Automated System for Antenna Parameters Measurements in Anechoic Chamber

Chavdar P. Levchev[1] and Nikolay M. Stoyanov[2]

***Abstract* – In this paper presents the block scheme of automated system for measurements control of the antennas with parallel computations in anechoic chamber is presented. Measurement methods and measurement methodology are developed. The functions of each measurement device are explained. Special features related to near-field and far-field measurements are presented. Fragments, figures and diagrams obtained by specially developed software for automated measurements are shown.**

***Keywords* – Anechoic Chamber, Automated System for Measurement, Antenna Parameters**

I. INTRODUCTION

Measurement of antenna parameters often takes a long time. The antenna pattern, gain, direction, efficiency and voltage state wave-ratio (VSWR) are the parameters which require special measurement antenna test areas and precisions equipment ensuring accurate measurements [1]. Antenna test areas have to provide measurements in the far-field zone. They can be realised as open area test site (OATS) or as closed area – Anechoic chambers. The measurement equipment include positioners for the receiving and transmitting sides, providing precise adjustment in azimuth and elevation of receiving antenna and transmitting antenna and device under test (DUT). Measurements conducted by the contemporary measurement equipment are fully automated. Antennas, RF devices, amplifiers and cables are calibrated and their parameters are under permanent control.

In the present work, an automated system for measurements in the anechoic chambers is presented. The explained method and system can be used for measurement of open area test site.

II. AUTOMATED SYSTEM FOR CONTROL OF ANTENNA PARAMETER MEASUREMENTS IN ANECHOIC CHAMBER

The block scheme of an automated measurement system in anechoic chamber is shown on fig. 1.

[1]Chavdar P. Levchev is with the Ministry of Interior, Bulgaria, E-mail: ch_levchev@ncc.mvr.bg

[2]Nikolay M. Stoyanov is with the Ministry of Interior, Sofia, Bulgaria, E-mail: nmstoyanov@gmail.com

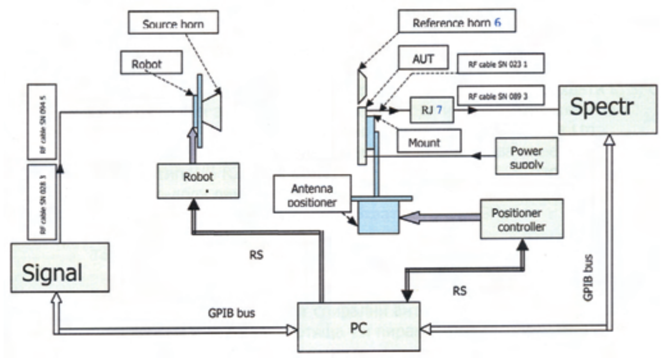

Fig.1. Automated system for measurements of the antenna parameters in anechoic chamber

The above presented system is designed for measurement of antenna gain, antenna pattern of antennas with linear polarization and axial ratio of antennas with circular polarization. The signal-generator, spectral analyzer and the computer are located outside of the anechoic chamber. All the other equipment such as robots, positioners, etalon and measurement antennas and accessories necessary for the measurements is installed in the anechoic chamber. The shielding of the chamber together with the RF absorbing material [2] ensure environment suitable for purpose of the measurements. This kind of measurement chamber simulates free space environment. The shielding reduces the noise level from the surround area and other external influences. The microwave absorbers minimize unwanted waves reflected from the walls, which could influence the measurements. In practice, it is relatively easy high levels of attenuation of the interferences in the surrounding area (from 80 *dB* to 140 *dB)* to be reached by screening, which usually makes these interferences negligible.

The possibility for measurements on the anechoic chamber is limited from the physical dimentions (for aperture antennas), weith, frequency band and equipment which is availability. The physical dimensions are related to the distance *R* between the transmitter and received antennas. Antennas, measured the anechoic chamber, must be fulfill the following condition:

$$R > 2D_1^2 / \lambda \; ; \qquad (1)$$

where:

$$R > D_1 D_2 / 0.32\lambda \qquad (2)$$

R – distance in meters between receiving and transmitting antennas;

D_1 - the largest dimensions of the aperture of antenna under test in meters;

D_2 - the largest dimensions of the aperture of the transmitting antenna in meters;;

λ - wavelength of the radiated signal in meters.

