motion (velocity, angle) by radio waveforms	• Recognition, classification by images	• 360° 3D view by laser / light
Applications	• Adaptive Cruise Control, Automatic Emergency Braking Systems, Blind Spot Detection, Parking Assistance	• Traffic Sign Recognition, Land Keep Systems, Parking Assistance, Blind spot detection, ACC, AEBS	• Emergency Brake Assist for Pedestrian, Crash Imminent Braking, Mapping
Advantages	• Working in all environmental conditions • Light weight • Longer detection distance than LIDAR	• Lower cost • Smaller sensor size • High resolution • Color recognition • Imaging processing	• High accuracy • High resolution • Intelligent signal processing with large amount of captured data
Limitations	• Limited information of detected obstacles • Lower resolution than LIDAR	• Various performance in some environments (e.g. weather, lighting)	• (still) expensive sensor • (still) big sensor size • Expensive and complicated signal/data management • Affected by weather

Automotive Radar

APPLICATION EXAMPLES

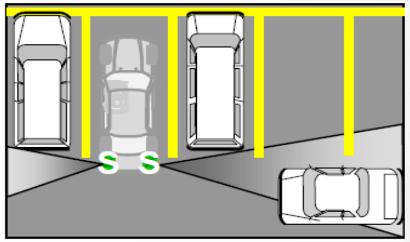




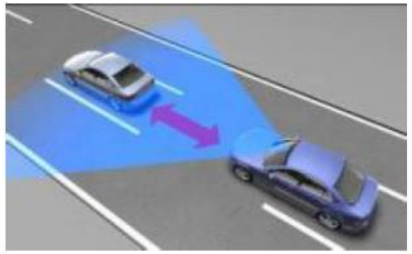
Auto Emergency Braking / Pre-tensioning Seatbelts

Blind Spot Monitoring

Lane Change Assist



Real Collision Protection



Adaptive Cruise Control

Stop & Go Cruise Control

Making Roads Safer with 360 Degree Vision!

Making Autonomous Driving Possible!

Automotive Radar

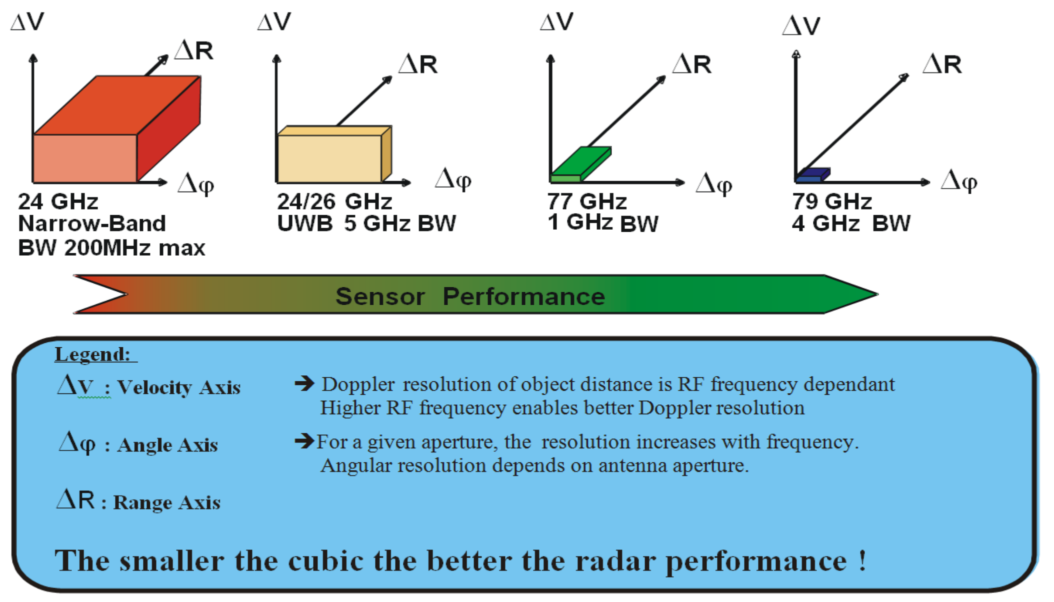
MAJOR TECHNOLOGIES

- High Frequency and wide bandwidth millimeter wave (24, 77, and 79GHz)
- Modulation (FMCW)
- Antenna
- Automotive Ethernet / Serial Buses (BroadR-Reach, 100 BASE-T, CAN/CAN FD)
- Power Control (ETSI conformance specification, EN 302 264 for 79GHz)
- More

Automotive Radar Major Technologies

HIGH FREQUENCY & WIDE BANDWIDTH MILLIMETER WAVE (77/79 GHZ)

- Benefits
  - Better spatial angular (smaller wavelength), velocity (doppler), and range resolution
  - Higher range (up to 300 meter)
  - Smaller and lighter sensor
  - Rapid signal attenuation (better for interference), improved interference mitigation
  - Higher attenuation per km → higher spectrum re-use (sharing) scheme on the busy road
  - Better power efficiency (less emission power → lower possibility of interference issue)



Source: CEPT Report 37

Fig.1 Comparison of sensor performance showing key parameters Angular resolution, Range resolution, Doppler resolution

Automotive Radar Major Technologies

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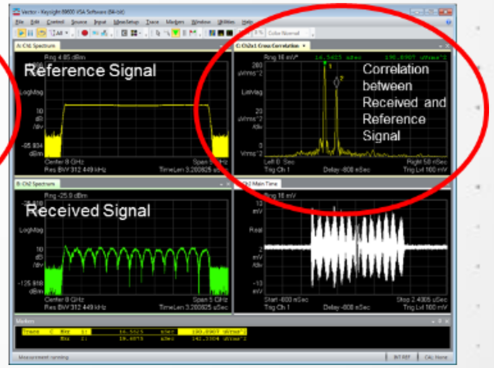
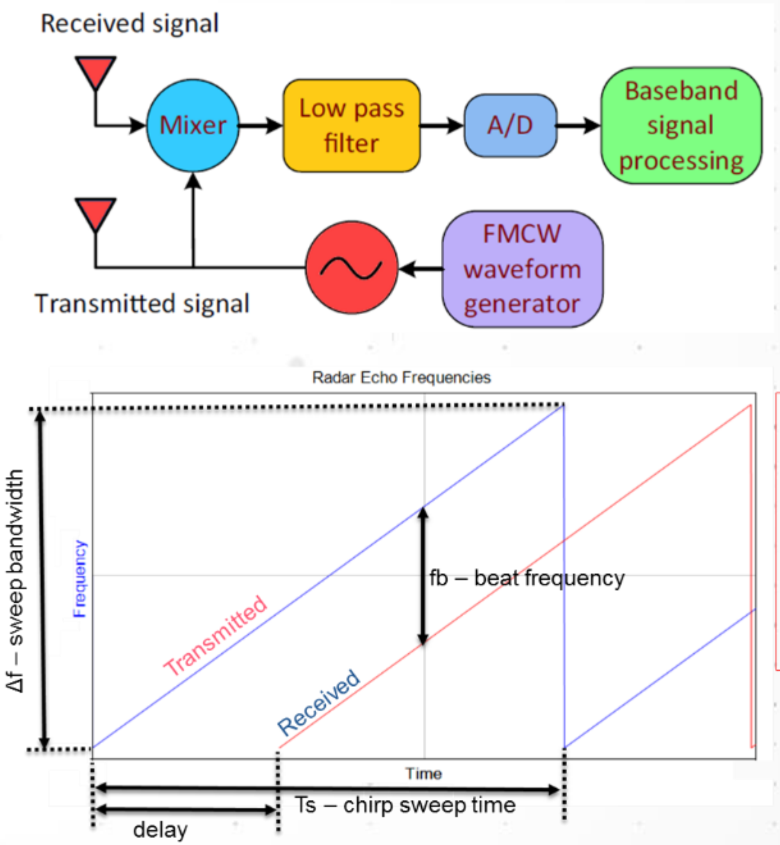
- Challenges
  - Higher propagation loss
  - Phase noise, IQ and frequency response errors degrade
  - Repeatability
  - More noise to impact on EVM
  - Complex test set up
  - Generate and characterize accurate wide bandwidth millimeter wave signals



Automotive Radar Major Technologies

MODULATION (FMCW)

- Benefits
  - Avoid high peak-to-average power ratio (PAPR) in transmission
  - Simplifies the design process for antennas and RF components (narrow-band IF processing)
  - Good performance with simplified RF components → small size, light weight, and low cost.
  - Improved noise floor
  - Interference tolerance
  - Reduced RF intermodulation
  - Simpler / easier waveform to generate (compared to very narrow, high power pulsed)
  - Constant high average power, without requiring high peak powers, managed close-in blind-range issues (always transmitting and receiving)



Range Estimate

$$\tau = \frac{2R}{C} = \frac{f_b T_s}{\Delta f}$$

$$R = \frac{f_b T_s C}{2\Delta f}$$

Fig.4 FMCW diagram and frequency detection

Automotive Radar Major Technologies

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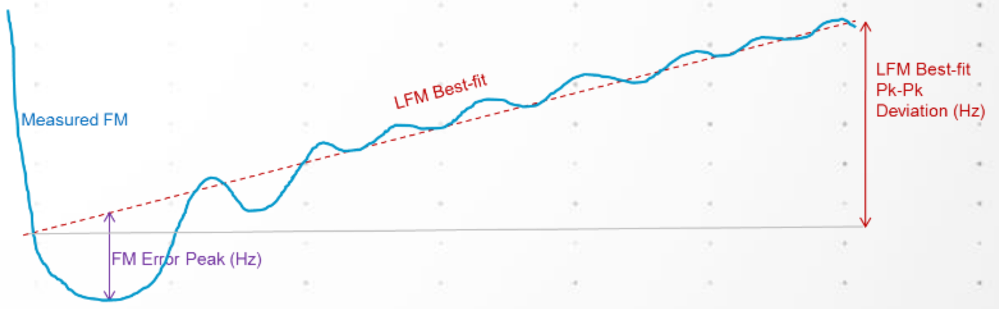
- Challenges
  - FM Linearity modulation quality
  - Phase Noise and AM Noise of transmitter
  - RF leakage from Tx to Rx
  - Dealing with clutter from multiple undesirable reflections between sensor and targets
  - Dealing with interference from other radar sensor band users
  - Thermal Power Challenges

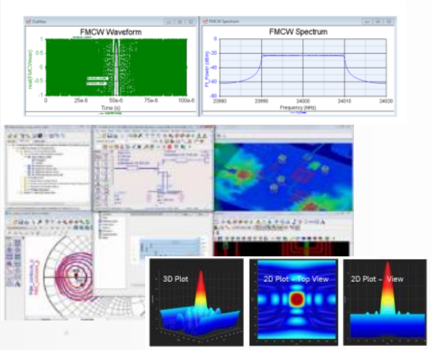


FM Error Peak (Hz) = max(Measured FM – LFM Best-fit)

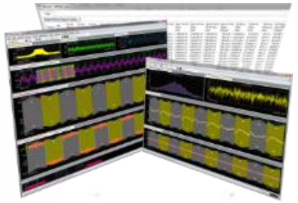
INL Best-fit (%) = [FM Error Peak (Hz) / LFM Best-fit Pk-Pk Deviation (Hz)] * 100

Keysight Automotive Radar Solutions

OVER WHOLE DESIGN AND TEST LIFECYCLE



W1908 SystemVue Simulation SW



89600 VSA SW with FMCW option

PXI Modular VSA/VSG/Digitizer /Network Analyzer

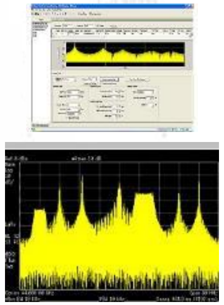
E8740A-060 Performance SA

E-Band Power Sensor and Meter

Architecture / Design → **Development** → Validation & Mfg.

