EDITORIAL BACKGROUNDER
Keysight's Radar Scene Emulator (RSE) Solution

Introduction

The vision of fully autonomous vehicles is fast approaching, promising to improve the overall efficiency of transportation systems and enable greater driver and passenger safety. In fact, U.S. Department of Transportation researchers estimate that self-driving cars could reduce traffic fatalities by up to 94 percent by eliminating those accidents due to human error.

However, making this vision a reality requires automotive OEMs to move beyond the current state of the Society of Automotive Engineers (SAE) levels of vehicle autonomy—from level 2+/3 to level 5 (Figure 1). Doing so generates a unique set of challenges that require a number of technical advancements.

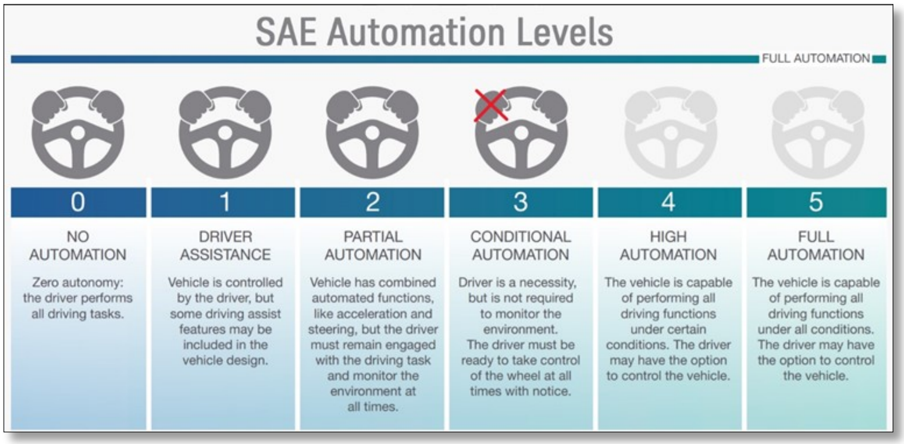

Figure 1. SAE levels of vehicle autonomy

Warning: Challenges Ahead

A number of key challenges and gaps must be overcome to advance vehicle autonomy. These include:

- **Closing the gap between roadway and software simulation testing.** Today sensors and control modules are tested by simulating environments with software in the loop test. Software simulation is valuable, but it cannot fully replicate the real-world and potential imperfect, sensor response. Fully autonomous vehicles must know how to deal with those imperfections.

Road testing of the complete integrated system within a prototype or road-legal vehicle enables OEMs to validate the final product before bringing it to market. While road testing is vital and a needed part of the development process, the cost, time required, and challenge of repeatability makes relying on real-world road testing alone unrealistic. Using this approach, it would take hundreds of years for vehicles to be reliable enough to navigate urban and rural roadways safely 100% of the time.

- **Training Advanced Driver Assistance Systems (ADAS)/Autonomous Vehicle (AV) algorithms to real-world conditions.** Testing automotive radar is critical to training autonomous driving algorithms. These algorithms use the data acquired by a vehicle's radar sensors to make decisions about how the vehicle will respond in any given driving situation. When those algorithms are not properly trained, they may make unexpected decisions that undermine driver, passenger or pedestrian safety.

  As an example, consider that a person is required to make many decisions while driving a car. It often takes time and experience to be a good driver. Taking vehicle autonomy to the next level requires complex systems that exceed the abilities of the best human drivers. A combination of sensors, sophisticated algorithms, and powerful processors are key pieces that will make autonomous driving possible. While the sensors help in sensing the immediate environment, the processors and algorithms allow for making the right decision and keeping in accordance with road rules. Extreme confidence in new ADAS functions is critical. With an unproven system, premature roadway testing is risky. The ability to emulate real-world scenarios that enable validation of actual sensors, electronic control unit (ECU) code, artificial intelligence (AI) logic, and more is needed. Testing more scenarios, sooner, provides OEMs a clear sense of when to stop, and when to confidently sign off on ADAS function.

Where Current Solutions Fall Short

Today's test systems are unable to effectively address these challenges. Some systems use multiple radar target simulators (RTSs), each presenting point targets to radar sensors and emulating horizontal and vertical position by mechanically moving antennas around. The mechanical automation slows overall test time. Other solutions create a wall of antennas with only a few RTSs. This means an object can appear anywhere in the scene, but not concurrently. In a static or quasi-static environment, this approach enables test with a handful of targets moving laterally at speeds that are limited by the speed of robotic arms.

Current radar sensor test solutions also have a limited field-of-view (FOV) and cannot resolve objects at distances less than 4 meters. Testing radar sensors against a limited number of objects delivers an incomplete view of driving scenarios and masks the complexity of the real-world.

Addressing the Challenges

Full-scene emulation in the lab is key to developing the robust radar sensors and algorithms needed to realize ADAS capabilities on the path to full vehicle autonomy. Keysight's first-to-market full-scene emulator combines hundreds of miniature radio frequency (RF) front ends into a scalable emulation screen representing up to 512 objects and distances as close as 1.5 meter.

Delivering this solution required two key breakthroughs, a proprietary miniature RF front end, each with its own antenna, and integrating 8 of those RF front ends on one circuit board (Figure 2). Sixty-four boards were then arranged in a semi-circular array to form an emulation screen.