On the other hand, the distance R must be smaller than the largest distance A between two antennas, which depends on geometrical dimensions of the anechoic chamber

$$2D_1^2 / < R < A,\ m\ .$$

The weight of the antenna under test cannot exceed the maximum weight allowed for each positioner. For example, with the positioner antennas can be manually or automatically orientated to the opposite direction through electrical motor. When automated system with electrical motor is used, should be paid attention to the maximum allowed conditions defined from the nominal start and stop moment of the motor. These parameters are usually marked on the motor in kg/m.

The frequency band of measurements of the antenna under test is related to the geometrical dimensions of the anechoic chamber, to the pyramidal absorbers and their price and to the price of the measurement equipment. With the increasing of the frequency band, the bandwidth becomes wider and the price of the anechoic chamber increases.

III. Antenna Parameters Measurement in Anechoic Chamber

The following main antennas parameters can be automatically measured in the anechoic chamber:

1. Antenna radiation pattern;
2. Antenna gain (G).
3. Polarization characteristics of the antennas:
   - Axial ratio (AR);
   - Cross polarization discrimination (XPD).

Values of antenna directivity (D) and antenna efficiency η, based on the measured diagram pattern, measured and computed antenna gain could be calculated.

$$G = D.\eta \tag{3}$$

A. *Measurement of the antenna radiation pattern*

The antenna diagram pattern describes the power or voltage space function. Usually this function describes in spherical coordinate system for fixed distance from the antenna (far field) and fixed frequency. Normally, the diagram pattern consists of main beam, which defines the direction of the maximum radiation and side lobes. Space diagram pattern or antenna pattern cuts, depending on the used method of measurement, could be defined.

Antenna co-polarization and cross-polarization pattern cuts can be taken down, when the wave polarization of the transmitting antenna is opposite to the polarization of the antenna under test. After capturing of these cuts, they may be presented in logarithmic scale.

In order to conduct above-mentioned measurements, special software is developed. The software provides remote control of the positioners, which are situated in the anechoic chamber, and it is necessary to be rotated on azimuth or elevation. In the same way the antenna rotation, height and polarization is controlled. In the most frequently used in practice measurements test set for the antenna pattern, the positioner rotates the AUT and the reference antenna stays fixed at one point from surface of the radiation sphere in the far field, in a way that starting position for axis of the main beam for two antennas is common. Short fragment from the software, which controls of the positioner and orientate the two antennas against each other is shown on fig. 2.

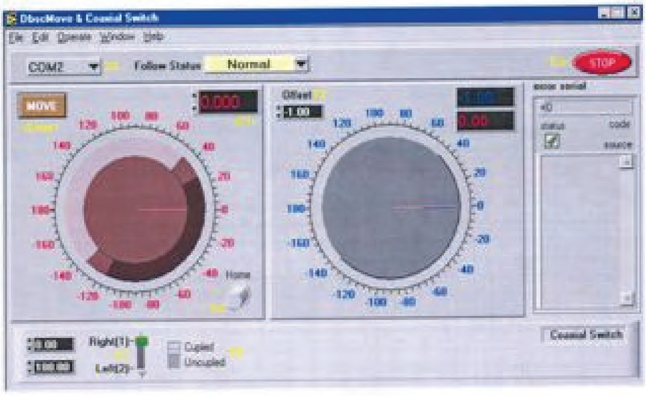

Fig.2. Fragment from the software, which controls of the positioner and orientate the two antennas against each other

The software provides visualization of the measurement procedures. The measured pattern cuts for the co-polarization and cross-polarization are shown on fig. 3.

