On the trail of 5G

How well a smartphone transmits and receives has a major influence on the maximum achievable data transfer rates. That is why connect and Testlab use sophisticated measurement technology to investigate the LTE and 5G radio quality of mobile phones.

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The criteria of battery life and camera quality – in addition to an affordable price – are regularly at the top of the list in customer surveys on smartphone purchase decisions. The main annoyance in practical use, on the other hand, is a lack of network availability or data that only trickles in slowly. In these cases, smartphone users have often identified their mobile phone provider as the culprit.

There is often a grain of truth to this, but the quality of the smartphone's own transmission also determines how fast the data flows, especially at greater distances from the base station.

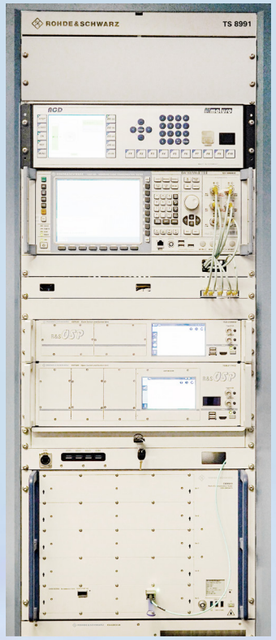
And thus, this characteristic ultimately also defines the direction in which the user's pendulum swings between pleasure and frustration. Reason enough for connect to meticulously analyse the sending power and receiving sensitivity of smartphones. To do this, the editorial Testlab uses a system from the German measurement specialist Rohde & Schwarz, which has to be regularly updated with the latest technology.

The upgrade from 2G and 3G to 4G alone required an investment of almost half a million euros. However, for LTE measurements, one mobile radio cell still supplies one smartphone - for 5G, two are required. So the upgrade to 5G has become significantly more expensive once again.

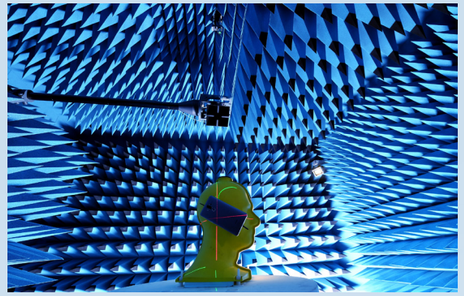
The step towards 5G

The reason for this is that 5G poses particular challenges for the measuring device developers at Rohde & Schwarz. This refers both to the "sub-6 GHz" range below and around 6 GHz and the mmWave range around 24 to 40 GHz. In the latter, there is a particularly large amount of free bandwidth available, but it is also particularly difficult to utilise for the network operators.

The second hurdle of the 5G measurements is perhaps even higher: it is hidden behind the abbreviation NSA, which stands for Non-standalone. This means that 5G could initially only be used together with 4G. The mobile network establishes two connections: one in the LTE network and the other in the 5G network. This is because mobile connections always require some degree of coordination between the cell and the smartphone in addition to the pure data transmission.



The publishing house's own Testlab has invested more than half a million Euros in the expansion of its measuring station from Rohde & Schwarz to 5G.



The walls of the test chamber serve as shields for mobile networks on the outside as well as absorbers for unwanted reflections from the inside.

For example, the mobile radio station tells the end device with what power it needs to send its signal so that it can be received without errors. However, the frequencies allocated for transmission, the time slots and the transmission coding must also be precisely harmonised so that the two communication partners understand each other at all and do not interfere with the numerous other mobile connections.

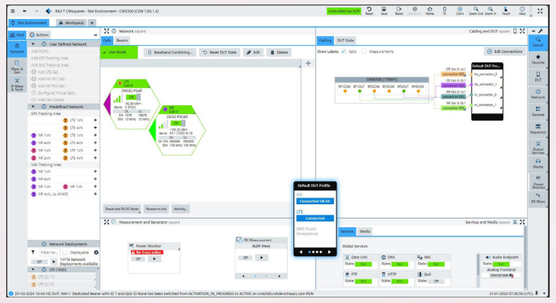
With LTE, communication and data transmission take place via the 4G standard, with exclusive resources reserved for communication. 5G only handles data transmission in NSA mode. Questions such as in which frequency ranges, in which time intervals, with which coding and with which transmission power the signal is sent, are all handled on the LTE "anchor" band.

