The most advanced automotive radar object simulation solution

#### **REALISTIC TESTS ON VIRTUAL ROADS** ACCELERATE YOUR AUTOMOTIVE RADAR TESTING WITH THE MOST ADVANCED SOLUTION

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#### ROHDE&SCHWARZ

Make ideas real





#### COMPANY CONFIDENTIAL

## AGENDA

- ► Introduction
- ► R&S®RTS - R&S®QAT100
  - R&S®AREG800A
- Exemplary configurations
- Summary



## RADAR BASED AUTONOMOUS DRIVING THE SITUATION



## **CUSTOMER CHALLENGES**



Roadworthy prototype required

Limited test capabilities

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OTA stimulation missing

Limited scenario testing



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Advanced Automotive Radar Echo Generation

## ... OUR SOLUTION



OTA stimulation included



Built-in realt-time interface







Signal Generation

Radome Testing



Advanced echo generation

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Static echo generation







Shielded chambers

## **RADAR BASED AUTONOMOUS DRIVING**



## **ADAS / AD RADAR CONFIGURATION - PAST**



## **ADAS / AD RADAR CONFIGURATION - PAST**



## **ADAS / AD RADAR CONFIGURATION - FUTURE**





Make ideas real







### **R&S TOGETHER WITH AVL** A SUCCESSFUL PARTNERSHIP FOR A GAME-CHANGING VIL SOLUTION

## REALISTIC TESTING ON VIRTUAL ROADS

### Part II THE SYSTEM

#### Simulated parameters:

Object distance







Automotive radar sensor (regular operation mode)



#### Simulated parameters:

- Object distance
- Radial velocity
- Object size

Angular direction





Automotive radar sensor (regular operation mode)



## **UNIQUE FEATURES – AREG800A TOGETHER WITH QAT100**



#### System Overview

### **EXEMPLARY DRIVING SCENARIOS** MATCHING INSTRUMENT CONFIGURATIONS



Enables selected NCAP, AEB and ACC scenarios

- Simulation of targets moving in azimuth, range, radial velocity and target size.
- Stimulation of a single radar sensor.



#### System Overview

### **EXEMPLARY DRIVING SCENARIOS** MATCHING INSTRUMENT CONFIGURATIONS



Enables advanced NCAP, AEB, ACC and other scenarios

- Simulation of targets moving in azimuth, range, radial velocity and target size.
- Simultaneous stimulation of multiple radar sensors.



## R&S®QAT100 AND R&S®AREG800A

THE MISSING PUZZLE PIECES FOR TESTING RADAR BASED AUTONOMOUS DRIVING FUNCTIONS



**R&S®AREG800A** Automotive Radar Echo Generator R&S®QAT100 Advanced Antenna Array



# FRONTEND - R&S®QAT100 ADVANCED ANTENNA ARRAY

## **R&S®QAT100 UNIQUE FEATURES**



### R&S®QAT100 OVERVIEW



Front panel with two lines of TX antennas. The offsetted RX antennas operate with their respective segments.



Back panel with SMA connectors for the individual segments. LCD display for direct interaction with the panel.

### **R&S®QAT100** MECHANICAL OUTLINE



## **R&S®QAT100 ADVANCED ANTENNA ARRAY** QAT-Z50 SHIELDING SYSTEM



- QAT-Z50 shielding system
  - 50 cm long
  - Direct mounting kit for QAT

## **ANGULAR RESOLUTION & FIELD-OF-VIEW**



The field-of-view (FOV) and angular resolution achievable with the R&S®QAT100 are dependent on the setup but can be calculated as follows:

Field-of-view:

$$\alpha = 2 \cdot \tan^{-1}\left(\frac{351mm}{d}\right)$$

Angular resolution:

$$\Delta \alpha = \tan^{-1} \left( \frac{3,7mm}{d} \right)$$

## **ANGULAR RESOLUTION & FIELD-OF-VIEW**

Distance (d)	Field-of-view ( $\alpha$ )	resolution ( $\Delta \alpha$ )
500 mm	38,7°	0,42°
700 mm	28,1°	0,30°
1000 mm	19,9°	0,21°
1500 mm	13,34°	0,14°
2100 mm	10,0°	0,10°



$$\Delta \alpha = \tan^{-1} \left( \frac{3,7mm}{d} \right)$$

$$\alpha = 2 \cdot \tan^{-1} \left( \frac{351mm}{2 \cdot d} \right)$$

## **ANGULAR RESOLUTION AND FIELD-OF-VIEW**



- There is an airgap of about 27 mm from the outer-most antenna to the edge of the QAT.
- When positioned next to each other, this results in a gap < 54 mm between the two instruments.
- It is therefore advisable to use an uneven number of QATs in the setup to not have the gap in the middle of the FOV.