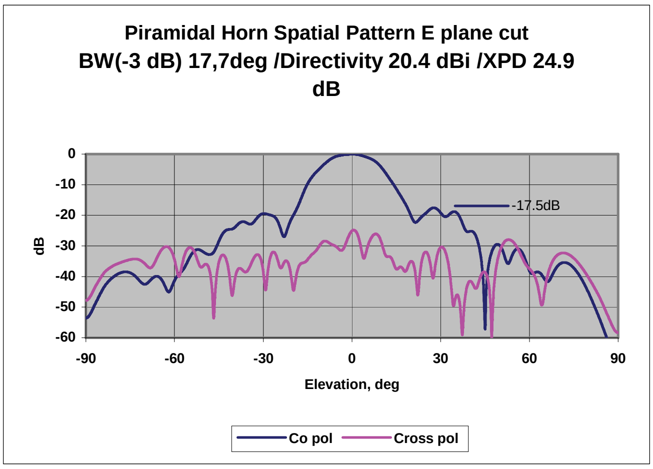

Fig.3. Measured pattern cuts for co-polarization and cross-polarization

B. Measurements of the coefficient of axial ratio of the antenna pattern

It is possible polarization pattern of the anechoic chambers to be taken. The polarization pattern of an antenna is the amplitude response of an antenna, as the antenna is rotated around its axis when illuminated by a linearly polarized plane waves radiated from the transmitting antenna, represented in a polar coordinate system. The axial ratio of an antenna is the ratio of the maximum and minimum of the measured polarization pattern, which is shown on fig.4.

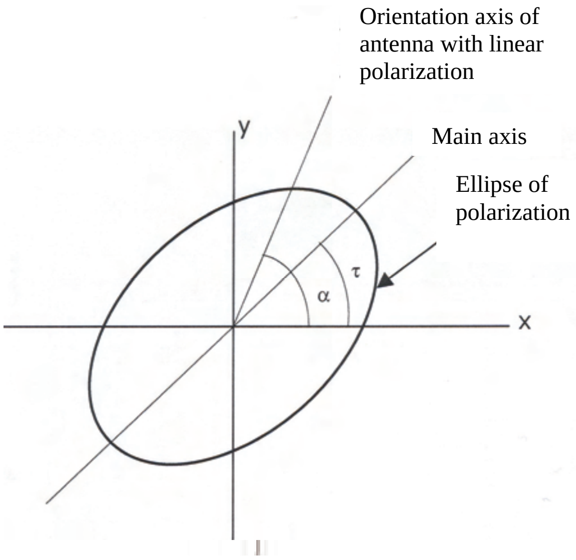

Fig.4. Measurements of the coefficient of axial ratio of the antenna patter

$$AR = P_{R,MAX} - P_{R,MIN}\, , dB$$

The whole measurement process is controlled by specially developed software allowing precise tuning of the positioners and the antennas. Fragments from the software are depicted on fig. 5 and fig. 6.

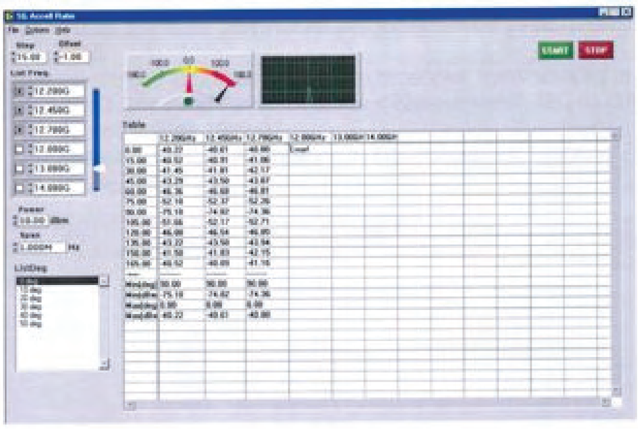

Fig.5. Fragment from the software, which controls the whole measurement process

Fig.6. Fragment from the software, which making tuning of the positioners and the antennas

C. Cross-polarization discrimination of an antenna

This parameter characterizes the ability of an antenna to divide waves with orthogonal polarization, i.e. the main polarization for the AUT and its cross-polarization.

$$XPD = P_{R,CO-POL} - P_{R,CROSS-POL}\, , dB \qquad (4)$$

where $P_{R,CO-POL}, P_{R,CROSS-POL}$ are the received power from AUT for a plane waves with main and cross-polarization respectively.

In order to conduct this kind of measurements, computer sends different commands to the positioner for polarization or antenna rotation, depending on the type of antenna and polarization used.

D. Antenna gain measurements in the anechoic chamber.

There are several different methods for an antenna measurement in an anechoic chamber. The gain comparison method is one of them. The measurements on this method are managed by specially developed measurement software. The computer transmits synchro-pulses for device synchronization through a GPIB buss to the signal generator and spectrum analyzer in the beginning of each measurement procedure.

The two antennas have to be co-axial directly aligned opposite each other. The positioner with control realizes the alignment of the antennas, by tuning the position of the AUT (height, azimuth and elevation) for maximum received power from the transmit antenna (fig. 7).