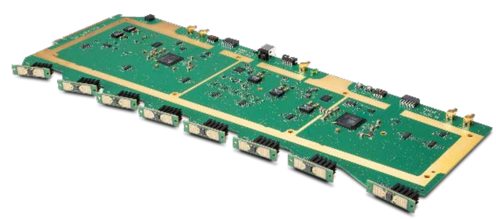

Figure 2. Compact RSE front end

Keysight's Radar Scene Emulator enables automotive OEMs to shift testing of complex driving scenarios from the road to the lab, accelerating the speed of test versus going to the test track.

Key Features and Benefits

The Keysight Radar Scene Emulator employs patented technology that shifts from an approach centered on object detection via target simulation to traffic scene emulation (Figure 3). This approach provides automotive OEMs with a number of key benefits:

- **See the big picture**: The Radar Scene Emulator helps radar sensors see more with a wider, continuous FOV and supports both near and far targets. This eliminates the gaps in a radar's vision and enables better training of algorithms to detect and differentiate multiple objects in dense, complex scenes. As a result, autonomous vehicle decisions can be made based on the complete picture, not just what the test equipment sees.
  - Thoroughly exercise radar sensors and systems with 512 independent targets with a continuous FOV of+/-70° azimuth and +/-15° elevation
  - Generate static and dynamic targets at ranges of 1.5 m to 300 m and with velocities of 0 to 400 kph
  - Address multi-target, multi-angle scenarios with angular resolution of less than 1 degree
  - Emulate complex, RF-dense urban scenes with realistic interference testing

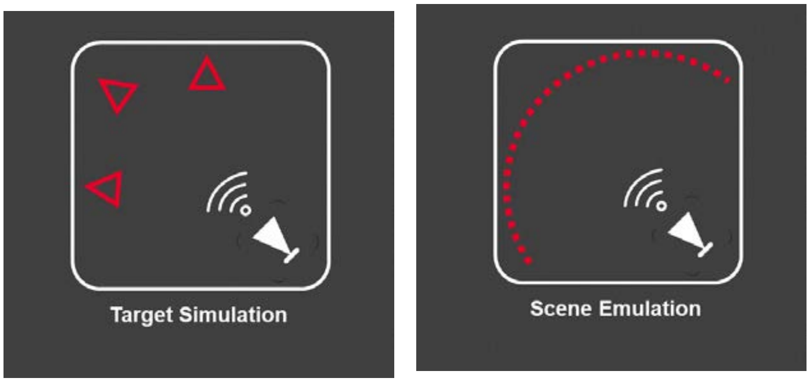

Figure 3. Comparison between target simulation and scene emulation

- **Test real-world complexity.** Testing radar sensors against a limited number of targets provides an incomplete view of driving scenarios and masks the complexity of the real-world. Keysight's Radar Scene Emulator allows OEMs to emulate real-world driving scenes in the lab with every variation of environmental condition, traffic density, speed, distance, and total number of targets. Testing can be completed earlier and for common to corner case scenes, while minimizing risk.
- **Accelerate learning.** Keysight's Radar Scene Emulator provides a deterministic real-world environment for lab testing complex scenes that today can only be tested on the road, if at all. Its industry-first test approach allows OEMs to significantly accelerate ADAS/AV algorithm learning by testing scenarios earlier with complex repeatable scenes, high density of objects (stationary or in motion), environmental characteristics, or any mix of these, while eliminating inefficiencies from manual or robotic automation.
- **Test more scenarios, sooner, and achieve greater confidence in required ADAS functionality.**
  - Readily detect gaps or misbehavior in ADAS software via rendering based on dynamic resolution adaptation
  - Emulate complex, real-world scenarios including those with large planar objects
  - Generate realistic driving scenarios such as high-speed cross traffic with multiple targets

Automotive companies understand how complex it is to test autonomous driving algorithms—and the safety issues at stake. Keysight's Radar Scene Emulator is ideal for autonomous driving developers who value safety first. Using full-scene rendering that emulates near and far targets across a wide continuous FOV, Keysight's Radar Scene Emulator lets you test automotive radar sensors in autonomous drive systems faster and with highly complex multi-target scenes.

Keysight's Radar Scene Emulator is part of the company's Autonomous Drive Emulation (ADE) platform, which was created through a multi-year collaboration between Keysight, IPG Automotive, and Nordsys. The ADE platform exercises ADAS and AV software through the rendering of predefined use cases that apply time-synchronized inputs to the actual sensors and subsystems in a car, such as the global navigation satellite system (GNSS), vehicle to everything (V2X), camera, and radar. As an open platform, ADE enables automotive OEMs and their partners to focus on the development and testing of ADAS systems and algorithms, including sensor fusion and decision-making algorithms. Automotive OEMs can integrate the platform with commercial 3D modeling, hardware-in-the-loop (HIL) systems and existing test and simulation environments.

Keysight's Radar Scene Emulator and the Autonomous Drive Emulation platform offers automotive OEMs the ideal solution to realize new ADAS functionality on the path to full vehicle autonomy.

RELATED INFORMATION

Other information: For more information, go to: https://www.keysight.com/find/DiscoverRSE