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MEASURING TECHNIQUE
Mobile RF Measuring Equipment for Performance Tests on Car Antennas

/// **INTERVIEW** Danny Shapiro [Nvidia]

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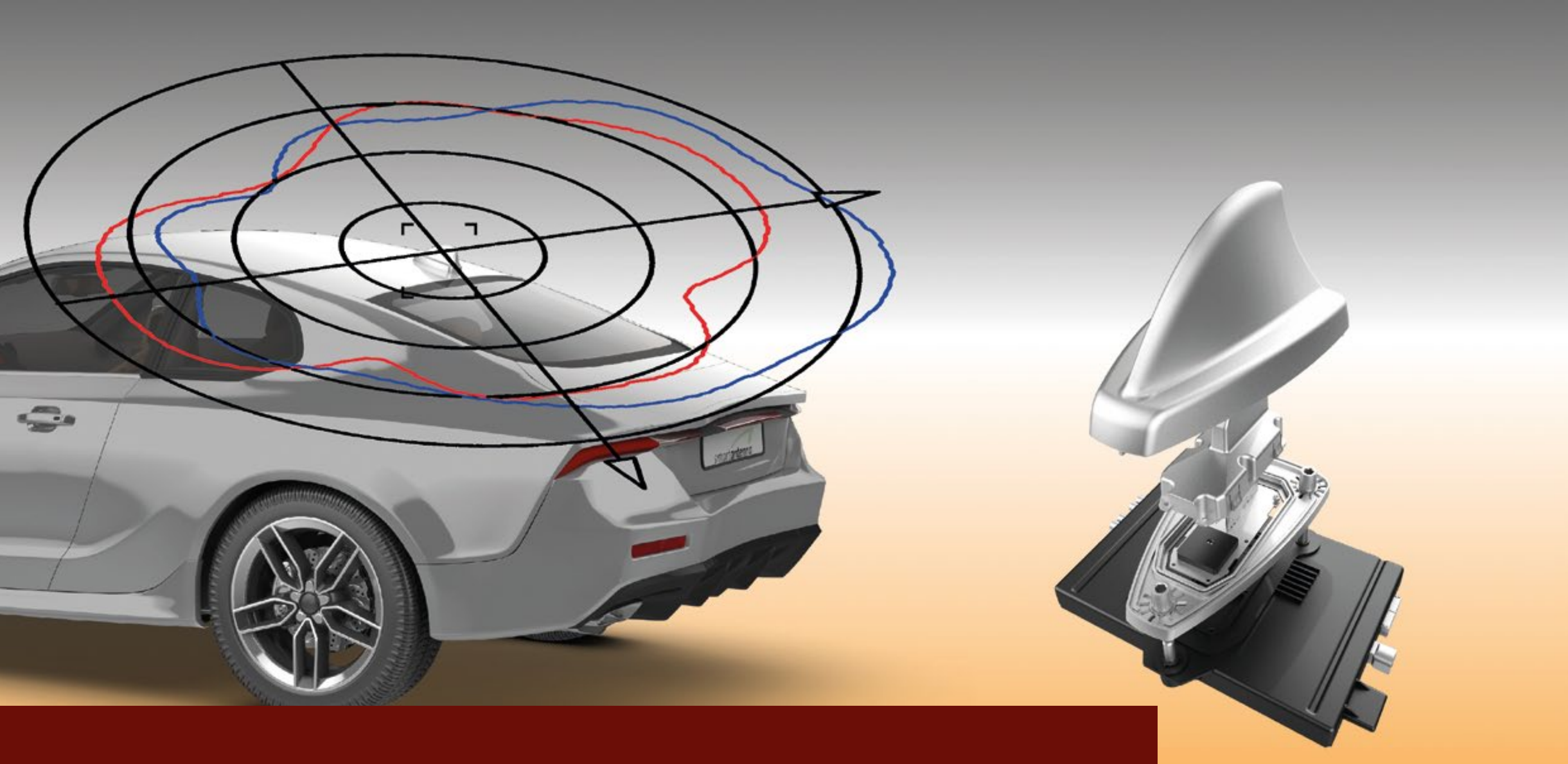

Use of Mobile RF Measuring Equipment for Performance Tests on Vehicle Antennas

Many more antennas are fitted into each of the latest vehicle models than ever before. Combination transmitter and receiver units have replaced the rod antenna. A wide range of high performance antennas supports the growing choice of new wireless services that are designed to make driving safer, more efficient, and more enjoyable. The development and implementation of new modules represents a growing challenge for carmakers and their development partners. Mobile performance testing using highly developed RF measuring devices takes on a key role in all of this as Narda describes in this article.