### Part IV BACKEND - R&S®AREG800A AUTOMOTIVE RADAR ECHO GENERATOR

## RADAR OBJECT SIMULATION FOR ADVANCED SCENARIOS APPLICATIONS AND T&M CHALLENGES

- Advanced tests during R&D of automotive radar sensors and testing of ADAS features require dynamic variation of artificial objects
- ► These artificial objects must be dynamic in terms of:
  - Distance
  - Size (Radar Cross Section RCS)
  - Radial velocity (Doppler frequency shift)
  - Angular direction
- Higher levels of autonomous driving require multiple radar sensors in a single vehicle which have to be stimulated simultaneously



installation point of SRR sensors
installation point of LRR sensor

## **AREG800A – SUPPORTED FRONTENDS**





## **R&S®AREG800A - UNIQUE FEATURES**



## THE APPLICATIONS

#### Production



#### Hardware-in-the-Loop



#### Bench top R&D



#### Vehicle-in-the-Loop (together with AVL)



## THE SOLUTIONS



### **R&S®AREG800A AUTOMOTIVE RADAR ECHO GENERATOR** OVERVIEW BASE UNIT





Weight: 16 – 25 kg (depending on options)

Power Consumption: up to 1300W (depending on options)

### **R&S®AREG800A – SCALABILITY AND FLEXIBILITY** TECHNICAL INSIGHTS



## **R&S®AREG800A – SCALABILITY AND FLEXIBILITY** MODULAR CONCEPT

- Hybrid echo generation concept
  - Mandatory digital echo generation : The digital baseband (DB) which automatically includes an IF switching board (SB)
  - Optional analog stepped delay line : Analog stepped delay line board (ASDL)
- ► DB, SB and ASDL form a module
- ▶ Up to 4 modules can be installed in one AREG800A base unit





## **OPERATION - AREG800A WITH QAT100** SIGNAL DISTRIBUTION OVERVIEW

A – One QAT100 and one AREG800A For simulation of dense scenarios



IF#5 to IF#8

Individual IF path for each of the 8 array segments of the QAT (each containing 24 TX antennas) Advanced Automotive Radar Echo Generation

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Individual IF path per QAT addressing one full antenna line (containing 96 TX antennas)

#8

IF#8

**B** – Multiple QAT100s and one AREG800A I

For covering wide Field-of-Views

IF#1

**C** – mmW Frontends and AREG800A For bench top test cases

IF#1

IF#2

IF#3

IF#4

Individual IF path per mmW frontend

### **OPERATION – AREG800A WITH QAT100** A - SIGNAL DISTRIBUTION



AREG800A – Base Unit



### **OPERATION - AREG800A WITH QAT100** B - SIGNAL DISTRIBUTION



AREG800A – Base Unit



## **OPERATION - AREG800A WITH MMW FRONTENDS** C - SIGNAL DISTRIBUTION





AREG800A – Base Unit

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## SUMMARY - R&S®AREG800A OPERATION



Up to 8 independent angular directions with max. 1 individual artificial object each.



#### R&S®AREG800A together with mmW remote frontends

 Up to 4 mmW frontends can be connected to a single base unit with up to 8 individual artificial objects each.

### **OUR SOLUTION FOR TESTING OF AUTOMOTIVE RADAR** UNIQUE SOLUTION FOR TESTING LARGE APERTURE AUT RADAR SENSORS



AREG800A together with ATS1500C shielded chamber AREG8 mmW remote frontend mounted in chamber

### **R&S®AREG800A – SCALABILITY AND FLEXIBILITY** SYNCHRONIZATION OF MULTIPLE FRONTENDS



### **R&S®AREG800A – SCALABILITY AND FLEXIBILITY** SYNCHRONIZATION OF MULTIPLE FRONTENDS & BACKENDS TO GENERATE LARGE SCENARIOS





### Part V RECOMMENDED CONFIGURATION

## EXEMPLARY CONFIGURATION I

BASIC BENCH TOP AND R&S®ATS1500C USAGE

#### Consists of:

- 1. R&S®AREG800A Automotive Radar Echo Generator
- 2. One mmW frontends (multiple frontends possible)

#### Key features:

- 4 GHz bandwidth with mmW frontend
- Fully harmonized with ATS1500C and CATR
- Dynamic artificial objects with individual distance, RCS and radial velocity
- Dynamic objects:
  - 1 object down to < 4m
  - Up to 8 objects in the range of <15m to >1000m
- IF input, IF output and HiL interface





### **EXEMPLARY CONFIGURATION II** BASIC ADAS FEATURE TEST

#### Consists of:

- 1. R&S®AREG800A Automotive Radar Echo Generator
- 2. One R&S®QAT100 advanced antenna array

#### Key features:

- 4 GHz bandwidth with R&S®QAT100A advanced antenna array
- Dynamic artificial objects with individual distance, RCS and radial velocity and **azimuth**
- Dynamic objects:
  - 1 object down to < 4m</li>
  - 2 objects in the range of <15m to >1000m
- IF input, IF output and HiL interface





#### EXEMPLARY CONFIGURATION III ADVANCED ADAS FEATURE TEST

#### Consists of:

- 1. R&S®AREG800A Automotive Radar Echo Generator
- 2. Three R&S®QAT100 advanced antenna arrays (up to 8 possible)



#### Key features:

- 4 GHz bandwidth with R&S®QAT100A advanced antenna array
- Dynamic artificial objects with individual distance, RCS and radial velocity and **azimuth**
- Dynamic objects:
  - 2 objects down to < 4m (up to 4 objects possible)</li>
  - 4 objects in the range of <15m to >1000m (up to 8 possible)
- IF input, IF output and HiL interface
- Capability to stimulate multiple radar sensors in parallel





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## Part VI SUMMARY



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For more information please visit our webpage:

www.rohde-schwarz.com/automotive/target-simulation