E8740A-070 Performance SG

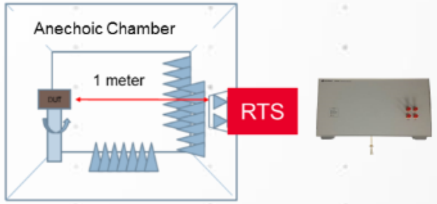
E8267D PSG Vector Signal Generator



Signal Studio for Pulse Building

Signal Source Analyzer

PNA Network Analyzers Banded mmW Solution



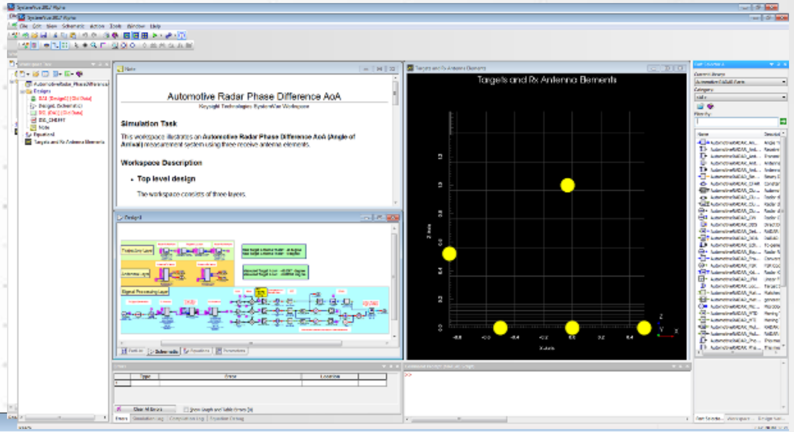
Radar Target Simulator (RTS)

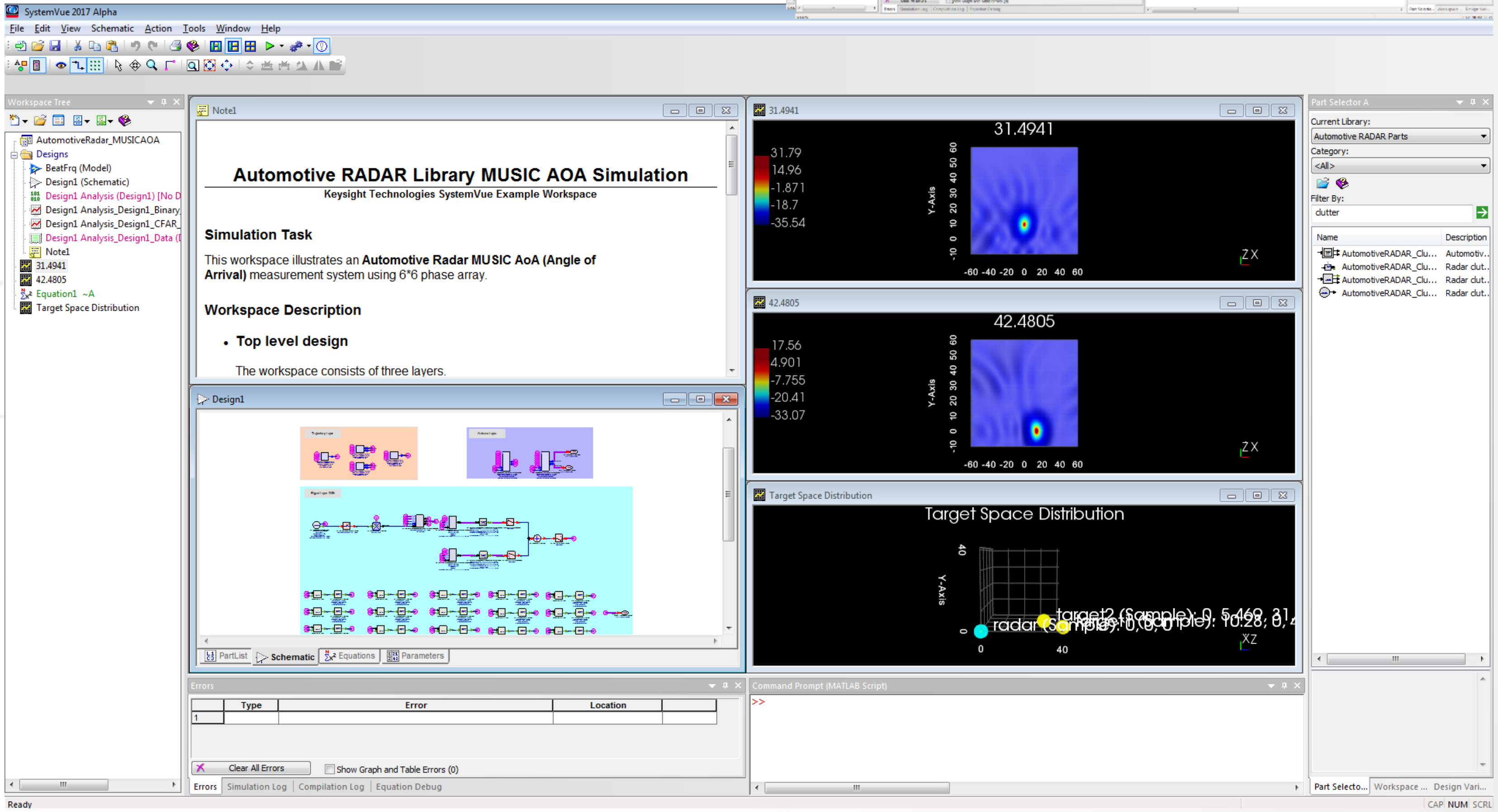
From Design Simulation, Wide Bandwidth mmWave Signal Generation & Analysis, Precise Power and Component Measurements to Manufacturing Tests

Automotive Radar Design Simulation

MUSIC AOA SIMULATION

- MUSIC AoA
  - Multiple Signal Classification, algorithm used for frequency estimation and emitter location
  - High resolution digital beamforming method with sensor array is required
  - Estimated by investigating the phase difference by a time delay

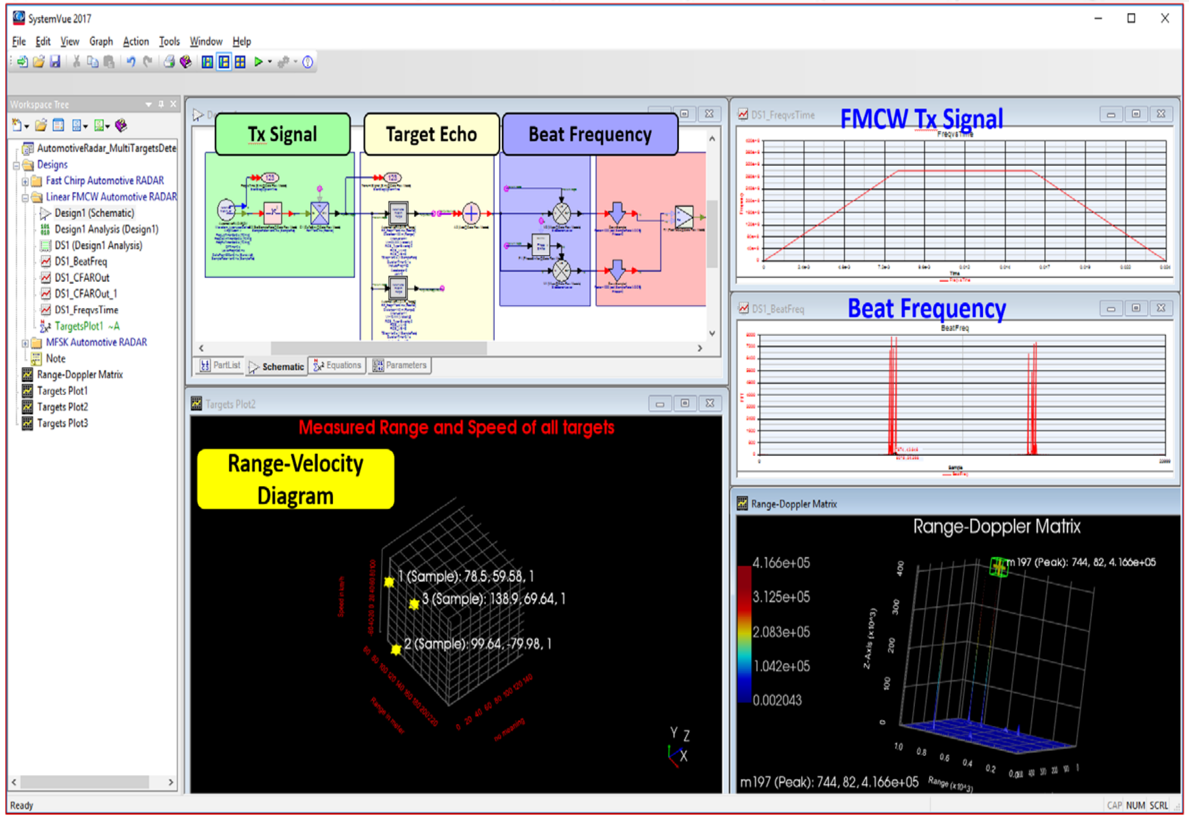




Automotive Radar Design Simulation

LINEAR FMCW MULTI-TARGET DETECTION

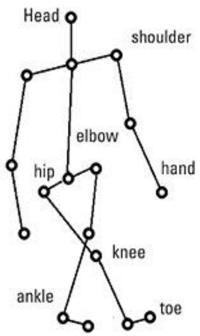
- Using single tone of linear FMCW signal with up-chirp and down-chirp with echo and beat frequency of every targets, users can simulate the multi target detection and show them in range-velocity diagram.
- Showing three targets detected and shown in range-velocity diagram

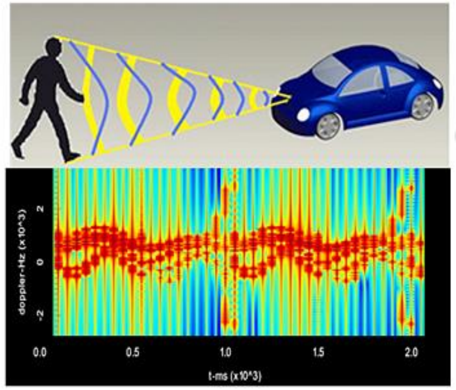


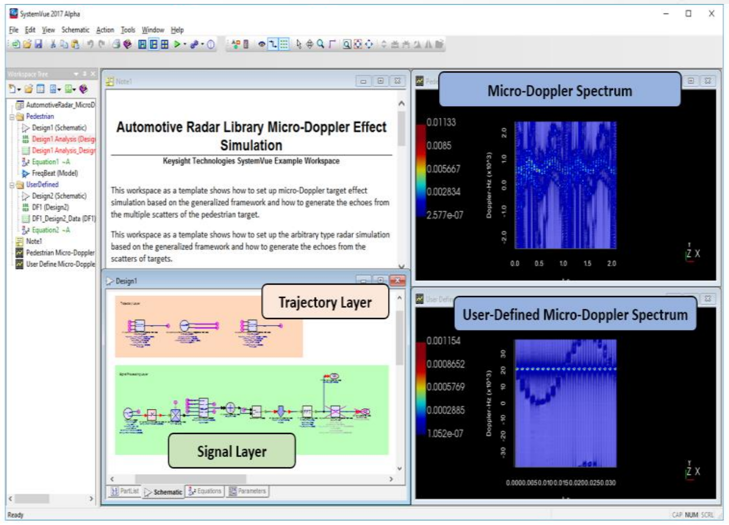
Automotive Radar Design Simulation

MICRO-DOPPLER

- Using the micro-Doppler spectrum distribution to distinguish the targets from pedestrian or vehicle
- Pedestrian target has more sub parts like arm, leg, head, neck, and torso with different instantaneous velocity
- The arms and legs move periodically in walking; the Doppler spectrum is changing periodically in time
- A common scenario model with
  - Pre-defined walking passenger
  - Pre-defined running passenger
  - Pre-defined moving car
  - Custom scenario with customized trajectory
- 10+ scatters for a walking passenger
- Accurate modeling for moving trajectory for each scatter
- Reference radar data processing to identify micro-Doppler signature of the walking passenger