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INCREASED REQUIREMENTS FOR ANTENNAS

New offboard functionalities and innovations in infotainment, Internet connectivity and mobile telephony have increased the complexity of E/E architectures. Luxury automobiles with up to 20 antennas that must work together without interference to give optimum performance are becoming commonplace. The upcoming hot topic is therefore coexistence, which for example means that when Bluetooth is transmitting, the data rate in the adjacent WI-FI must not drop. An antenna is not 100 % limited to its useful frequency range. Harmonics (multiples of the payload signal frequency) that are produced in the module can induce intermodulation frequencies as well as the "permitted" frequencies. Spurious emissions can affect nearby antennas by producing strong interference in neighboring frequency ranges if the frequencies mix with opposite phases.

The modules for various services are thus all competing for frequencies and precious space, **FIGURE 1**. As well as WI-FI and Bluetooth, the broadcast range requires antennas for AM, FM and DAB radio, for example. Navigation, automated driving and the automatic emergency call system (eCall) all use GNSS (Global Navigation Satellite System). LTE and 5G modules support mobile wireless and voice communications. Vehicle to everything (V-to-X) antennas for real time vehicle to vehicle and vehicle to infrastructure communications are a new arrival. As far as the quality assurance of automobile antennas is concerned, it is no exaggeration to say that this has entered a completely new era. Any deficiencies in transmission or reception quality or reliability are unacceptable, as the consequences of failure may be much more serious than an interruption in a radio program.

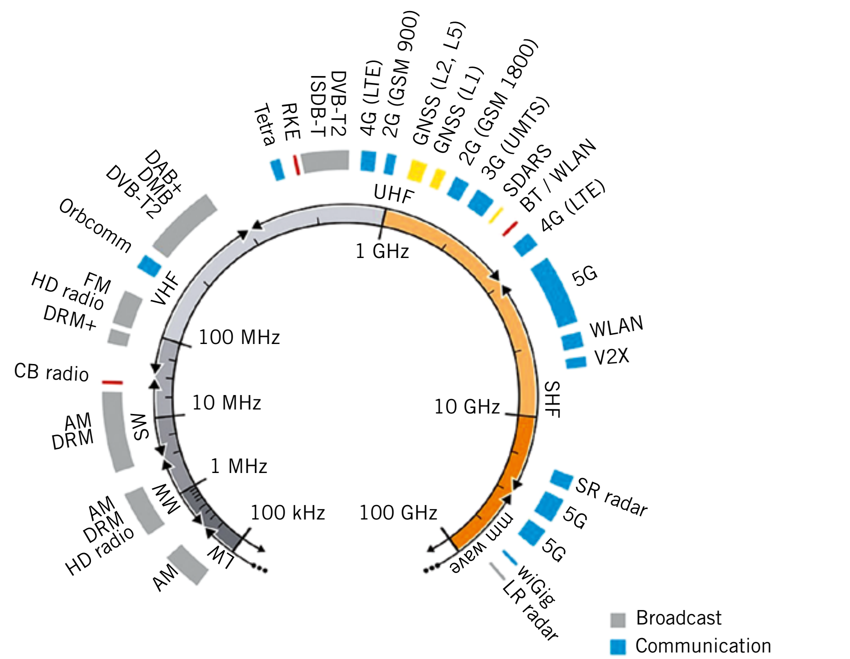

FIGURE 1 The spectrum covered by the various RF services used in modern vehicle types (© TE Connectivity)

COOPERATION

Vehicle antenna developer Hirschmann Car Communication, now a subsidiary of TE Connectivity (TE), has been cooperating with Narda Safety Test Solutions since 2018. The attention of TE's development engineers was drawn to the Narda SignalShark, **FIGURE 2**, in connection with the highly specific requirements of their mobile test applications. The performance data of this newly developed real time handheld signal analyzer, **TABLE 1**, promised progress in many respects compared to the RF measurement solution that had been used until then, **FIGURE 3**. Above all, the frequency coverage up to 8 GHz opened up new, existing and future applications for TE. Frequency ranges beyond 3 GHz were impossible with what they had been using.

