Application Note

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Mobile performance tests – Efficient precision measurement of vehicle antenna systems

Mobile performance tests on modern vehicle antenna systems have become extremely complex. Networked vehicle functions, wider bandwidth services, and higher frequencies mean that the limits of traditional RF measurement methods have quickly been reached.

Back in the early 1970s, a chrome-plated telescopic antenna mounted on the front wing of an automobile was all that was needed. The antenna was only there to provide more or less interference free reception of a local radio station broadcasting on VHF at between 87.5 and 108.0 MHz for the car radio. But such nostalgic times are well and truly in the past.

Vehicle antenna systems today

Hirschmann, now a subsidiary of TE Connectivity (TE), introduced their first automobile antenna way back in 1939, in Berlin. The "Auta 6000" range of telescopic antennas certainly contributed greatly to the good reputation that this traditional supplier has gained over the years that followed. However, the antennas used by the latest generation of vehicles must have much higher performance than before. Developers are focused on modules that support much wider bandwidth services than VHF and combined transmitter and receiver units. Also, significantly higher frequencies are considered in order to generate as large a bandwidth as possible for even faster transmission of ever increasing quantities of data. At the moment, frequencies of up to 6 GHz are relevant in the context of antennas for mobile use and the new 5G mobile communications standard. At its Neckartenzlingen facility, TE Connectivity develops its entire portfolio of antennas for the automotive sector. This Swiss technology company offers several solutions for each service, and adapts these individually according to customer requirements. This results in antenna systems that are tailor made for each model of vehicle.

The complexity of current architectures has increased dramatically as a result of the increasing networking of vehicle functions, offboard applications and innovations in infotainment, interconnectivity, and mobile telephony. One of the key components on which these systems depend are powerful antennas, or more precisely, various types of antenna with quite specific functions. The services involved include: AM, FM, and DAB radio; mobile telecommunications; WLAN and Bluetooth for coupling the individual onboard devices, as well as GNSS (Global Navigation Satellite System) and Car2X communications. The last of these uses radio frequency links for data transfer between vehicles and between the vehicle and its traffic infrastructure to provide safe, efficient, and intelligent mobility for the future. Quality control of modern vehicle antennas has already taken on new dimensions as a result. Any deficiencies in reliability, reception or transmission quality now have much more serious consequences than just an interruption in a radio program, however interesting it might be.

Real performance tests on modern vehicle antennas

Alongside this new complexity in modern automotive antenna solutions, the requirements for essential real performance tests have also grown. All the modules have to work perfectly and reliably with the network in their real installation situations. This means that there is no way to avoid final mobile tests “on the road” even after extensive simulations and stationary tests in the laboratory, e.g. in an EMC test chamber or radome.

Last year, the development engineers at TE Connectivity became aware of a new development from Narda Safety Test Solutions GmbH that was relevant to the specific requirements of their mobile application: the SignalShark. Even just based on the parameters listed in the data sheet, this new, real-time handheld signal analyzer from the RF test equipment specialists in nearby Pfullingen promised in many ways to be a significant improvement on the RF test equipment solution they had been using.

Antenna pattern – Test description

This mobile performance test measures the so-called antenna pattern. This pattern gives developers valuable insights into the antenna gain, G. This parameter indicates how well the antenna for a particular type of vehicle receives a signal as a function of the angle of incidence, i.e. how much of the power of the transmitted signal is actually received.

In practice, a vehicle fitted with various test antennas is driven around a circuit that covers a wide area and that is as free from reflections as possible. During this time, a signal generator is used to emit a signal towards the test vehicle at a defined power level alternating between vertical and horizontal polarization from a distance of around 100 m. At the same time, an electronic gyro-sensor and a separate compass record the angle from which the vehicle is receiving the radiation. In this way, the TE engineers obtain a circular plot (**figure 1**) of the instantaneous value of the received field strength in [dBμV] (decibel microvolts) or [dBm] (decibel milliwatts) at the antenna output against the corresponding angle of incidence.