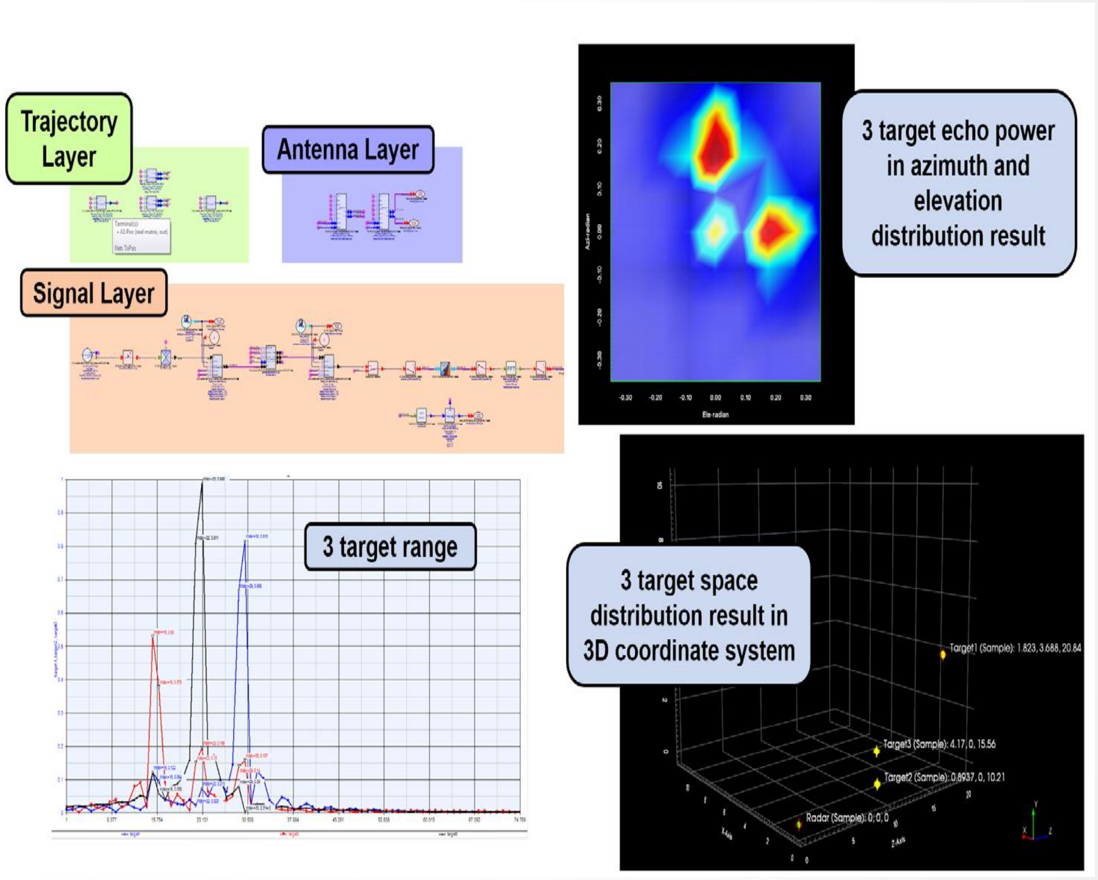




Automotive Radar Design Simulation

3D AUTOMOTIVE RADAR SCAN

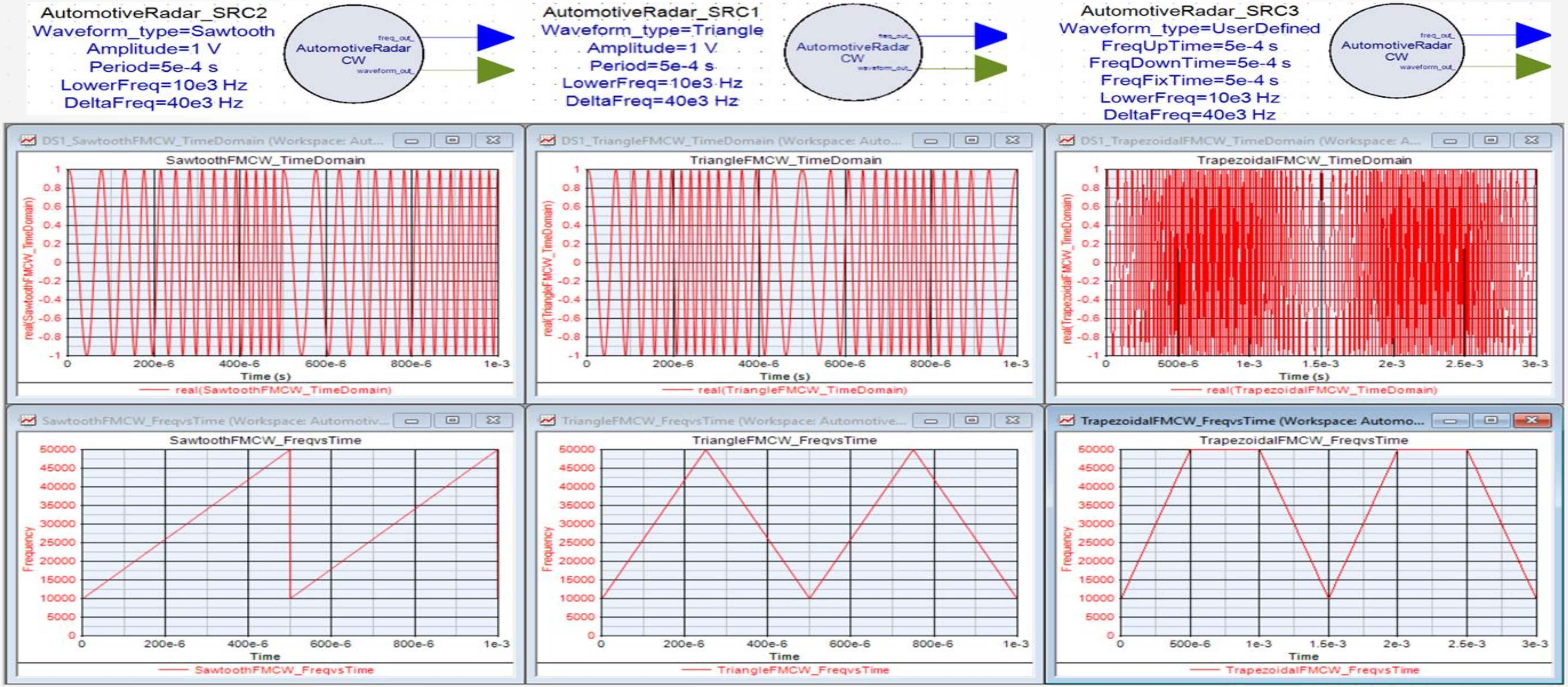
- Needed target elevation angle information
  - Azimuth angle as well as range and velocity
- 3D Automotive radar scan
  - Leveraging 2D scan system, additional elevation region scan is needed
  - With MN planer array, the spaces can be divided into azimuth, elevation, and angle grids to realize and visualize 3D scan
- Designers can obtain the various simulation results in numeric, sliced 2D and 3D space distribution in SystemVue



Creating 3D scan scenarios with platform and target position, velocity, target RCS and more parameters, designers can visualize the results in various traces and distribution plots.

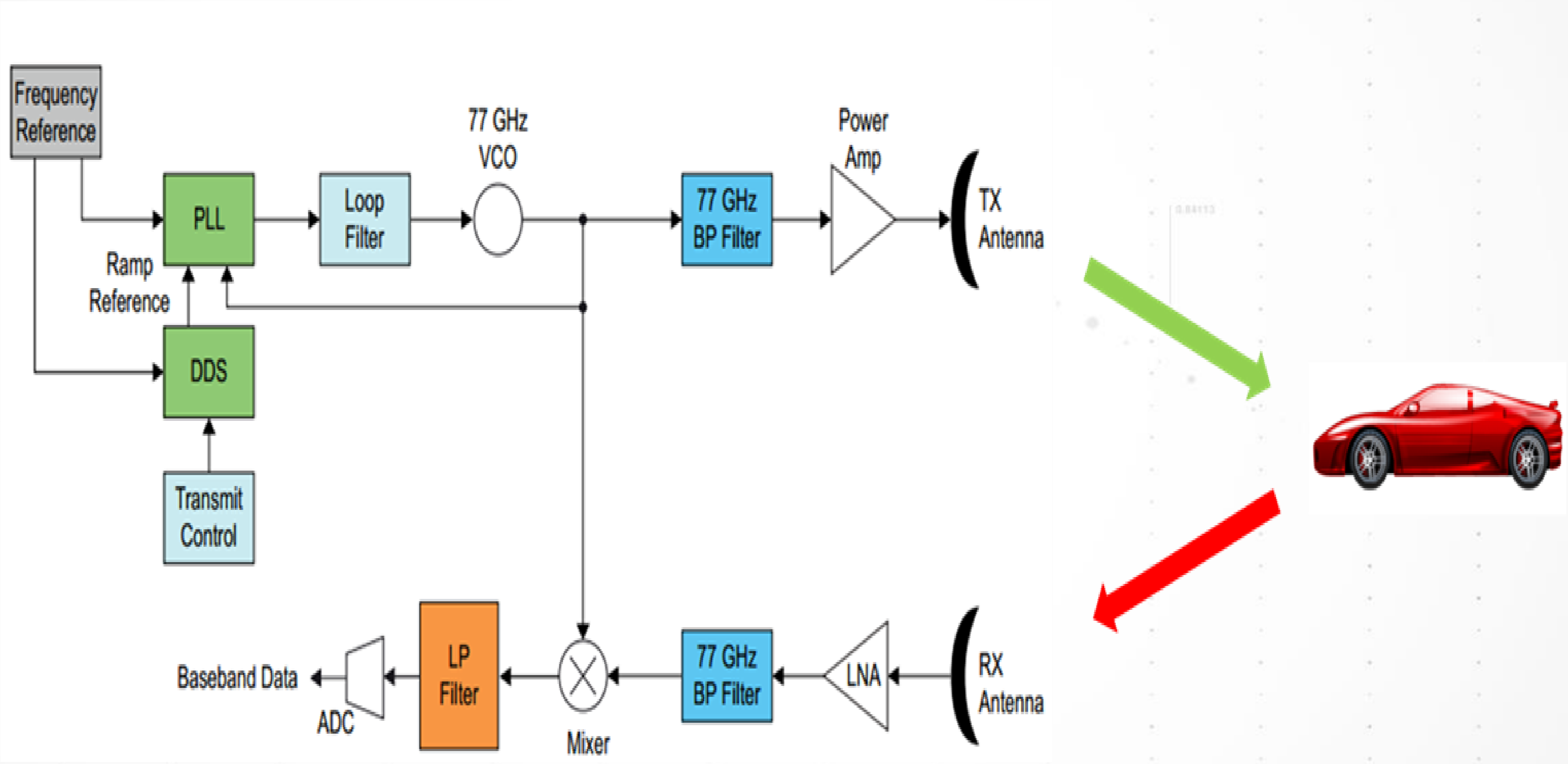
Automotive Radar Simulation

FLEXIBLE AUTOMOTIVE RADAR SIGNAL GENERATION WITH SYSTEMVUE



Automotive Radar Development

MILLIMETER WAVE TEST SET UP EXAMPLE



Automotive Radar Development

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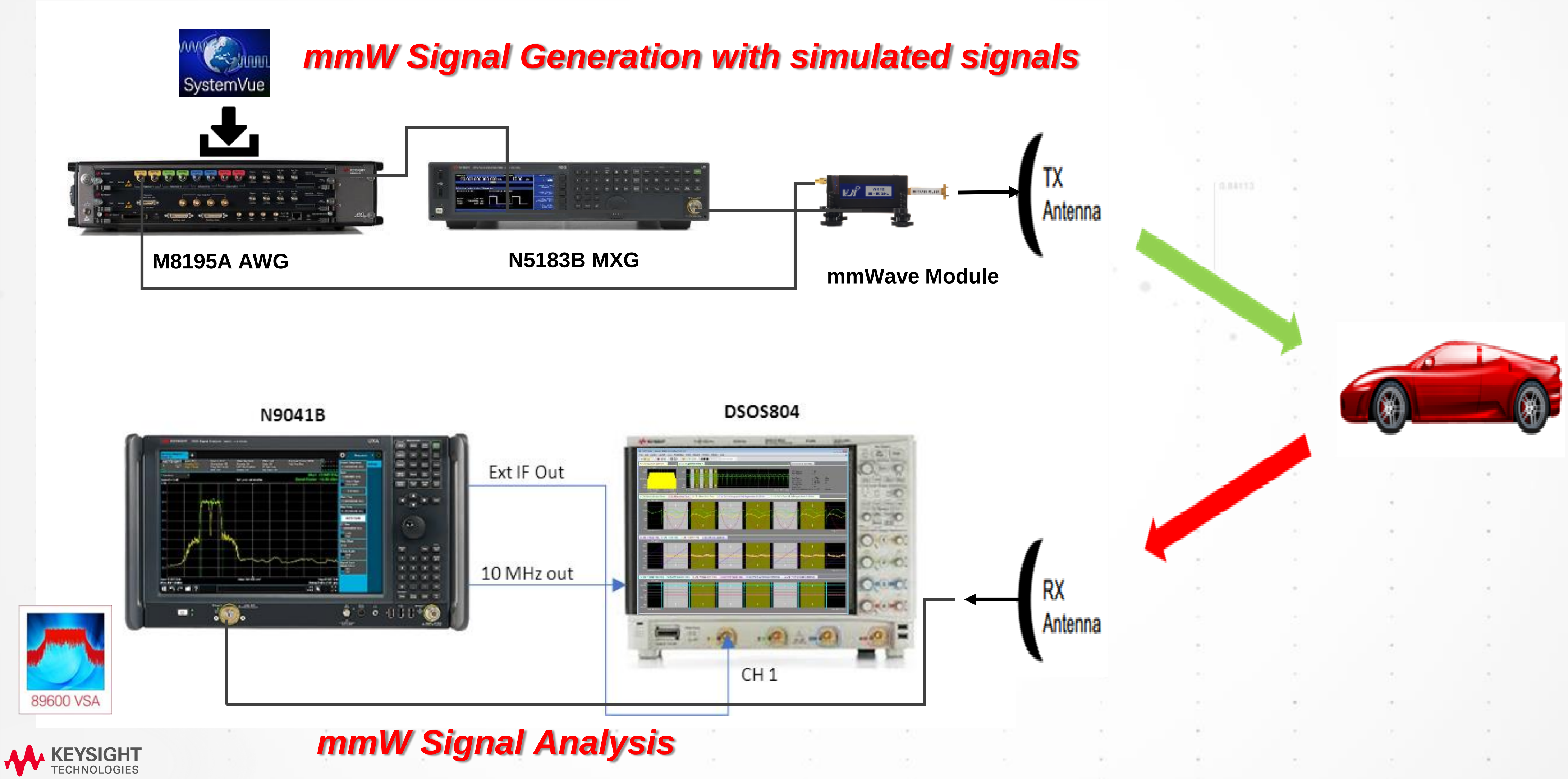
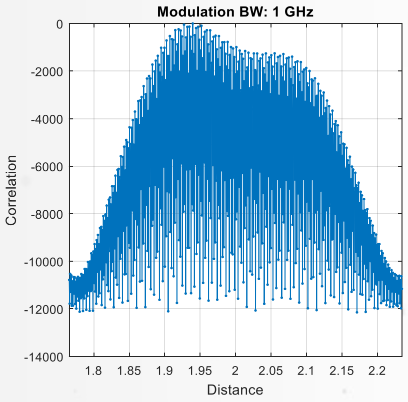
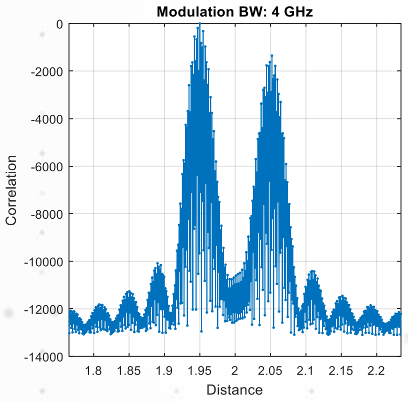


