Validation of OTA Measurement Setup At 28GHz Using A Plan Wave Generator

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Abstract— **In this paper, we thoroughly test and validate the complete active signaling measurement setup using a Plane Wave Generator (PWG), Radio Communication Tester (RCT), and a well-known antenna standard. The results of our study demonstrate excellent agreement between the Equivalent Isotropic Radiated Power (EIRP) measurements obtained using the active setup with the PWG, and those obtained using a passive measurement system employing the multiple probe spherical near-field technique. Furthermore, the Total Radiated Power (TRP) values derived from the active setup with the PWG are within expected uncertainty to the measured conducted power at the Horn input port. The measurements are done at 28GHz. The measured TRP using active OTA and conducted measurements are within 0.31 dB (6.9%) difference. This robust comparison illustrates the reliability and confidence in utilizing the PWG-based active measurement system.**

I. Introduction

The 5G NR FR2 frequency band integrated in modern smartphones have beamforming capabilities and it is important to take into account the integration environment and use case scenarios to deliver on the promise of high data rates associated with 5G technology. This critical task of antenna placement, and making sure that we obtain expected throughput for different use case scenarios, includes measuring the device's Effective Isotropic Radiated Power (EIRP) with different beam directions. Other key performance metrics include Effective Isotropic Sensitivity (EIS), Throughput, and Error Vector Magnitude (EVM). Over The Air (OTA) measurement technique is the only possible manner to obtain these metrics for such devices, and the methodology is standardized in CTIA test plan for millimeter wave frequencies [1].

Plane Wave Generators (PWG) based measurement systems have been presented in recent years for application in millimeter wave frequency band [2]-[4] Over the Air (OTA) measurements. This approach presents certain advantages as compared to other techniques used in the market today (e.g compact antenna test range CATR based systems). PWG based systems permit the Device to be static during measurements and hence phantoms or real persons can be easily integrated in the test scenario.

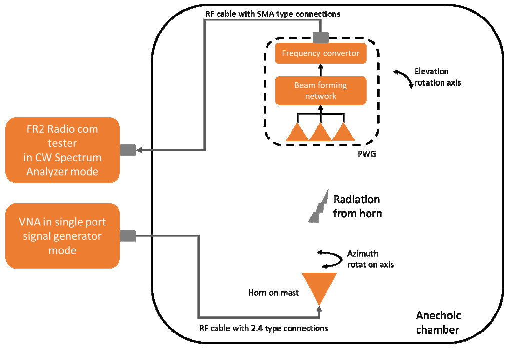
In this paper, we present the active measurement setup for EIRP and TRP (total radiated power) measurements. In order to evaluate the certainty of the measurements using the active measurement setup, a standard horn antenna (SH5000) from MVG industries was used as the Antenna Under Test (AUT). This work is a necessary step before measuring a real active device (Smart phone, Tablet, etc.). The idea is to use the same setup as for an active device but measuring an AUT with known characteristics in order to demonstrate that the calibrated EIRP and TRP results are in agreement with expected values. The approach to use active test setup as opposed to Vector Network Analyzer based approach permits to minimize the uncertainty budget of the overall measurement.

The paper is organized as follows. The test setup is presented in section II. The measurements results are presented in section III and compared to spherical near-field multi-probe measurement system. Conclusions are drawn in section IV.

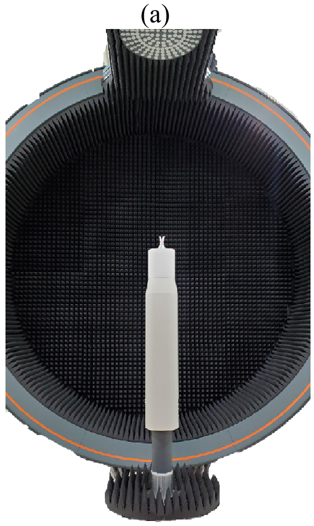
II. Active Measurement setup

The active measurement setup for EIRP & TRP validation consists of using a known horn antenna in emission mode. SH5000 antenna [5] was selected for this purpose whose directivity is close to 5G FR2 antennas integrated inside the device. The block diagram for system connections is presented in Figure 1(a). The horn Antenna Under Test (AUT) is connected to a signal generator through a RF cable with 2.4 type connectors at each end. A Vector Network Analyzer (VNA) is used as a signal generator in this case. The horn is placed on the mast which can rotate in the azimuth plane between 0° and 360°.

On the receiver side, the signal emitted from the horn is received by the PWG antenna and goes through the Beam Forming Network (BFN) sub module. The consolidated received signal is then down converted to intermediate frequency (IF) band and using SMA cables arrives to the Radio Communication Tester (RCT). The RCT is configured in Continuous Wave (CW) reception mode as a spectrum analyzer. The same setup can be used for EIS measurements by using the RCT as a signal generator and replacing the VNA by a spectrum analyzer in the block diagram Figure 1(a).