MOBILE PERFORMANCE TESTS

Along with the increasing demands on antenna systems, the requirements for real performance tests also increase beyond comprehensive simulations and laboratory tests. These tests measure the so-called antenna pattern, which gives insight into the antenna gain (G). The pattern indicates how well a particular model of antenna receives a signal according to the frequency and angle of incidence of the signal, which is the actual power level of the transmitted signal at the antenna base. A signal generator on the TE test site transmits eight frequencies in the band that is being tested, for example FM, in the direction of the test vehicle that is driving in circles approximately 100 m away. The performance of the antenna is measured for every angle of incidence to the signal source in this way, with an integrated gyro-sensor continuously recording the angle.

Radiation patterns result from the recorded signal levels, **FIGURE 4**. These show how strongly the antenna receives from each direction for each frequency. Consistently good reception from all directions is ideal for most services; this would be shown by a circular antenna pattern. Specific directivity is, however, needed for special applications. For example, GNSS modules should "look upwards" as much as possible, i.e. have best reception from above, where the satellites are.

CONVENTIONAL RF MEASUREMENT

Until now, reliable recording of measurement results to the required degree involved a complicated procedure each time. The RF measurement solution that was used was a large setup, **FIGURE 4**, comprising a measuring receiver with up to 3 GHz capability and a separate RF switch, plus an additional laptop and external gyro-sensor. The whole setup needed to be dismantled and then reassembled again and installed in the next

FIGURE 2 The complete "intelligence", apart from the electronic compass, is built into a single device (© Narda STS)

SignalShark specifications	
Frequency range	8 kHz – 8 GHz
Real-time bandwidth	40 MHz
Operating temperature	-10 – +55 °C
Battery operating time	3 h (nominally), hot swappable
Dimensions [mm]	231 × 333 × 85 (l x w x h)
Weight	4.4 kg
Scan rate	> 50 GHz/s at RBW = 1.6 MHz
Full span	> 32 GHz/s at RBW = 100 kHz

TABLE 1 Specifications of the SignalShark 40 MHz real-time spectrum analyzer (© Narda STS)

vehicle each time a different vehicle was tested on the site.

HANDHELD ANALYZER FOR UP TO 8 GHZ

TE has had to significantly increase the frequency range of their measuring equipment as a result of the trends in automobile manufacturing. The Narda SignalShark detects and analyzes, classifies and localizes RF signals between 8 kHz and 8 GHz. Handling of the mobile performance tests has become much leaner. The handheld analyzer, which is equally suitable for mobile and stationary measurements, reduces the number of components and the cabling to a minimum. Apart from the electronic compass, all the “intelligence” is contained in the instrument itself in the form of a powerful computer. It has four switchable RF inputs, so no external switch is needed. This eliminates potential sources of errors, as no unplugging and plugging of connections is needed when the vehicle is changed. As a result, many fewer connectors are subjected to the mechanical stresses of real driving.

SPECTRUM ANALYZER MODE

TE also uses the handheld device as a spectrum analyzer for checking situations where radiated interference occurs. Electrical current in a vehicle is generally regarded as a potential source of interference. A simple mode switch enables the technicians to analyze the payload signal or localize interference. If spurious emissions occur during the implementation of an antenna, preliminary measurements for receivers or transmitters made using the handheld device quickly give information about what is causing the problem. While laboratory measurements are getting more and more complex, fault sources can be rapidly identified in this way. If the problem occurs at the customer’s end, a new radiation situation caused for example by a change in construction can be reliably re-evaluated by means of rapid, dependable measurements. Alternative suggestions for a solution, such as a more suitable location for the installation of a particular module, can be determined by measurement directly on site.