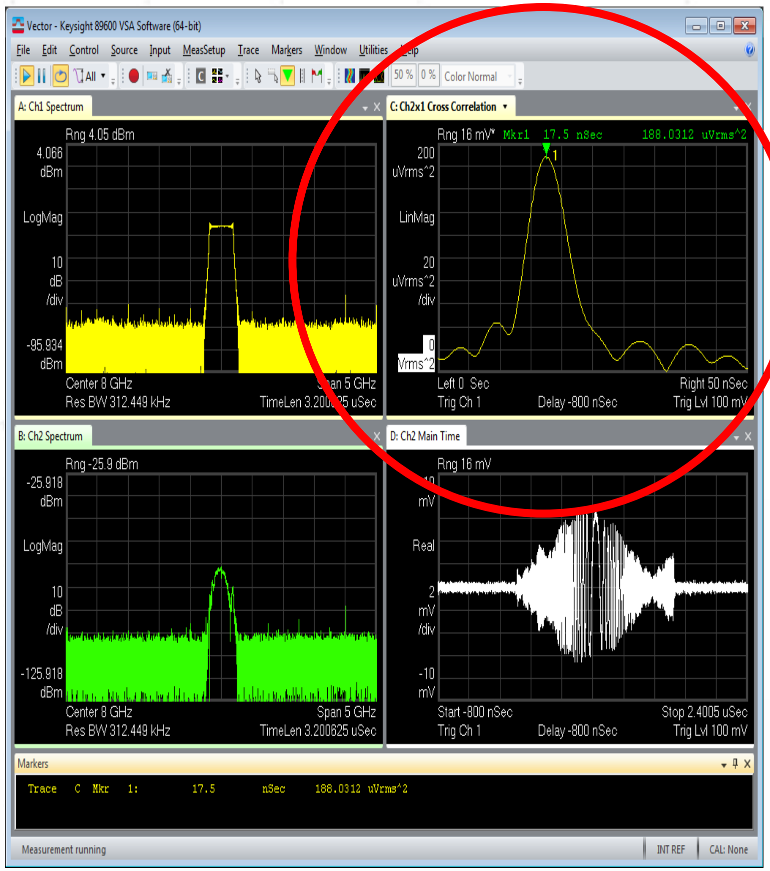
Automotive Radar Development

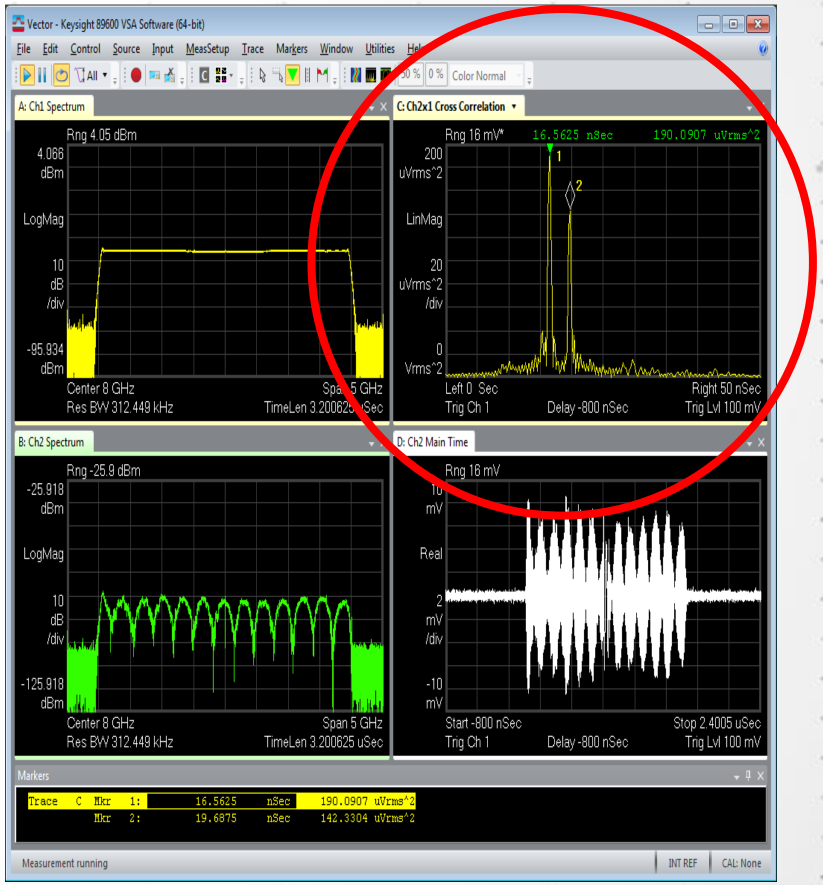
SIMULATION AND TEST RESULTS

- Two objects, 10 cm apart, FMCW, 1 GHz and 4 GHz modulation bandwidths
- Simulation result (left) and Measurement result (right)







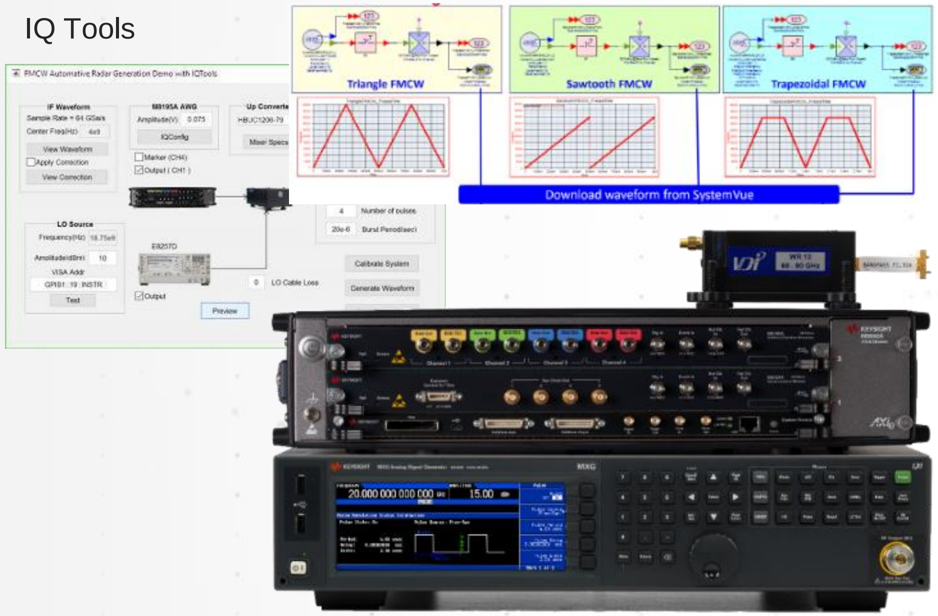


Automotive Radar Development

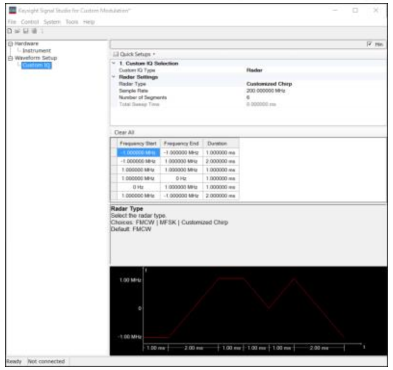
FLEXIBLE AND COMPLEX MODULATION SIGNAL GENERATION

IQ Tools

W1908 SystemVue Auto Radar Library



N7608C Signal Studio



Parameters	E8740A-070 Performance SG
Frequency Range	DC to 25GHz, 60GHz to 90GHz
Signal Bandwidth for IF/RF	IF/RF up to 25GHz
3dB Bandwidth for mmW	5GHz for FMCW @ 79GHz Fc (with correction)
Pout1dB	-14.6dBm@76GHz -13.5dBm@79GHz
Amplitude flatness (at SMA connector,* compensated for sin(x)/x)	±2 dB (typ), fout= DC to 10 GHz +2 dB, -3 dB (typ), fout = 10 to 25 GHz (typ)
Amplitude resolution	200uV (nom)
DAC resolution	8Bit
AWG Sample rate	13.44 GSa/s to 65GSa/s
Sample Memory (Internal / extended)	1 MSa / 16GSa
Frequency Switching time	505us / 38ps (opt FSW)
MIMO and beam forming	Expandable to 16 synchronized channels
mmW Modulation signals	FM, PM, FMCW, pulse sequence, MFSK, custom OFDM,……

*Measured at Data Out.

Key Features

- Download Radar FMCW signals from either: SystemVue, *IQ Tools, Signal Studio, or others*
- Generate ideal reference signals (replace Tx LO / VCO)
- Generate interferer, clutter, jamming test signals (Rx Test)

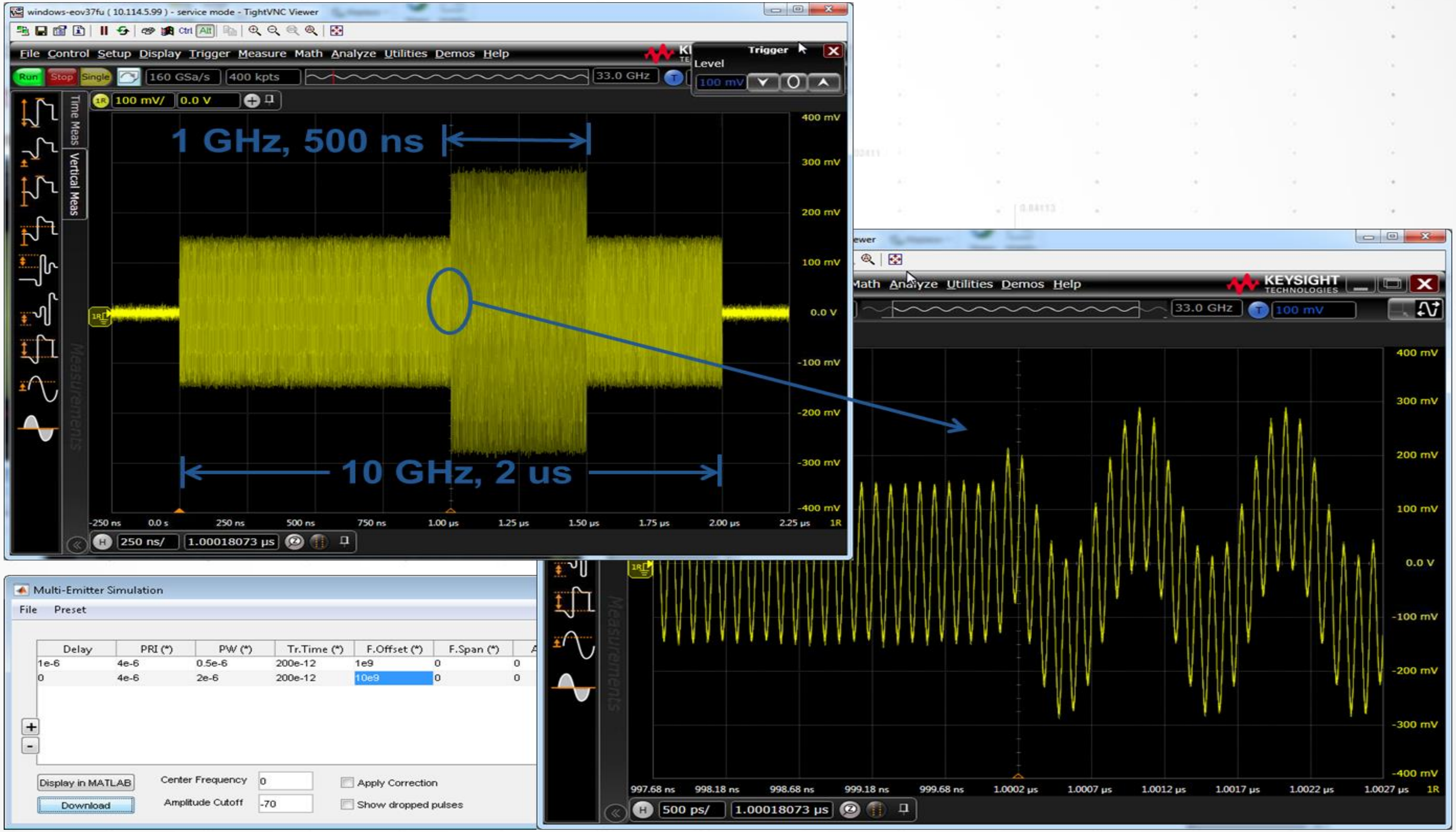
Automotive Radar Development

BENEFITS OF HIGH-SPEED ARBITRARY WAVEFORM GENERATOR

High Speed AWG functionality	Benefit for Radar Testing
Extremely **wide modulation bandwidth** (e.g. DC to 32 GHz)	**Discern targets** that are close together **Finer resolution** of a given object
Instantaneous **frequency hopping** **Overlapping pulses** at different frequencies	**Realistic simulation** of multiple emitters that are transmitting simultaneously
Phase-coherent, **multi-emitter, multi-channel** pulse generation	**Economical setup** to for testing multi-channel radar receivers (e.g. DOA)
Repeatable phase from pulse-to-pulse and channel-to-channel, perfect frequency ramps	**Repeatable** test results
Flexible modulation formats	Develop new modulation schemes that are more **tolerant to interference**
No **images** or **carrier feedthrough.** **Flat magnitude- and phase response** (after calibration)	Testing your device and not the instrument!