(a)



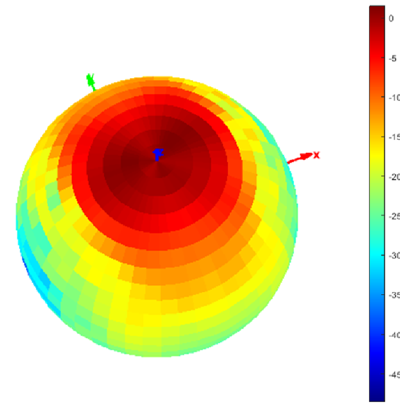
(b)

Figure 1. Active measurement setup, (a) block diagram, (b) measurement system picture

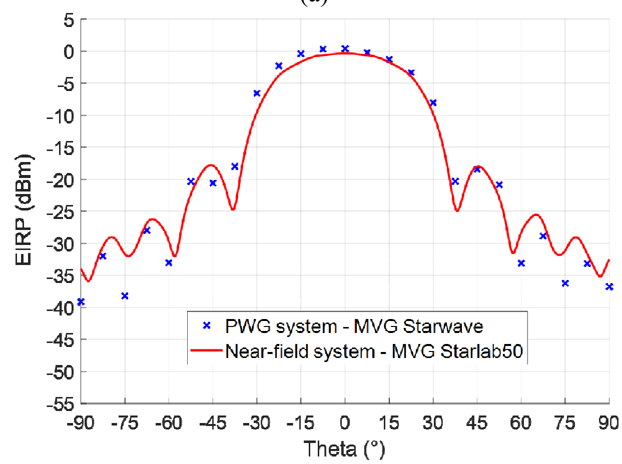
The dual-polarized PWG is rotating in elevation plane around the AUT at 1.2m distance as presented in Figure 1(b). The AUT is placed at the center of the Quiet Zone of the system (380mm spherical diameter).

III. EIRP AND TRP MEASUREMENT RESULTS

The measurement setup presented in the previous section is controlled using MVG WaveStudio software interface [6]. All instrumentation (RCT, VNA, BFN) and motors (Azimuth & Elevation) are configured to create the measurement scenario. The BFN coefficients are configured to generate a plane wave in receive mode. The VNA parameters are adjusted to obtain highest possible input power to the AUT and the IF bandwidth was adjusted to optimize the noise level. Raw E-field data for both orthogonal polarizations are measured with the PWG over a sphere with grid resolution of 7.5°. The truncation zone in elevation plane is ±45° due to the presence of the mast and the size of the PWG. For real device OTA measurements, in order to evaluate the fields over the full sphere, CTIA test plan proposes measuring the device twice by rotating the device by 180° around its center in the elevation plane. Hence, the whole sphere can be evaluated by combining the hemi-spherical data from the two measurements. In this study, it was not necessary to do that because the horn antenna radiation is primarily distributed in the upper hemi-spherical region.



(a)



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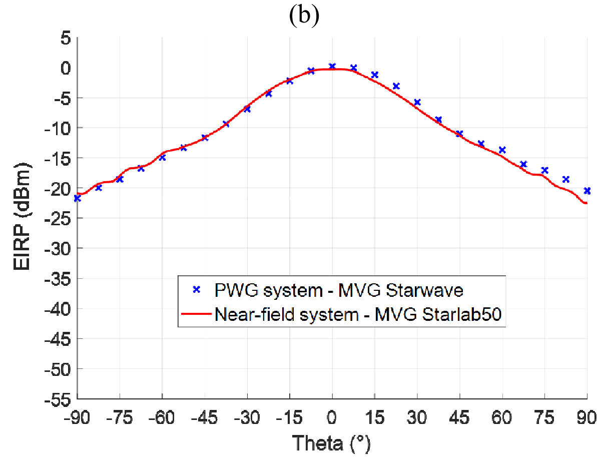

(c)

Figure 2. (a) 3D EIRP of SH5000 horn measured in PWG based MVG Starwave system at 28GHz, (b) E-plane, and (c) H-plane EIRP curves comparison between PWG based MVG Starwave and Multi-probe Near-field MVG Starlab50 system at 28GHz

The dual polarized raw measurements are then calibrated. The losses between the VNA output port to the input port of the horn are measured. The losses between the horn and the input port of the RCT are evaluated using single point measurements with a known standard gain horn antenna. The probe calibration is applied to remove the errors due to PWG probe between the two polarizations. The calibrated data represents thus, the EIRP values over the spherical grid. The 3D calibrated EIRP results are shown in Figure 2 (a) at 28GHz. The maximum EIRP level of about 0.4 dBm is measured. The same AUT was measured in the MVG Starlab50 system [7] which is a multi-probe spherical near-field measurement system. The EIRP results are compared in Figure 2 (b) and (c) for the E and H plane patterns. Excellent agreement is observed between the two systems. The resolution of the Starlab50 system is higher because of the near-field to far-field transformation which permits to obtain higher resolution of the data.

From the calibrated 3D EIRP values we can evaluate the TRP to be -12.59 dBm (using TRP = EIRP + antenna efficiency – antenna gain). The antenna gain and efficiency at 28GHz are known for this standard gain horn to be 12.8 dBi and 0.18dB respectively. To evaluate the accuracy of this result, the power at the input of the horn antenna was evaluated by removing the cable losses and knowing the VNA output power to be +5dBm. The result from connectorized measurement is -12.28dBm. The difference between TRP measured using the active setup and the connectorized measurements is only 0.31 dB. This difference is well withing the tolerances of different parts of the instrumentation (datasheet values) and thus validates the OTA measurement system.

IV. Conclusions

In this paper, the active measurement system based on PWG was presented. The objective was to measure a known antenna (gain, efficiency) inside the system with the measurement setup exactly the same as there would be for a smart phone. This step is important in order to have confidence in 5G FR2 OTA measurements with real device, where we do not have access to the connectors of the antennas. The EIRP and TRP parameters were evaluated for the know AUT with this setup at 28GHz. The same AUT was measured in a near-field multi-probe system as well. The 3D EIRP curves were compared between the two systems. The results are within the total uncertainty budget of the measurement setup. The TRP evaluated using the connectorized power measurement at the AUT input and active OTA setup were within 0.31dB or 6.89%. This close agreement between the EIRP and TRP values evaluated using different methods provides confidence in the measurement setup and validates the FR2 OTA setup based on PWG approach. The future work is to measure the real device in such systems.

References

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