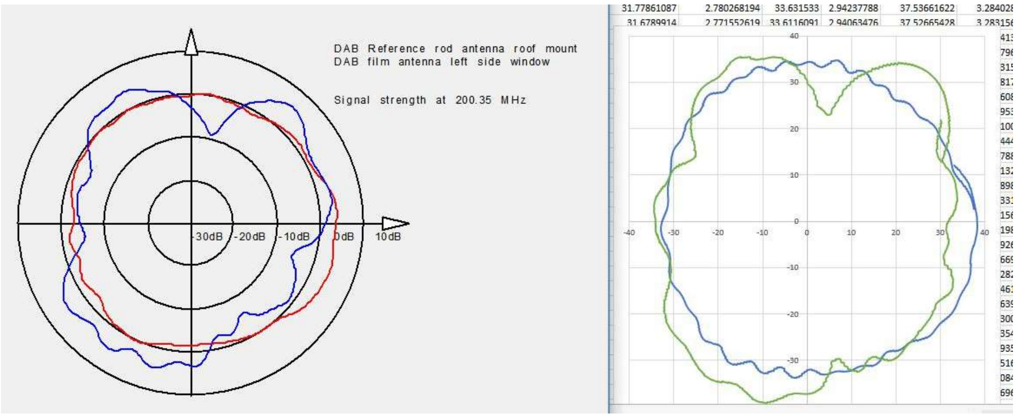

Figure 1: The resulting circular plot in the measurement documentation provides the TE engineers with valuable information about how well an antenna receives a signal according to the angle of incidence in the real installation situation. It shows the antenna gain G, and the instantaneous value of the field strength measured at the antenna output in [dBµV].

Test engineers face different challenges when making measurements on a test site in the open air than they do in a laboratory. The complete test rig including all the connector elements must be suitable for the situation in the test vehicle and the adverse conditions of a test drive. With regard to precise measurement results, it is essential that the whole system robust and error free even during acceleration, braking, and when centrifugal forces are acting and everything in the vehicle is rattling and vibrating. These tests are not carried out in a luxury limo in a high-class neighborhood. Farm vehicles also have to be tested. It is not possible to simply drive a massive combine harvester over to the Neckartenzlingen facility for testing. Such huge vehicles have to be tested on site where they are manufactured.

Original and current RF measurement methods

The RF measurement solution used until now in Neckartenzlingen involved a large complicated setup comprising a measuring receiver configured for up to 3 GHz with a separate RF switch, an additional laptop and an external gyro-sensor. To dependably capture trustworthy measurement results with the required degree of reliability regularly required a great deal of technical work on the part of the TE engineers. For example, all the measuring equipment, which was difficult to move anyway, had to be dismantled and reassembled in a different place each time the vehicle was changed during a series of tests. A lot of time was needed to properly connect up the equipment on the test site and install it as securely as possible in the test vehicle. The complex procedure surrounding these mobile antenna tests was comparatively complicated and time consuming, which made it slow and cost intensive.

- Compact all-in-one device

In comparison, the major advantages of the Narda SignalShark **(figure 2)** used for the first time by TE quickly became apparent. The first noticeable advantage was the significant streamlining in the overall handling of the antenna tests, with all the positives that this brought. The number of devices and thus the cabling requirements was reduced to a minimum, as the handheld analyzer is equally suitable for both mobile and fixed use. All the “intelligence” needed apart from the electronic compass is built in to the device in the form of a powerful computer. The four switchable RF inputs make a complicated external RF switch unnecessary. The test engineers can thus eliminate the potential sources of errors that existed in the past. Making successive measurements on further antenna modules for different vehicle models no longer requires the wearisome, time consuming disconnection and reconnection of all the connectors, for example. And far fewer connectors are subjected to the mechanical strain of vehicle operation, making the measurements more reliable and less subject to error.