A challenge for the measurement technology

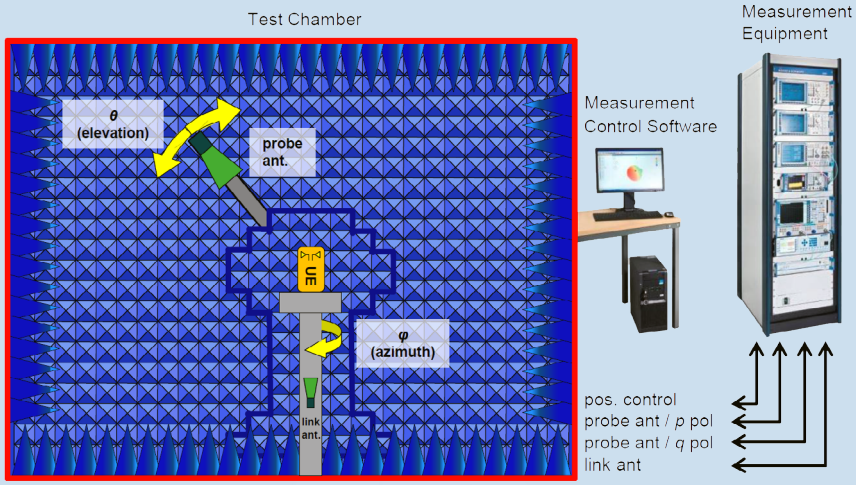
Accordingly, the new TS8991 measurement system from Rohde & Schwarz requires two mobile radio stations for the OTA (over-the-air) measurement of the radio interface of 5G smartphones. A classic R&S CMW500 wideband radio communication tester is used for LTE operation and controlling 5G, while the new R&S CMX500 signalling tester takes care of the 5G data transfers. Together, the wideband communication tester and the 5G one-box signalling tester fuel the New Radio (NR) with the impressive performance of 100 MHz bandwidth, 2 x 2 MIMO and modulations up to 256QAM in the download direction

Basically, however, the two units only handle the communication; the signals are measured elsewhere. Where spectrum analysers were used in previous measurement systems, which also displayed the measured power in the analysed frequency spectrum, two units called NRQ6 are now performing the actual measurements. These frequency-selective power analysers can record bandwidth-filtered signals anywhere from 50 MHz to 6 GHz and from -130 to +20 dBm in the frequency and time domain.

Two power meters are necessary because electromagnetic waves are polarised. While water waves largely move up and down horizontally, electromagnetic waves can oscillate in any orientation (polarisation planes) in space. In the connect measuring system, the radio waves are detected by a cross-polarised antenna in two orthogonal polarisation planes and then measured by the two NRQ6s. The actual power of any polarised wave can be calculated as the root mean square of the two power values.



Complex cockpit: In order to be able to measure 5G in non-stand-alone mode, connections must be established to a LTE network for control and to a 5G network for measuring the sending power and receiving sensitivity.



Smartphones are measured in a room-sized absorption chamber. The tower with the R&S measurement system is located outside of it. The measurements as well as the turntable with the smartphone and the rotatable measuring antenna are controlled automatically by a PC.

For these power measurements, it must be ensured that only the radio waves transmitted directly from the measuring system to the smartphone and in the opposite direction are recorded. A chamber made up of several metal stripes serves to keep the live mobile phone networks outside; at the same time, however, it also prevents the high transmission power that occurs during the measurements from influencing the actual mobile phone traffic outside the chamber. To ensure absolute tightness, the metal stripes are connected with more than 2000 screws at the wide folded joints, while fine-meshed copper gauze between the joints ensures that even the smallest leaks are eliminated.