MEASUREMENTS IN EMC CHAMBERS

Everything that itself produces radiation is “banned” from EMC chambers, as the measurement results could otherwise easily be corrupted. The SignalShark is a particularly “quiet” computer, i.e. including its display, it is so well screened that it can be used to measure during operation inside a sensitive EMC chambers. The device is immune to field strengths of up to 100 V/m, which is much more than required by EMC and allows correct, error free measurements even in strong electromagnetic fields (EMF). Good screening works both ways: protection from external fields means that the environment is also protected from internal fields.

REAL TIME MEASUREMENTS

The real time bandwidth (RTBW) of the SignalShark of up to 40 MHz allows extremely rapid measurements. Within this 40 MHz, the receiver captures completely in real time even random phenomena such as short Bluetooth signals, which have a high potential to cause interference. They appear briefly, then disappear. None of these events are

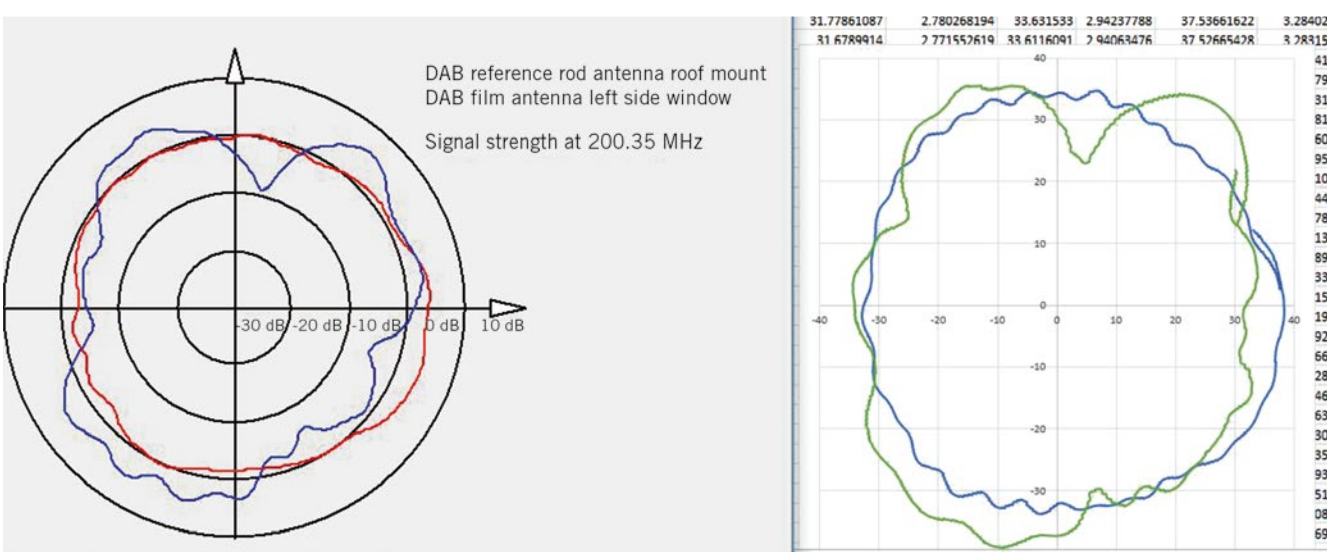

FIGURE 3 The radiation diagram shows how well an antenna in the actual installed position receives a signal as a function of the angle of incidence: the antenna gain (G), and the actual field strength measured at the antenna output (© TE Connectivity)