Automotive Radar Development

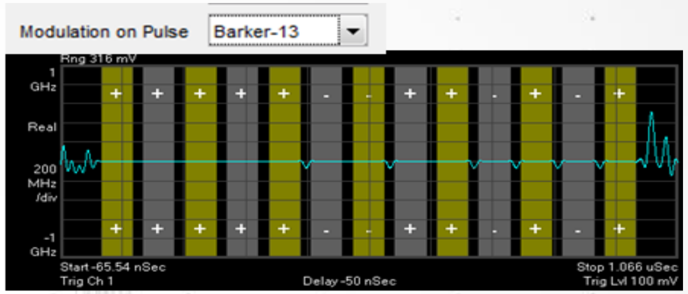
OVERLAPPING PULSES AT DIFFERENT FREQUENCIES

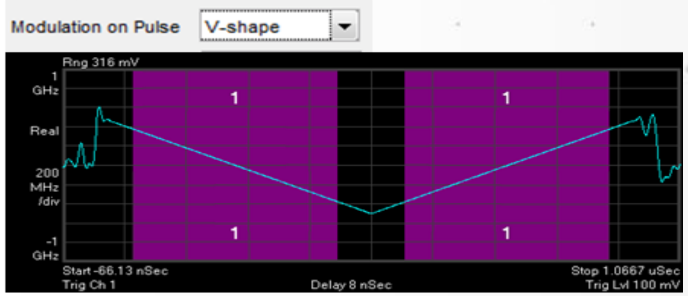


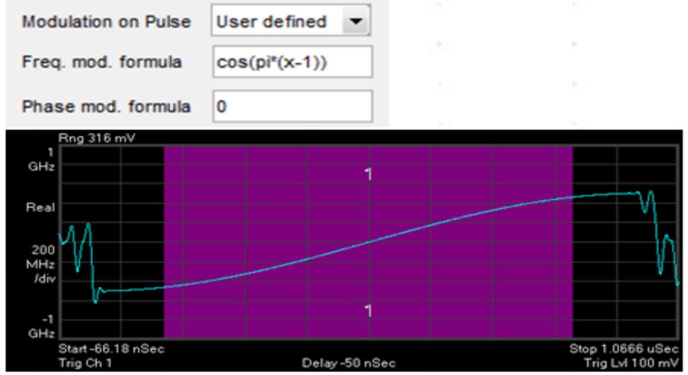
Automotive Radar Development

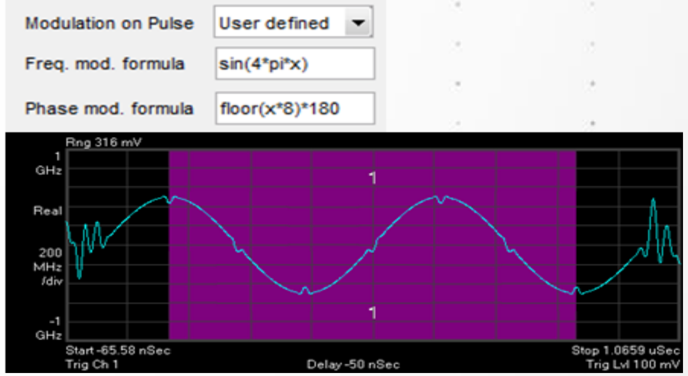
FLEXIBLE MODULATION FORMATS

- Any mathematical expression can be used to describe the modulation on the pulse including CW, FMCW, LFM chirp, Barker, non-linear chirp, user-defined frequency- and phase modulation









Automotive Radar Development

INDUSTRY'S MOST POWERFUL AUTOMOTIVE RADAR SIGNAL ANALYSIS

E8740A-060 Performance SA

Key Features

With N9041B UXA

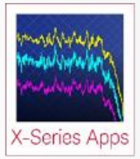
- Continuous Freq sweep 3Hz~ 110GHz
- 5GHz BW (with external oscilloscope)
- Up to 1GHz internal BW with adding opt H1G
- -150dBm/Hz DANL up to 110 GHz
- Dual input rugged 2.4mm and 1mm connector
- 50M RBW with adding opt H1G and opt RBE
- RF Power, Harmonic and spurious, Spectrum Emissions, OBW, Frequency Stability
- Phase Noise with N9068C
- Noise Figure with N9069C and opt P50 at input port 1 (up to 50GHz)

With DSOS804A Scope and VSA s/w

- 10 Bit ADC up to 8GHz bandwidth with minimum resolution : 0.781 mV) 4x better resolution than RTO 8 bit ADC
- Analog/Digital I/Q input

Key Measurements

- RF Power
- Spectrum Emissions
- Phase Noise
- Frequency Stability
- Modulation Quality



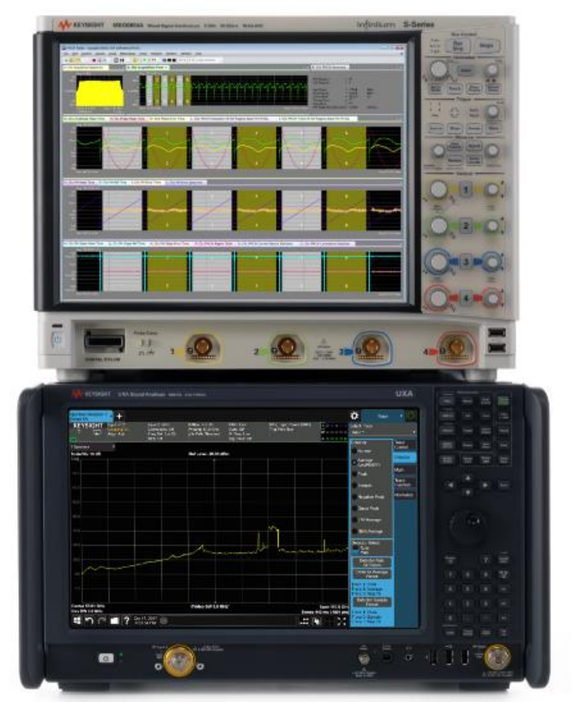
1st — 3 Hz - **110 GHz** Continuous sweeps

1st — **5 GHz BW** (with external oscilloscope)

1st — Up to **1 GHz** **internal** BW

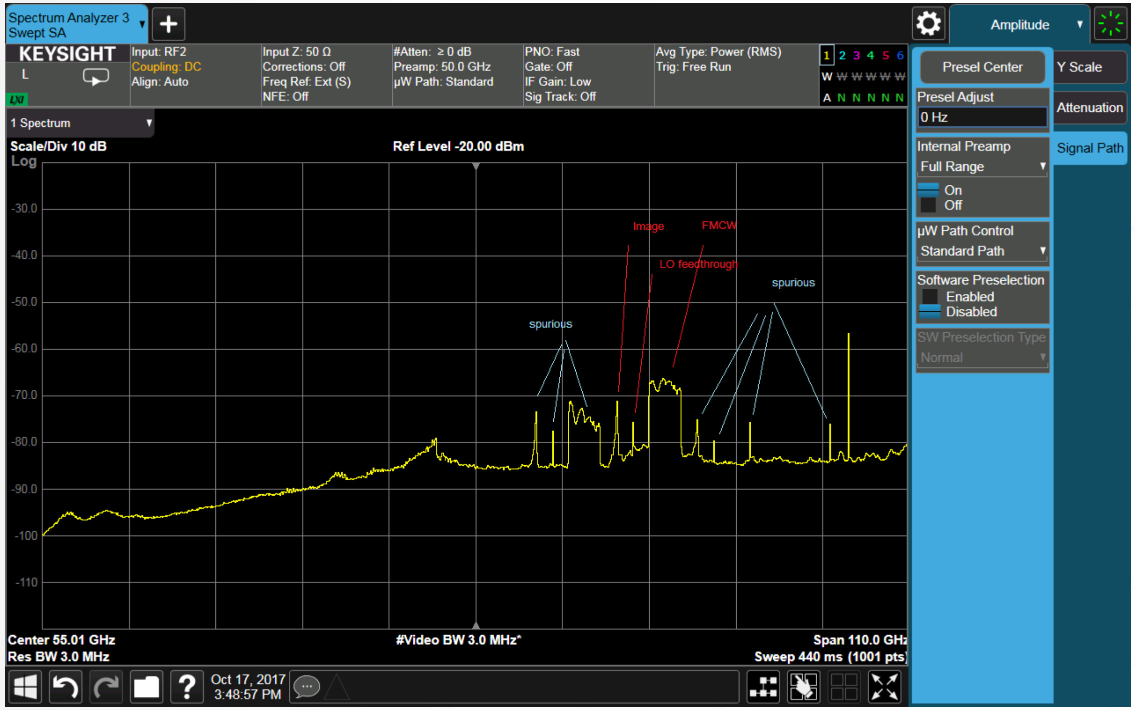
1st — **-150 dBm/Hz** DANL up to 110 GHz

1st — Dual input **rugged 2.4 mm** and 1 mm connector

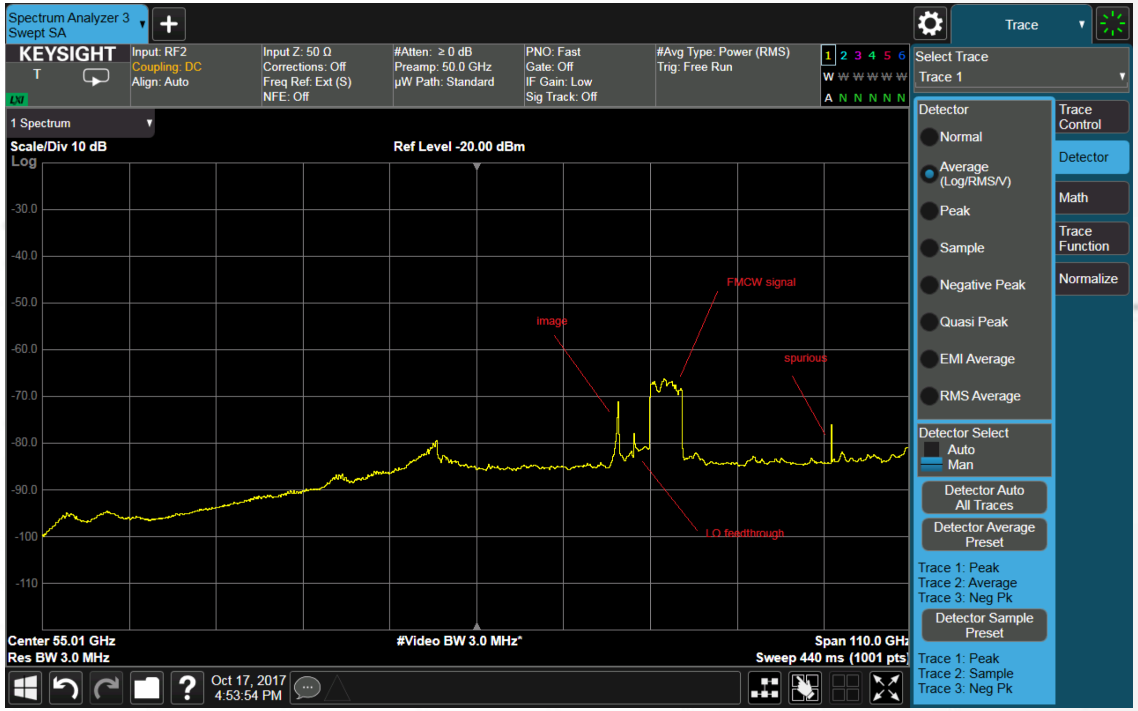


Automotive Radar Development

EFFECT OF SOFTWARE PRE-SELECTOR



FMCW spectrum without software pre-selector



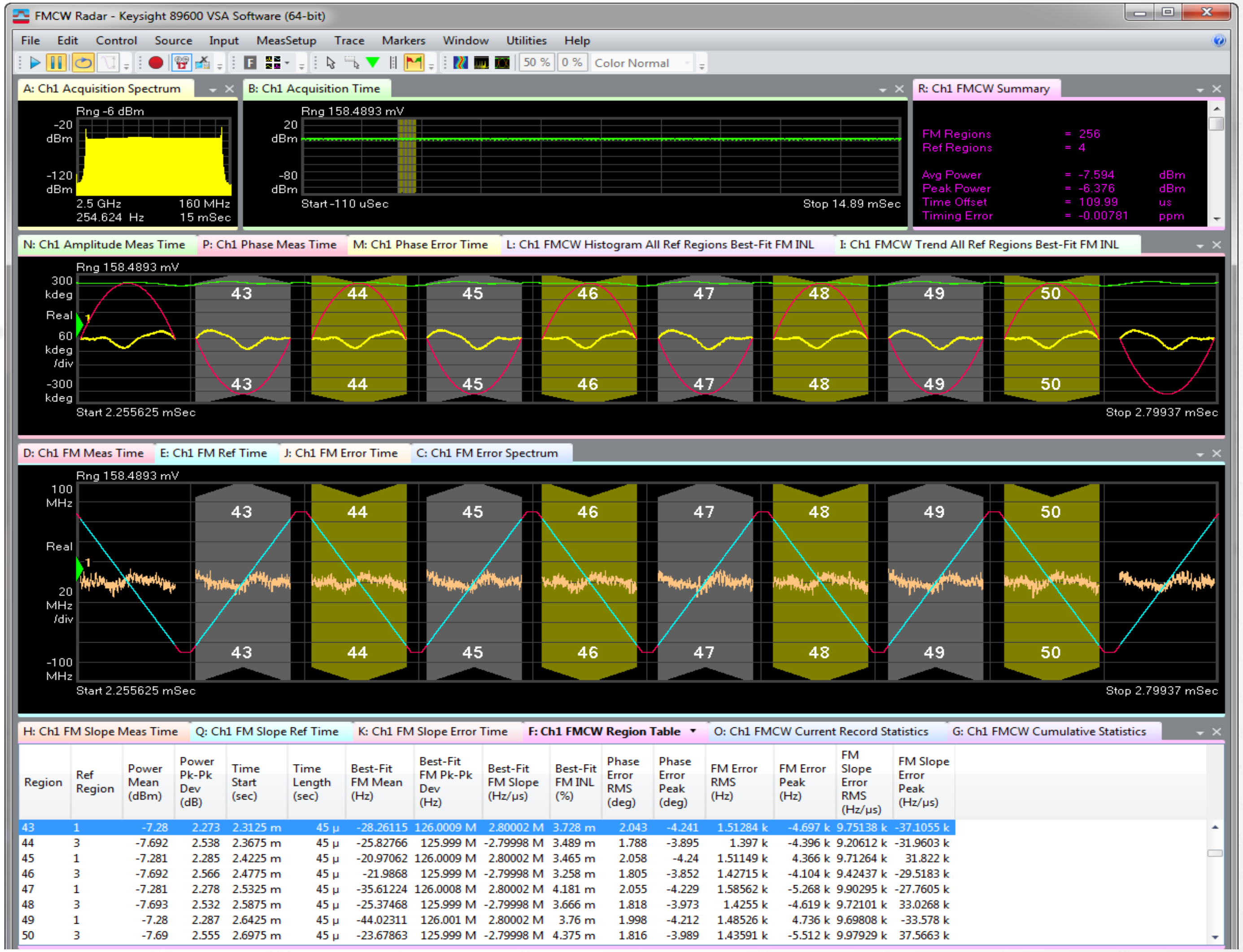
Observed FMCW signal and spectrum with software pre-selector ON