To prevent electromagnetic waves from reflecting off the inner walls and bouncing back onto the measurement and smartphone antennas which would distort the measurement of the direct waves, the walls are lined all over with wedge elements made of carbon-soaked polyurethane foam. This construction ensures that the high-frequency energy hitting the walls is almost completely converted into heat.

From all directions

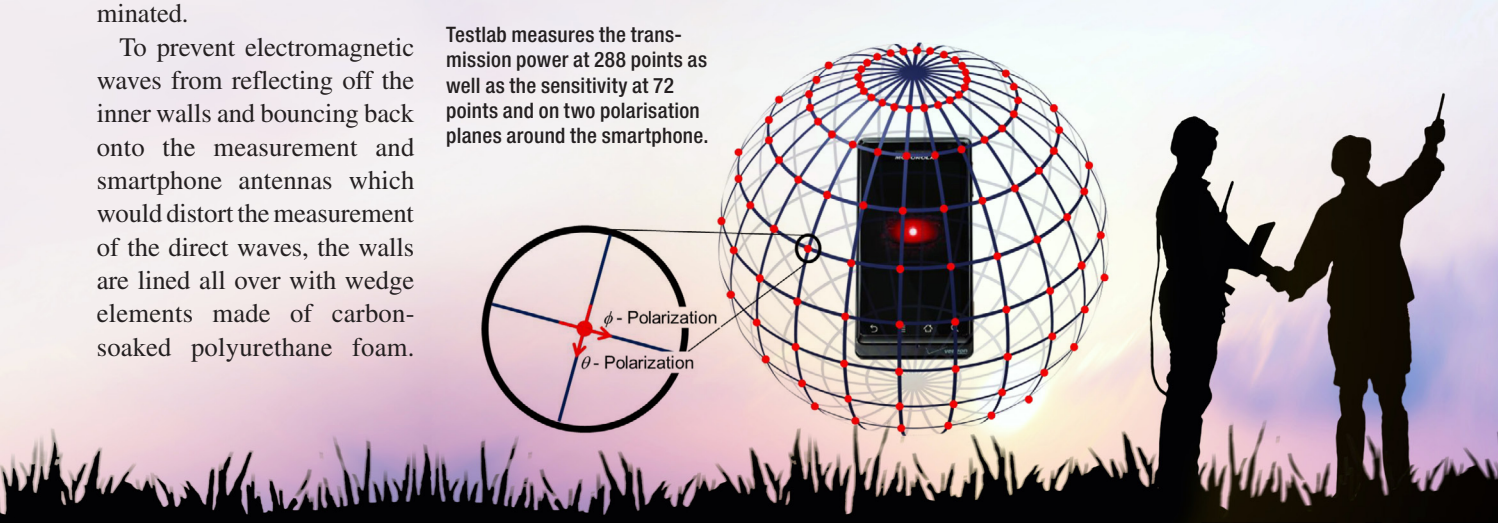
In order to determine the radio quality of a smartphone, it is of course not possible to measure just in one direction. This is because reception sensitivity and transmission power can vary considerably depending on the direction in which the signals are travelling. This is why the smartphone is placed on a Maturo turntable made of a material that is transparent to radio waves. This table rotates horizontally. The cross-polarised measuring antenna, which is attached to a rotating bracket also made by Maturo, moves around it in the vertical plane. This allows any angle to be measured on the sphere around the smartphone. In practice, the sending power is measured in a maximum grid of 15 degrees, while one with a maximum resolution of 30 degrees is used for sensitivity.

Almost 5000 measurement values

This results in more than 700 individual data points for each frequency band measured in one mobile communications standard. The three LTE and four 5G bands add up to almost 5000 measurement results. From this, two characteristic values per frequency band are calculated and uploaded to the connect product database.

Finally, a standardised evaluation scheme based on the relevance of the respective measurement results is used for classification and scoring. The knowledge of realistic smartphone operating conditions acquired by connect in its regularly conducted mobile network tests also pays off here.

Bernd Theiss



Testlab measures the transmission power at 288 points as well as the sensitivity at 72 points and on two polarisation planes around the smartphone.