1. Anis Jouini[1], 2. Azer Hasnaoui[2], 3. Fethi Mejri[3], 4. Adnane Cherif[4], 5. Salem Hasnaoui[5]

Sys'Com Research Laboratory, National Engineering School of Tunis, University Tunis El-Manar Tunis, Tunisia(1)(2)(3)(5).
Research Unite of Processing and Analysis of Electrical and Energetic Systems, Faculty of Sciences of Tunis, University Tunis El-Manar Tunis, Tunisia.(4)

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A Real time Software Tool for 2D/3D Antenna Radiation Pattern

***Abstract**. In this paper, we propose an automatic measurement software tool for real time plot radiation patterns of antenna. Notably the proposed software allow the control of a Turntable in Phi and theta angle, a signal generator and a spectrum analyzer via GPIB and TCP/IP interface. So the radiation pattern is plotted in real time on graphical user interface developed based C# software. The proposed test setup is verified by comparing the results with other existed results. This allowed us to achieve good results, which enable this software tool, to be employed for test laboratory and educational purposes.*

***Streszczenie**. W niniejszym artykule proponujemy automatyczne narzędzie pomiarowe do wykreślania charakterystyk promieniowania anteny w czasie rzeczywistym. W szczególności proponowane oprogramowanie umożliwia sterowanie gramofonem w kącie Phi i theta, generatorem sygnału i analizatorem widma za pośrednictwem interfejsu GPIB i TCP/IP. Tak więc charakterystyka promieniowania jest wykreślana w czasie rzeczywistym na graficznym interfejsie użytkownika opracowanym w oparciu o oprogramowanie C#. Proponowana konfiguracja testu jest weryfikowana poprzez porównanie wyników z innymi istniejącymi wynikami. Pozwoliło nam to osiągnąć dobre wyniki, które umożliwiają wykorzystanie tego narzędzia programowego do celów laboratoryjnych i edukacyjnych. (**Narzędzie programowe czasu rzeczywistego do wzorców promieniowania anteny 2D/3D**)*

Keywords: antenna, Radiation Pattern, design.
Słowa kluczowe: antena, projektowanie.

Introduction

The isotropic antenna [1], which radiating the same way in all directions, moreover it is an impractical theoretical model. In reality, the energy radiated by an antenna has unequal distributed in space, where certain directions being favored: these are the "radiation lobes". Additionally the radiation pattern of an antenna makes it possible to visualize these lobes in 2D/3D, in the horizontal or in the vertical plan including the most important lobe. In fact, the proximity and conductivity of the ground or conductive masses surrounding the antenna can have a significant influence on the radiation pattern.

As well as the complete radiation pattern can be summarized into a two useful parameters: directivity and gain.

Notably, the directivity of the antenna in the horizontal plan is an important characteristic in the choice of an antenna where an omnidirectional antenna radiates the same way in all directions of the horizontal plan.

A directional antenna has one or two much larger lobes than the others called "main lobes". In addition, it will be more directive as the larger lobe will be narrow [2].

For all antennas, the dimension constitutes a fundamental parameter to determine the directivity. Antennas with high directivity and high gain will always be large relative to the wavelength [3].

The gain G (θ, φ) of an antenna in one direction (θ, φ) Is the ratio of the power radiated in a given direction P (θ, φ) to the power that an isotropic antenna would radiate without losses. In general, the gain G corresponds to the gain in the direction of maximum radiation (θ0, φ0).

In this work, we have developed a software tool to measure the antenna radiation pattern from 1 Ghz to 18 GHz.

Materials and method

The measurement setup consists of two main parts that are the transmitter side and the receiver side. For the signal generation on the transmitter side, we use the Agilent generator N5182 [4] Consequently, This generator allows us to produce RF signals in a frequency range of 300 MHz and 30 GHz.

Moreover, on the receiver side, we use the Agilent. It is a spectrum analyser capable of measuring electromagnetic waves at frequencies from 100 MHz To 40 GHz. For the rotation of the antenna; an AMTTC-300 controller control turntable to turns 360 ° in the theta and phi angles. What this means that our software tool controls all instrument of the measurement setup by sending SCPI commands through the TCP / IP and GPIB port.