Automotive Radar Development

FLEXIBLE FMCW SIGNAL ANALYSIS IN SPECTRUM & TIME DOMAINS

89600 VSA Key Features:

- **Automatically synchronize** to **FMCW radar signals** comprised of multi-chirp linear FM modulation patterns.
- Synchronized **Amplitude** & **Phase**
- Synchronized **Frequency (FM)** Modulation
- FMCW Region Tabular metrics
  - **Power** and **Time**
  - **Best-Fit FM**
  - **Phase Error**
  - **FM Error**
  - **FM Slope Error**

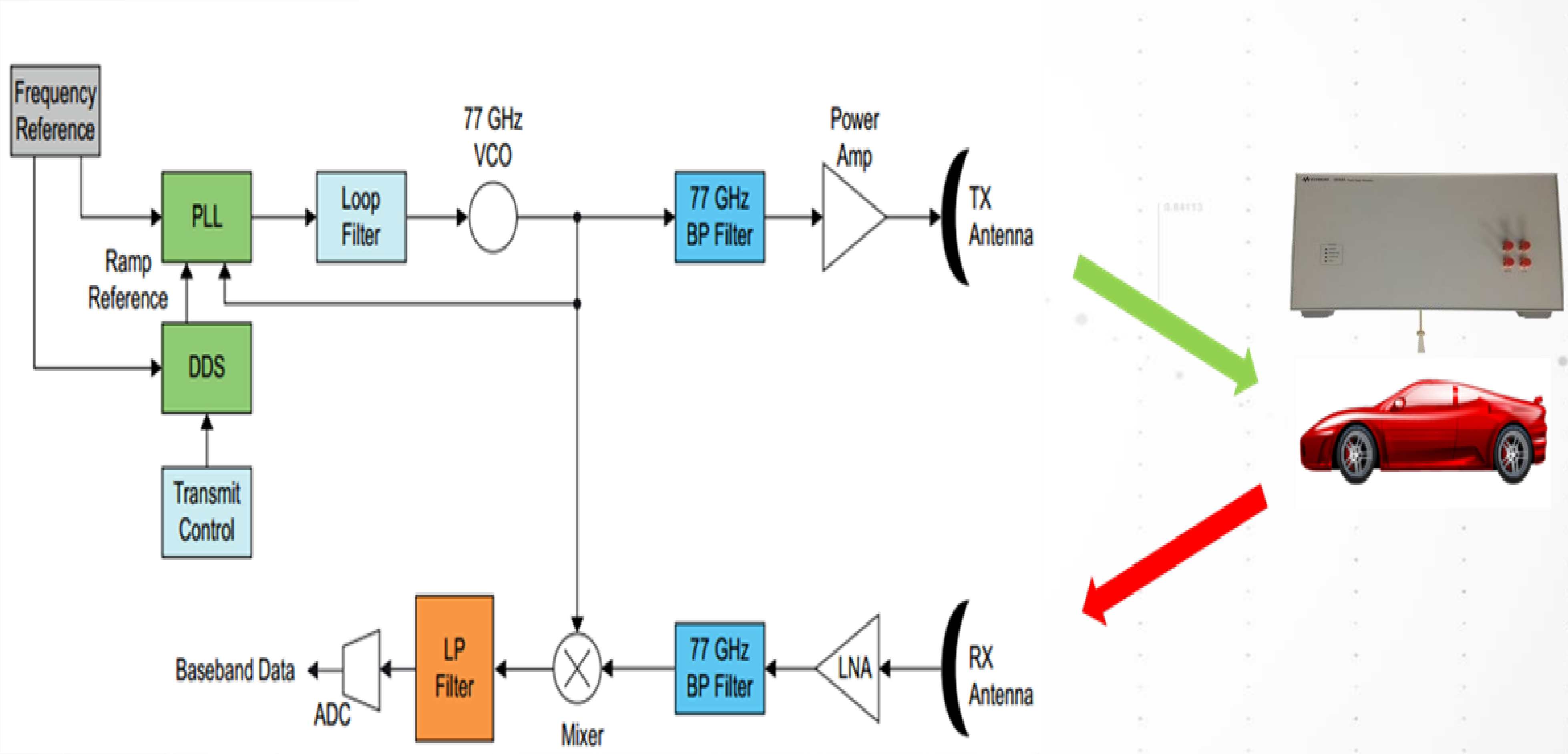


Region	Ref Region	Power Mean (dBm)	Power Pk-Pk Dev (dB)	Time Start (sec)	Time Length (sec)	Best-Fit FM Mean (Hz)	Best-Fit FM Pk-Pk Dev (Hz)	Best-Fit FM Slope (Hz/μs)	Best-Fit FM INL (%)	Phase Error RMS (deg)	Phase Error Peak (deg)	FM Error RMS (Hz)	FM Error Peak (Hz)	FM Slope Error RMS (Hz/μs)	FM Slope Error Peak (Hz/μs)
43	1	-7.28	2.273	2.3125 m	45 μ	-28.26115	126.0009 M	2.80002 M	3.728 m	2.043	-4.241	1.51284 k	-4.697 k	9.75138 k	-37.1055 k
44	3	-7.692	2.538	2.3675 m	45 μ	-25.82766	125.999 M	-2.79998 M	3.489 m	1.788	-3.895	1.397 k	-4.396 k	9.20612 k	-31.9603 k
45	1	-7.281	2.285	2.4225 m	45 μ	-20.97062	126.0009 M	2.80002 M	3.465 m	2.058	-4.24	1.51149 k	4.366 k	9.71264 k	31.822 k
46	3	-7.692	2.566	2.4775 m	45 μ	-21.9868	125.999 M	-2.79998 M	3.258 m	1.805	-3.852	1.42715 k	-4.104 k	9.42437 k	-29.5183 k
47	1	-7.281	2.278	2.5325 m	45 μ	-35.61224	126.0008 M	2.80002 M	4.181 m	2.055	-4.229	1.58562 k	-5.268 k	9.90295 k	-27.7605 k
48	3	-7.693	2.532	2.5875 m	45 μ	-25.37468	125.999 M	-2.79998 M	3.666 m	1.818	-3.973	1.4255 k	-4.619 k	9.72101 k	33.0268 k
49	1	-7.28	2.287	2.6425 m	45 μ	-44.02311	126.001 M	2.80002 M	3.76 m	1.998	-4.212	1.48526 k	4.736 k	9.69808 k	-33.578 k
50	3	-7.69	2.555	2.6975 m	45 μ	-23.67863	125.999 M	-2.79998 M	4.375 m	1.816	-3.989	1.43591 k	-5.512 k	9.97929 k	37.5663 k

KEYSIGHT TECHNOLOGIES

Automotive Radar Manufacturing

SOLUTION



Introduction - Radar Target Simulator

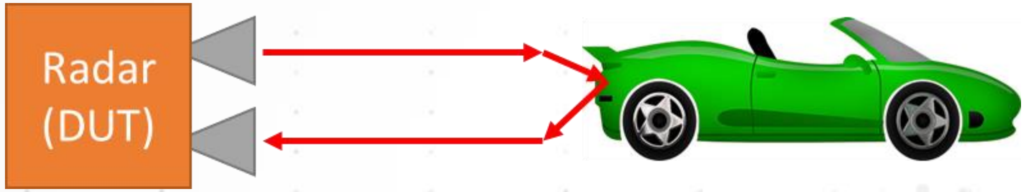
HIGH FREQUENCY & WIDE BANDWIDTH MILLIMETER WAVE (77/79 GHZ)

- How we understand the market today:
  - Automotive radar is fast evolving, while the short-range-radars (SRR) are evolving from 24GHz to 79GHz, there is also the long-range-radars (LRR) at 77GHz
    - Some are not yet invested in 79GHz and have a huge 24GHz capacity, some are just getting into 24GHz
    - Those investing into 77GHz LRR, are looking to maximize capital expenditure to 79GHz SRR
      - But 77GHz required < 1GHz of bandwidth, and 79GHz is demanding for 4GHz bandwidth
      - SRR required a lower simulated distance, as low as the RTS can go
  - As we discussed with more manufacturing customers, it is apparent that more are leaning towards an analog method of testing
    - Regulatory requirements (eg. European Standards Organization (ETSI), and Federal Communications Commission (FCC)) defining bandwidth, power levels, interference testing methods
      - For bandwidth a full 4GHz sweep is expected vs interpolation
    - Analog method was more direct in revealing DUT failures

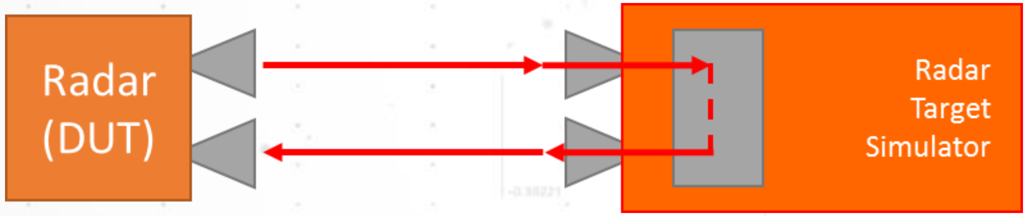
Introduction - Radar Target Simulation

BASICS

- Below, is a representation of a Radar unit functionality



- Now we replace the car with a Radar Target Simulator



1 meter min. physical distance

Basic Functionality

1) Radar DUT signal is received
2) Signal is manipulated in the Radar Target Simulator
3) Signal is then re-transmitted back to the Radar DUT

Radar Target Simulator will apply…	to simulate…
Time delay	Range (Distance)
Doppler Frequency Shift	Radial Velocity (Speed)
Attenuation	Radar Cross Section (Object Size)

Introduction - Radar Target Simulator

RADAR TARGET SIMULATOR (RTS) BENEFITS

E8708A

Radar Target Simulator

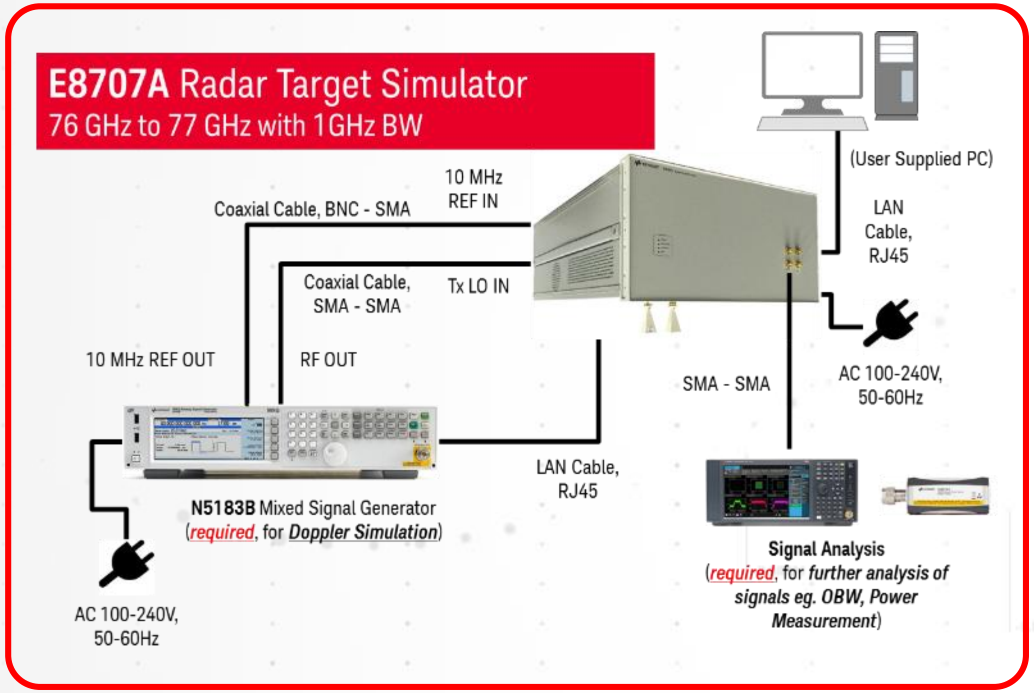
- Wide simulated range coverage with ***minimum distance starting from 4m***
- ***4GHz*** Bandwidth support wide range of module without the need of changing center frequency
- ***Scalable*** for both Manufacturing and Verification test
  - Basic – Fixed range simulation (eg. 75m & 150m)
  - Comprehensive – Full range, RCS, Doppler & DUT Transmit Power
- ***Reliable***, ***accurate*** and ***repeatable*** performance
- ***Ease of use GUI*** and ***API*** where all parameters controllable in ***C++ & C# programming environment***
- Designed, manufactured and ***supported by Keysight Technologies***
- ***World wide support***, calibration and warranty
  - Default 1 years factory warranty, optional 3 and 5 year warranty
  - Optional upgrade with on-site calibration and support packages
- CE and Safety certified