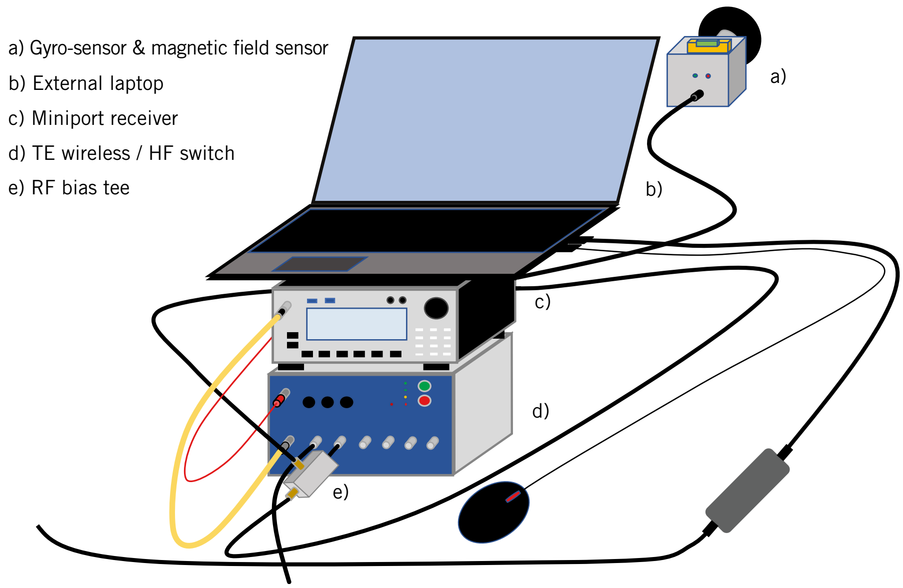

FIGURE 4 The RF measurement solution used so far was a complicated setup comprising a measuring receiver with up to 3 GHz capability and a separate RF switch, plus an additional laptop and external gyro-sensor (© Texterei Jungmann)

missed by the instrument, thanks to its POI (probability of intercept) of 100 % for signals having a duration of greater than 3.125 µs. The RTBW plays a significant role to the extent that many of the power supplies in vehicles are switched, and this switching activity is extremely fast and radiation-intensive.

WINDOWS-BASED COMPUTER

The SignalShark is equipped with a "Windows 10" computer, which brings with it all the advantages offered by this operating system, such as customization to individual requirements. The control system is open and the SCPI based remote control commands are described. An open platform is available, for example, to use own Python scripts to customise the range of functions and to automate complete measurement sequences. The programming effort is reduced by the NardaScriptLauncher through the API which provides the remote control commands in Python. Scripts can be displayed as buttons and conveniently started from within the application. The same freedoms provided by the Windows OS also apply to the documentation of the measurement results. For example, the compass is powered from the device and read out via the USB bus during mobile performance testing. The readout and collation of the compass and gyro-sensor data with the spectrum analysis measurement results is thus performed by the SignalShark itself and therefore shown directly as a radiation pattern on the instrument display.

DEMANDS OF THE AUTOMOTIVE INDUSTRY

Automobile manufacturers demand the best performance at reasonable cost. As well as a high degree of functional integration, the requirement that innovative systems should be as small as possible, aerodynamically optimized and preferably invisibly installed in the tiniest space is high on the list of specifications. And all of this should preferably work cross carline, i.e. be suitable for all model ranges.

There is a chronic lack of space within vehicles. Although a smartphone can provide standards such as LTE, Bluetooth, WI-FI and NFC in the smallest of packages, this is not easy in a vehicle as it is, by definition, on the move when used as designed. The radiation situation is thus constantly changing as a result of shadowing and reflexions in the vehicle's environment. The demands on the antennas are therefore completely different and much higher than those for a mobile handset. The vehicle antenna must be of a certain size and performance. In medium-sized vehicles, diversity systems with multiple radio antennas and several tuners that automatically add the signals together with the correct phase are needed to compensate for fading, the loss of signal caused by reflexions.

In future, it will be a requirement for "intelligent" vehicles to be able to reliably exchange large quantities of live data with other road users, their environment, and IT backend systems. As the interface between embedded onboard systems and off-board functionalities, highly developed antennas are gaining ever greater importance with regard to reliable connectivity. The developers of vehicle antennas are confronted with much broader bandwidth services than VHF. They utilize higher frequencies in order to realize as large a bandwidth as possible in the context of rapid transmission of high data rates. Currently, frequencies of up to 6 GHz are relevant for antennas for mobile use with the new 5G mobile communications standard.

SUMMARY

Trends in vehicle development are placing ever increasing demands on automobile antenna systems, and the further improvement of these systems will play a central role in future. TE Connectivity uses the newly developed Narda SignalShark for the mobile performance tests. The up to 8 GHz frequency range, high real time bandwidth and open architecture make the accomplishment of complex measurement tasks faster, more efficiently, and more reliably in future.