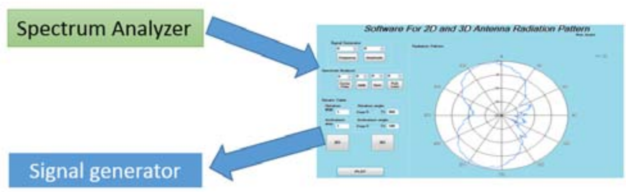

Fig 1. Measurement instruments.

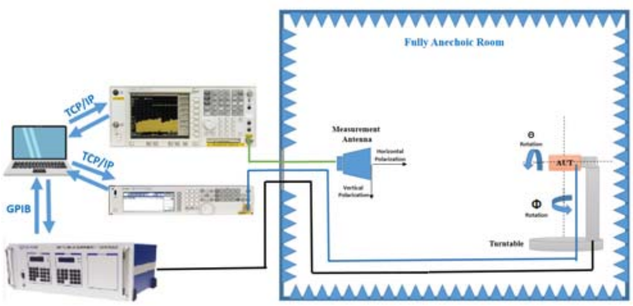

Fig 2. Measurement Setup Configuration.

Radiation pattern measurements are performed inside a full-anechoic Room (FAR).

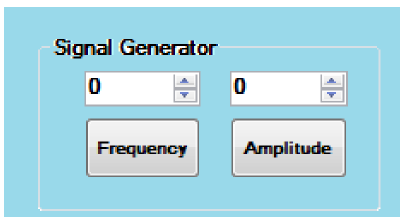

Fig 3. Command of Frequency & Amplitude.

An antenna under test is chosen as the transmitting antenna. It is connected to the Agilent generator. The frequency and amplitude is adjustable using the developed graphical interface, as shown in Figure 3.

The rotary control system is configured as detailed in the previous section. The innco turntable is connected to the AMTTC-300 Antenna turntable controller Fig 4.a that is connected to the computer through the GPIB port as shown in Fig 4.b.

Fig4.a.Turntable controller.

Fig 4.b. Turntable.

The receiving antenna, which is a horn antenna, is placed at a far field distance from the antenna under test. It has been calculated that the minimum distance to place the horn antenna for a far field distance is less than 1 meter from the patch antenna. However, during this test, the horn antenna is placed 3 meters away from the AUT, as shown in Figure 5.

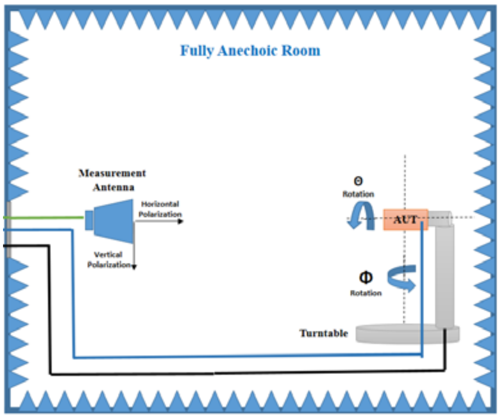

Fig 5. Measurement Full Anechoic Room.

In addition to the above-mentioned study, there is also a need to develop software to control the signal generator, turntable and capture real-time data from the spectrum analyzer. Thus, we used the C# language for the development of this GUI.

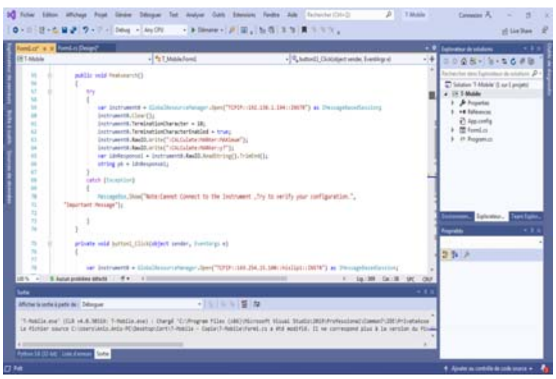

Fig 6. C# development in Visual studio IDE..

In this interface, it is necessary to enter the start angle, the end angle and the rotation step to move the table as shown in Figure 7. Also, enter the amplitude and frequency of the antenna under test as shown in Figure 3.