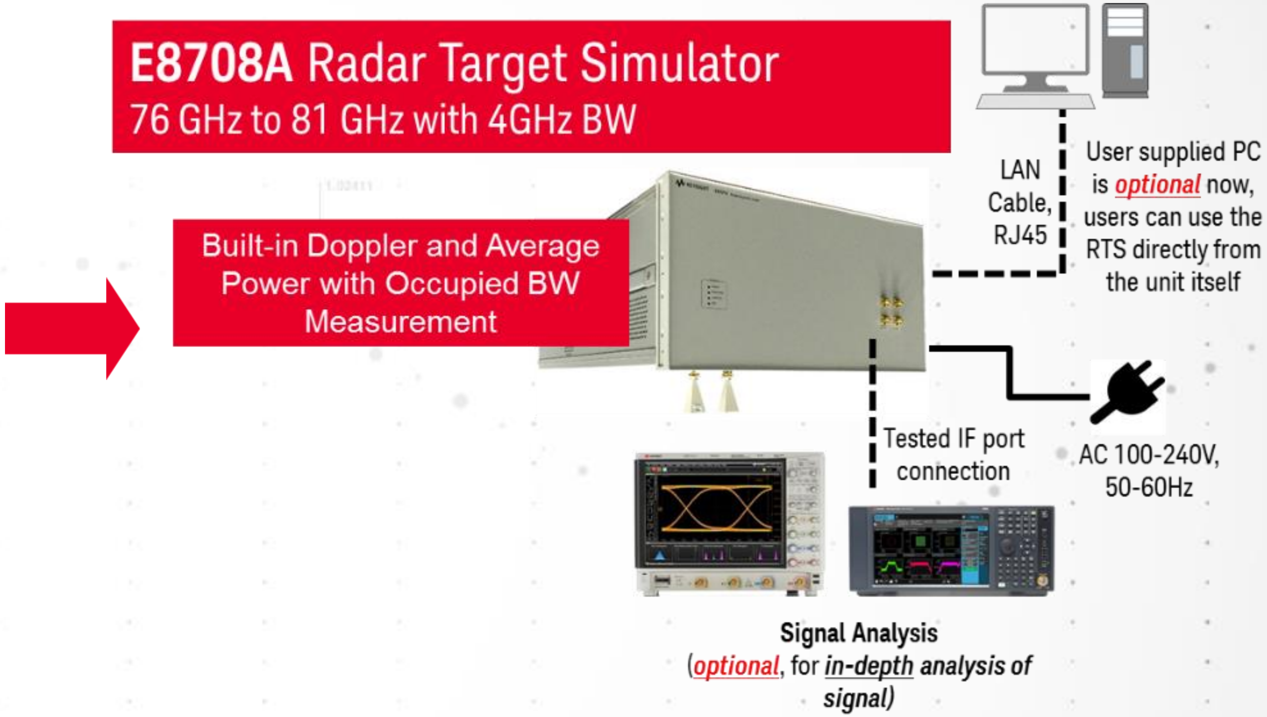
Key Product Specifications

Performance	Specifications
Frequency Range	76 – 81 GHz
Instantaneous Bandwidth	4 GHz
Min. target distance	4 m (1m physical + 3m simulated)
Max. target distance	300 m
Distance step	0.1m
Doppler shift range	+/- 360km/h with 0.1km/h resolution
Transmit/Receive Gain Control (object target size) 4m 300m	61.5 dB with 0.5 dB step -32dBsm to 30dBsm (typical) 43dBsm to 105dBsm (typical)
Spurious	-35dBc
Phase Noise	-90dBc/Hz @ 10kHz
Max. Input Power	-13 dBm at RF In Flange
Recommended Input Power	-20dBm at RF In Flange
Min. Input Power	-65dBm at RF In Flange
Max. target distance	300 m
RF In to 'IF OUT 1' Conversion Loss	-5dB (typical)
RF IN to 'IF OUT TO SA' Conversion Loss	+5dB (typical)

Keysight E8708A Radar Target Simulator

IMPROVEMENTS OF NEW SYSTEM





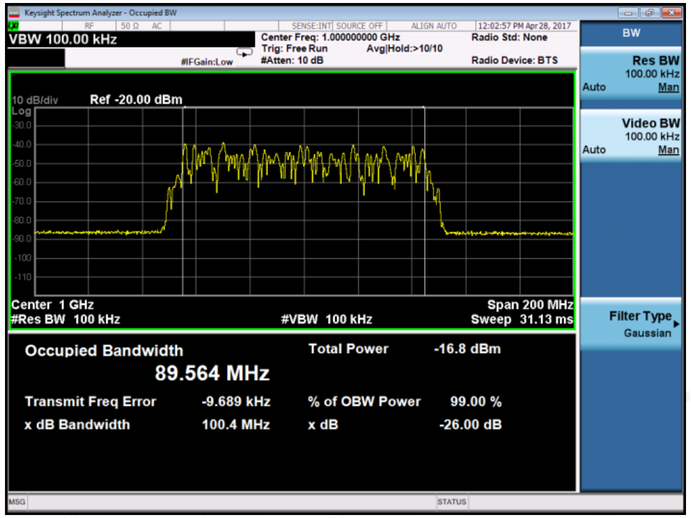
- **New option!** Built-in signal analyzer for ***Occupied Bandwidth Measurement*** and ***Power Measurement***
  - No need for external Signal Analyzer outside, ***only if*** customers need in-depth analysis of their DUT radar signal
- **Doppler simulation included**
  - No need for external Signal Generator

Introduction - Radar Target Simulator

IN-BUILT RF POWER MEASUREMENT (PRE-LIM)

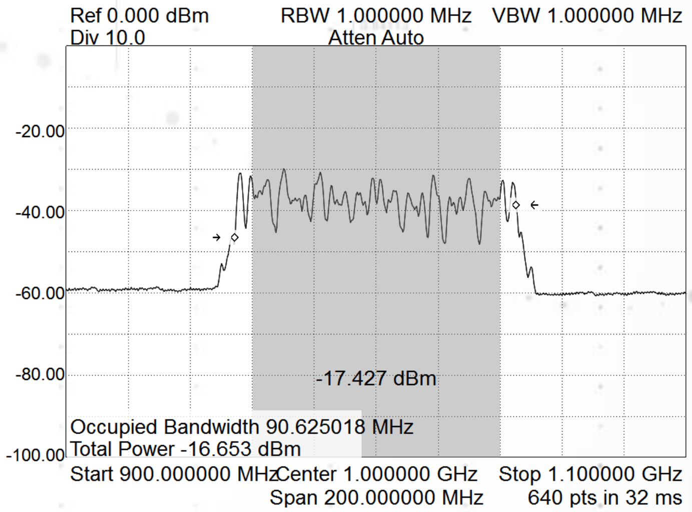
- Built-in signal analyzer for ***Occupied Bandwidth Measurement*** and Power Measurement
  - Below is a comparison between Keysight's N9000B CXA and the analyzer built into the RTS

Keysight N9000B CXA



OBW = 89.564 MHz

Keysight E8708A integrated SA



OBW = 90.625 MHz

Test Conditions

Test Signal Type : Linear FM Chirp 1GHz
Power Level : 0 dBm
Signal Source : Keysight ESG E4438C

SA Settings

Center Freq	: 1 GHz
SPAN	: 200 MHz
RBW	: 100 kHz
VBW	: 100 kHz

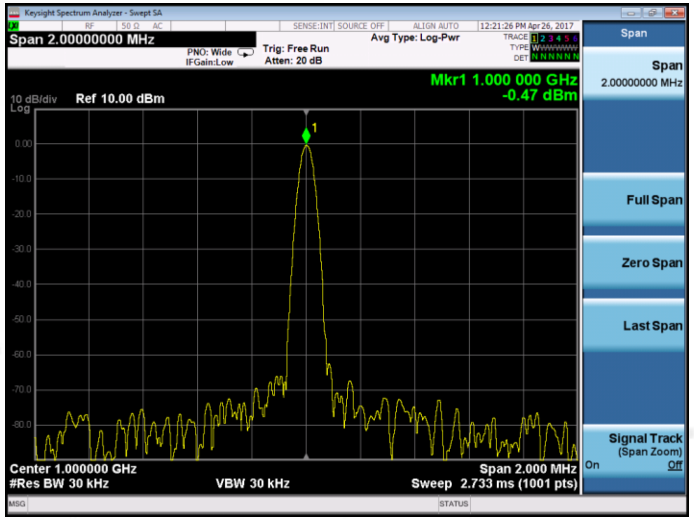
Note: Preliminary results from the initial investigation

Introduction - Radar Target Simulator

IN-BUILT RF POWER MEASUREMENT (PRE-LIM)

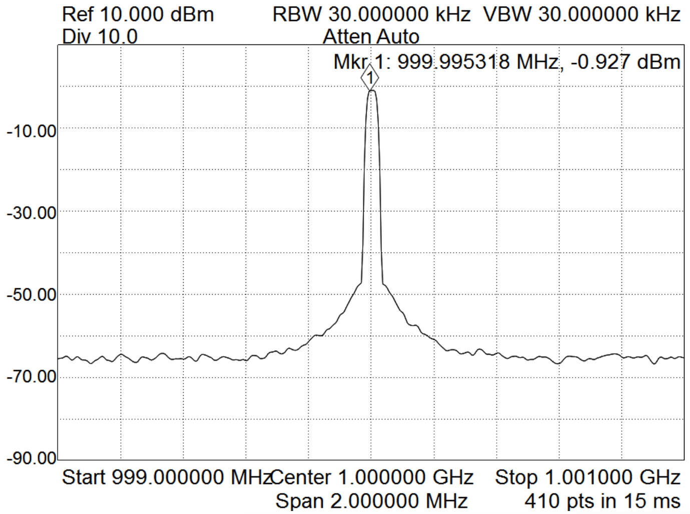
- Built-in signal analyzer for Occupied Bandwidth Measurement and ***Power Measurement***
  - Below is a comparison between Keysight's N9000B CXA and the analyzer built into the RTS

Keysight N9000B CXA



RF Power = -0.47 dB

Keysight E8708A integrated SA



RF Power = -0.93 dB

Test Conditions

Test Signal Type : CW 1 GHz
Power Level : 0 dBm
Signal Source : Keysight ESG E4438C

SA Settings

Center Freq	: 1 GHz
SPAN	: 2 MHz
RBW	: 30 kHz
VBW	: 30 kHz

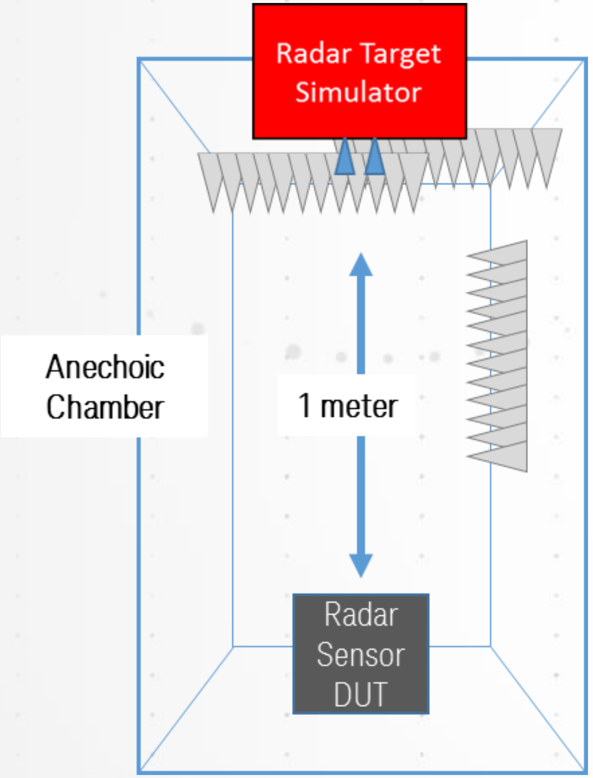
Note: Preliminary results from the initial investigation

Introduction - Radar Target Simulator

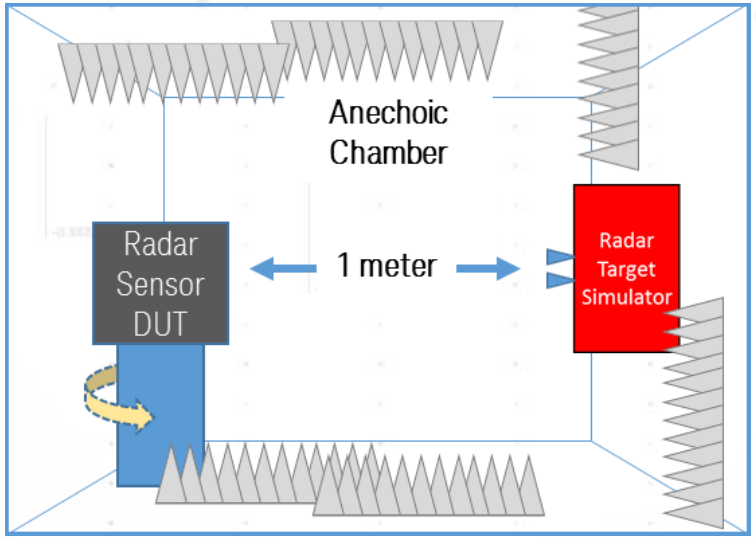
RADAR TARGET SIMULATOR (RTS) SETUP OVERVIEW