Figure 2: TE have been able to increase the frequency range for performance tests from 3 GHz to 8 GHz by using the new Narda SignalShark. At the same time, the overall handling of the antenna tests has been significantly streamlined because all the “intelligence” needed — apart from the electronic compass — is incorporated into a single device in the form of an inbuilt powerful computer.

- Frequency increase to 8 GHz

Frequency ranges above 3 GHz could not be examined using the previous mobile equipment. TE has had to increase this frequency range to match developments and trends in vehicle antennas. The SignalShark detects and analyzes, classifies and localizes RF signals between 8 kHz and 8 GHz. This gives the company access to new, current, and future applications in the automotive sector.

- Providing more service

The versatility of the SignalShark means that the TE staff can use it for more than just the antenna application. By using its spectrum analyzer functionality, for example, they can take a closer look at the interference emission situation for a particular type of vehicle. They basically only have to press a button to set the instrument to the correct mode for analyzing the payload signal or tracing potential interference. This, coupled with the maximum mobility provided by the handheld device, allows them to quickly and reliably analyze the radiation aspects of modified installations directly on site at the customer's facility and immediately offer concrete suggestions for solutions. Even the best antenna is useless if it is installed near an auxiliary headlamp with a switch-mode power supply that severely disturbs reception. The TE engineers can provide a better service by giving useful information about where to install a particular antenna module. Thanks to the SignalShark, this involves hardly any additional work.

- Rapid measurements

The measurement engineers can perform extremely fast measurements with the SignalShark because of its real time bandwidth (RTBW) of up to 40 MHz. This is much faster than traditional spectrum analyzers. It means that the receiver is able, in real time, within this 40 MHz to record even brief, sporadic signals without any interruptions without missing any single event. This is guaranteed by a 100% POI (probability of intercept) for signals of duration greater than 3.125 µs. The RTBW is particularly advantageous in the automotive field because many modern vehicles use switching power supplies and the switching processes are extremely short and emission-intensive.

- Low intrinsic emissions

With this new measuring device, the TE staff can enter the sensitive EMC chambers and make measurements and optimizations while the system under test is running. This is because of the excellent screening of the SignalShark. It is immune to field strengths of up to 100 V/m, which is much higher than necessary for EMC measurements, so it can be used without problems even in the vicinity of strong field sources. This high-quality screening works both ways, so that the reverse is also true: If the device is well screened against external fields, it will also protect its environment from any internal fields that it generates. The SignalShark thus operates as an extremely "quiet" device in terms of electromagnetic radiation. Any device that itself emits radiation is unwelcome, particularly inside an EMC test chamber, where the emissions of the device under test are being investigated.

- Windows-based computer

A computer with full Windows10 functionality is built in to the SignalShark. Users can thus take advantage of all the facilities that this provides. As well as disclosure of the entire device controls and full description of the remote control commands, this means that the measuring device can also "remote-control" itself. The pre-installed "Python" programming language, for example, gives TE the opportunity to easily implement its own measurement programs. The device can be adapted without problems to the individual requirements of the user. The external compass is supplied with power from the SignalShark and read out directly via USB. Compass value read out and the combination of these values with the measurement values from the spectrum analysis can be performed and the result displayed by the SignalShark itself. For the TE engineers, this advantage was manifest in the display of the circular chart. All the freedoms offered by the Windows operating system also apply when it comes to documentation of the test results. TE is able to fully utilize the open platform approach offered by Narda in the SignalShark.

Summary

TE Connectivity has been able to handle its measurement tasks much faster and with greater efficiency, thanks to the Narda SignalShark and its open architecture. The SignalShark sets a new standard here in the spectrum analyzer and receiver market segment. The RF measurement methods used until now were complicated, slow, and difficult to use. This current cooperation with Narda STS has opened up completely new perspectives that have resulted in significant progress.

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