The signal of the standard antenna comes from the sweep-generator. The level of received signal at the measurement antenna is measured with a spectral analyzer. After the antenna, is measured, as a replacement of measurement antenna is put a standard antenna and measure her level. The levels could be measured by a spectral analyzer and by a vector network analyzer/ VNA (fig.8).

The Gain is calculated as follows:

$$Gaut = L_1 - L_2 + C$$

where Gaut is the gain of the measurement antenna (dBi);

L_1 – measured level of the received signal from the AUT (dB);

L_2 – measured level of the received signal from etalon antenna (dB);

C –gain of the etalon antenna (dBi).

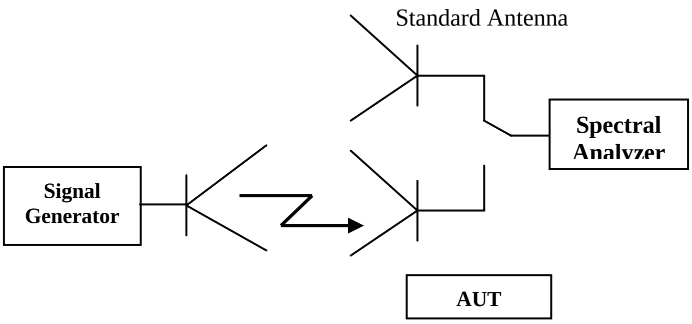

Fig.7 Gain comparison method

The VSWR of the cables and amplifiers used during the antenna measurements are measured by VNA /vector network analyzer/, because of the mishmash loses in them.

Cables and amplifiers are measured for attenuation loses and gain coefficient. All these measurements are made by means of VNA /vector network analyzer/. The VNA can measure the magnitude and phase of S-parameters of the DUT in desired frequency range of measurement. The measurement is automated and together with gain could be done by the computer (fig. 8).

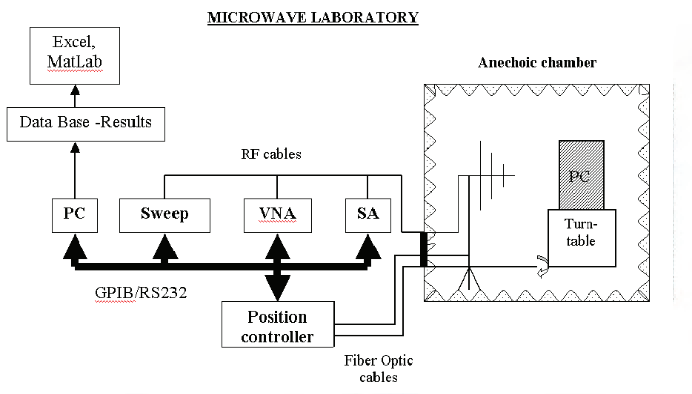

Fig.8 for automatic antenna measurements and radiated emissions from electronic devices

IV. Conclusion

The represented automated system for measurements of the antenna parameters in anechoic chamber increases very much the speed and accuracy of the measurements. All space coordinates of the receiving and transmitting antenna are defined by software and optimal tuning levels are automatically obtained. Synchronization between the transmitting and receiving part accelerate data receiving and processing, likewise data visualization and results from the measurements.

As a disadvantage of the system, it could be mentioned the high cost of the equipment, but as practice shows the money investments quickly returns. When the anechoic chamber and software are used for antennas measurements and EMC measurements for different type of devices and commercial technical equipment the profit becomes bigger.

The anechoic chamber on fig.8 can be used for automatic antenna measurements and radiated emissions from electronic devices.

The developed automated system for control of the measurements, parallel data processing and methodology for antenna radiation pattern measurements and surface wave radiation leads to incessantly improvements of the measurements procedures.

References

[1] P. Watson, K. C. Gupta, “EM-ANN Models for Microstrip Vias and Interconnects”, IEEE Trans., Microwave Theory Tech.,vol. 44, no. 12, pp. 2395-2503, 1996.

[2] B. Milovanovic, Z. Stankovic, S. Ivkovic and V. Stankovic, "Loaded Cylindrical Metallic Cavities Modeling using Neural Networks", TELSIKS'99, Conference Proceedings, pp.214-217, Nis, Yugoslavia, 1999.

[3] S. Haykin, *Neural Networks*, New York, IEEE Press, 1994.