- Minimum physical distance of 1m, minimizing space requirements
- The RTS works standalone, or can be connected remotely via LAN for control or monitoring

Vertical Setup

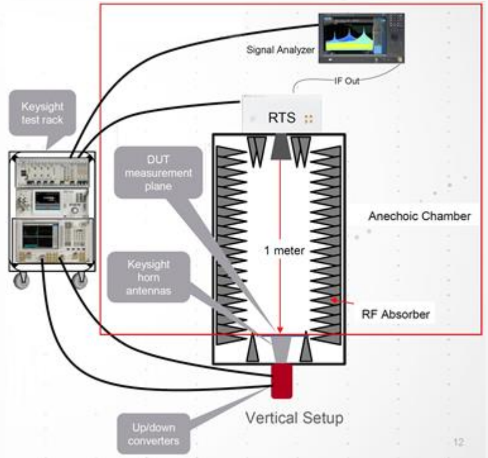


Horizontal Setup



Value Added Service

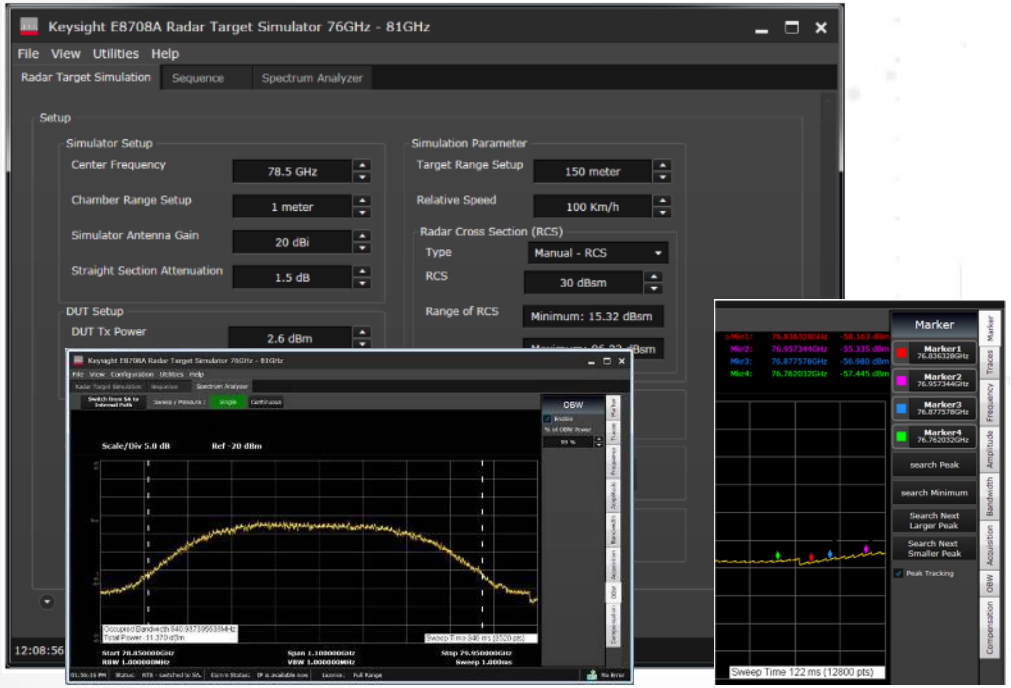
Keysight Calibration services, can automate your chamber calibration, with measurement uncertainty report within an hour!



Introduction - Radar Target Simulator

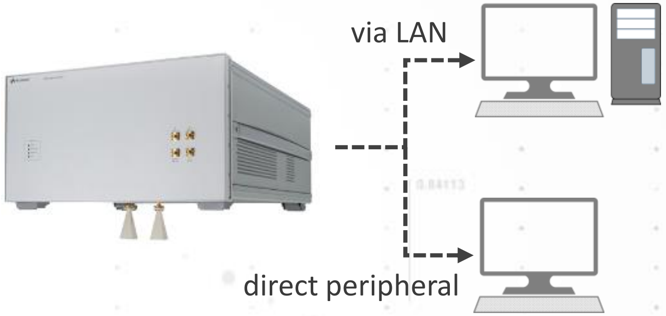
USER INTERFACE AND SOFTWARE CONTROL

Bench Environment

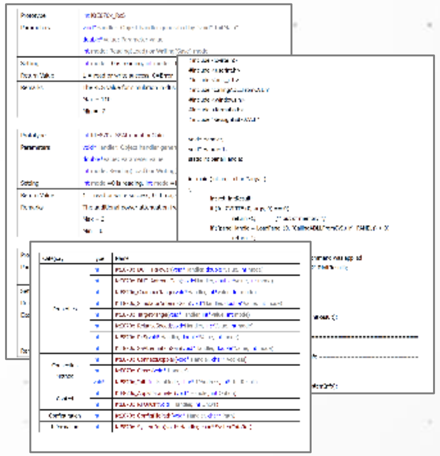


Simple and Ease-of-Use GUI

Manufacturing Environment



Programming Guide



Software API supporting C++ & C# environment

Keysight E8708A Radar Target Simulator

PRODUCT OPTIONS – 76 GHZ TO 81 GHZ VERSION

Description	Range Options	+ Doppler	+ DUT Tx Power & Occupied BW Measurement
Performance Features	• E8708A-D01 Full Delay Module (4m to 300m) • E8708A-D02 2 Fixed Ranges* • E8708A-D03 3 Fixed Ranges* • E8708A-D04 4 Fixed Ranges* * Fixed ranges are customer defined	• +/- 360 km/h with 0.1 km/h resolution • Built-In	• Enable DUT Tx power measurement (EIRP) • OBW measurement • Built-In
Additional Features Options	• Single or Dual Horn Antenna, 25dBi standard (optional 20dBi antenna available) • Positioning Laser		
Support & Warranty	• 1 Years Keysight Factory warranty with calibration certificate valid for 1 year • Optional 1, 3 & 5 years contract ○ Return to Keysight and onsite calibration		

KEYSIGHT TECHNOLOGIES

Automotive Radar Design and Test Lifecycle

SUMMARY

- Advanced automotive radar with millimeter frequency and wide bandwidth are now an indispensable part of Advanced Driver Assistance Systems (ADAS) and autonomous driving vehicles
- Growing demand of advanced technologies, such as 79GHz frequency with 4GHz modulation bandwidth and micro-Doppler to detect and protect pedestrians, has led to new design and test challenges
- Keysight Automotive Radar solutions from early design simulation through Research & Development (R&D) and manufacturing to solve current and future automotive radar design and test challenges

Keysight Solutions

R&D SOLUTIONS FOR AUTOMOTIVE RADAR DESIGN AND ANALYSIS

Signal Analysis Solution

eRF 24GHz 77/79GHz

E8740A-010
Radar RF SA
Leading cost effective Auto Radar RF test tool
- 10 Hz to 26.5 GHz, 60 GHz to 90 GHz
- FMCW RF analysis

RF SQ 77/79GHz

E8740A-020,030
Basic, Basic Plus SA
Optimum choice for Auto radar signal quality test
- 60 GHz to 90 GHz,
- 2.5 GHz BW, >5GHz BW (Basic +) for FMCW Quality analysis

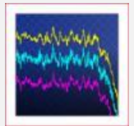
eRF SQ 24GHz 77/79GHz

E8740A-040,050
Advanced, Advanced Plus SA
Benchmark for demanding applications
- 10 Hz to 26.5 GHz, 60 GHz to 90 GHz
- 2.5 GHz BW , >5GHz BW (Advanced +) for FMCW Quality analysis

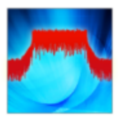
eRF SQ 24GHz 77/79GHz

E8740A-060
Performance SA
Wide-open performance
- 3 Hz to 110 GHz
- >5 GHz BW for FMCW Quality analysis
- DANL-171dBm/Hz@1GHz, -150dBm/Hz up to 110GHz
- 2.4 mm, 1 mm input

X-Series applications
Ready-to-use RF measurements



89600 VSA software
Comprehensive demodulation & vector signal analysis



FMCW Radar Analysis Assistant
E8742A-001 Easy U/I for Downconverter set up and FMCW analysis (VSA utility)

Signal Generation Solution

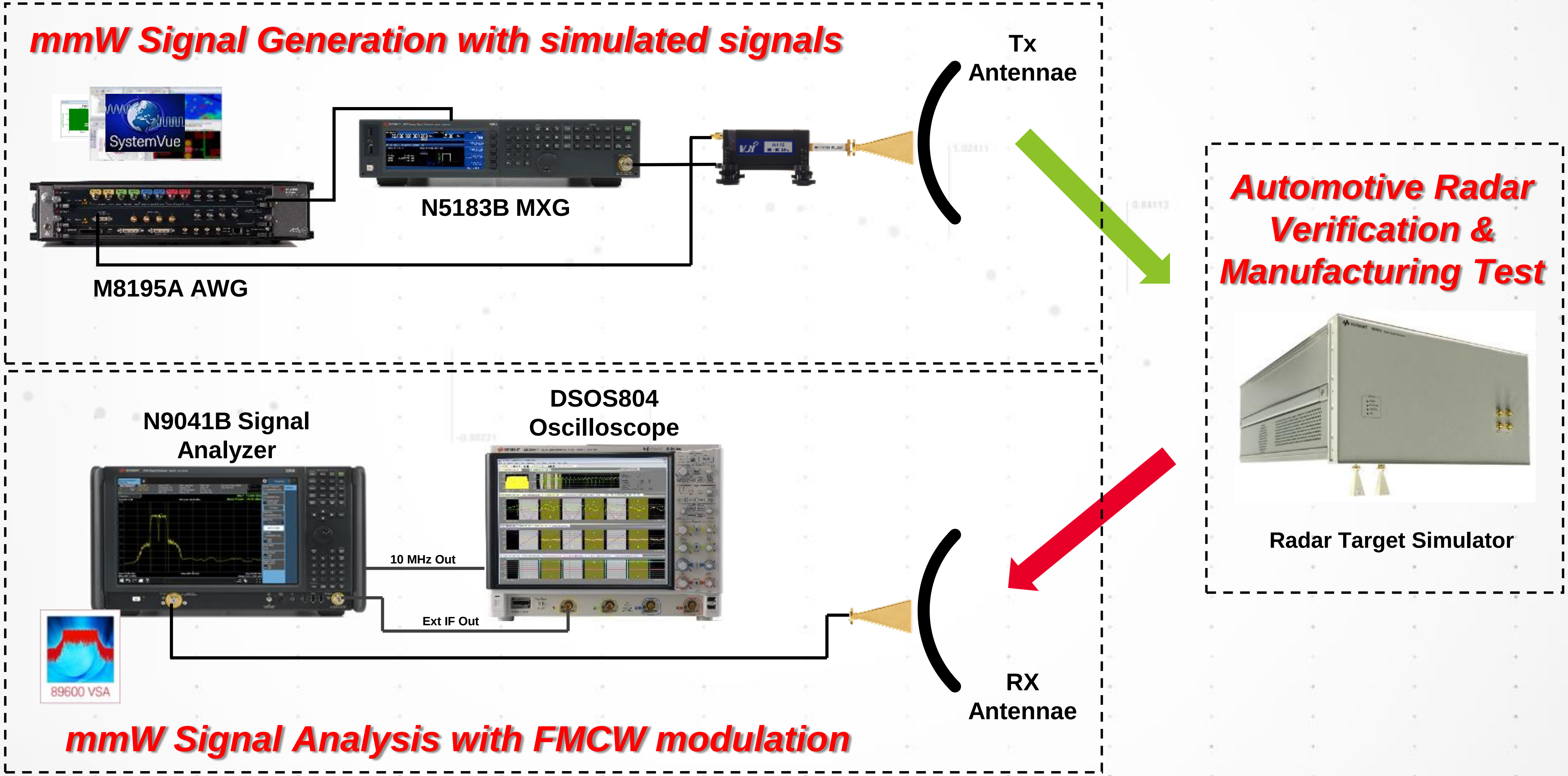
24GHz 76/79GHz

E8740A-070
Performance SG
Wide-open performance
- 60 GHz to 90 GHz
- >5 GHz 3dB BW
- FM, PM, FMCW, pulse sequence, MFSK, customer OFDM
- Linear FMCW Multi-Targets Detection, Automotive radar 3D Scan with systemVue

SystemVue
W1908 Auto radar library measurements
Signal Studio
N7608C Pulse/FCM/FMCW/MFSK signal creation
FMCW Radar Generation Assistant
E8742A-002 Easy U/I for Upconverter set up, FMCW/FCM signal creation and wideband calibration (IQTools utility)

Keysight Solutions

ADDRESSING DESIGN AND MANUFACTURING FOR AUTOMOTIVE RADARS



Automotive Radar Design and Test Lifecycle

FOR MORE INFORMATION

- **Keysight Automotive & Energy website:** www.keysigth.com/find/automotive

- **Next Keysight Automotive Webinar Series**
  - Automotive Ethernet Applications and Test Challenges
  - To Register: https://event.on24.com/wcc/r/1636543/5B1139C469759A34147F104DC4B66707

KEYSIGHT TECHNOLOGIES

Thank you!