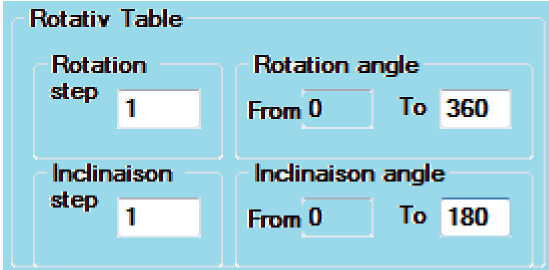

Fig 7. Rotation angles configuration panel.

A part of the graphical interface is dedicated to enter the parameters that allows clarifying the signal received by the spectral analyzer for example: Center Frequency, RBW, SPAN, and Path Loss as indicated in figure 8.

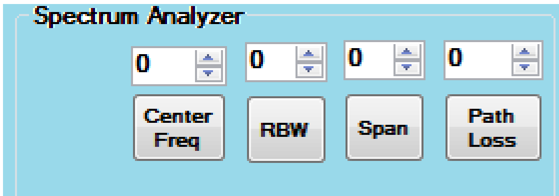

Fig 8. Spectrum analyser configuration panel

Given this points, the spectrum analyzer is connected to computer via GBIP interface. For software development, it is required to define the visa resources and the other related attributes. The final GUI shows a small window to input the angle to step and the current angle, remote show of the spectrum analyzer and real time plotting window of the radiation pattern as shown in Fig. 9.

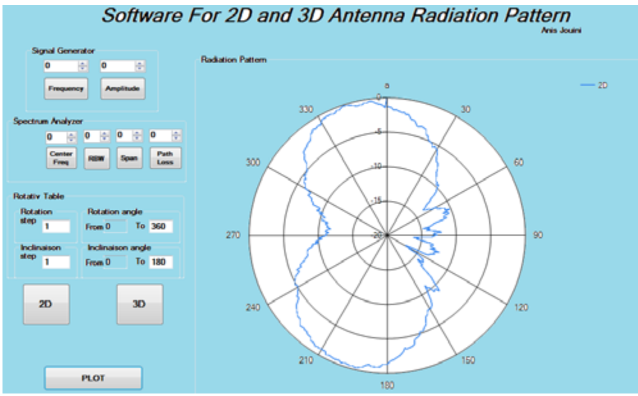

Fig 9.Interface of developed Software.

Result

To validate the proposed measurement application, we tested two different antennas. Thus results of the simulation are compared with the measurement results obtained using the proposed software tool.

The first example is a commercial omnidirectional antenna operating at a frequency of 2.4 GHz and 5.8 GHz.

The Omni antenna is illustrated in Figure 10.

Figure 11, represents both a 2D polar plot declared in the datasheet and measurements by the proposed interface. Therefore, the results of the measurement and the simulation are different.

Fig 10. Test of Commercial Omni-directional Antenna.

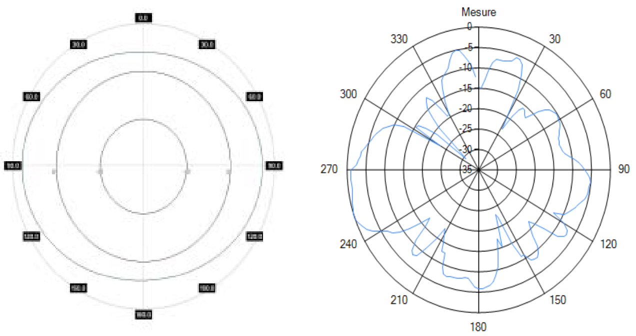

Fig11**.** Comparison between datasheet and real measurement.

The second example is a micro-strip patch antenna with a frequency of 3.5 GHz; this patch antenna is modeled in CST. The fabricated antenna is shown in Figure 12.

Fig 12. Test of micro strip patch antenna.

The normalized 2D radiation patterns of the CST simulation and the measurements are shown in Figure 13. As it is shown, the main lobe is in the direction of the z-axis.

As illustrated in Figure 13, the measurement results are quite close to the simulation results. Importantly, the measurement results of the main lobe and the back lobe are adequate, although the null values of the measurement do not correspond very well to the results of the simulation.

Using the tool we have developed, we can draw the radiation diagram in 3D. our software allowed us to generate an excel file containing the phi and Theta rotation angles, and the amplitude levels received by the analyzer. as it is shown in the Figure 14 by entering this excel file in Originlabs we can see the radiation diagram in 3D.

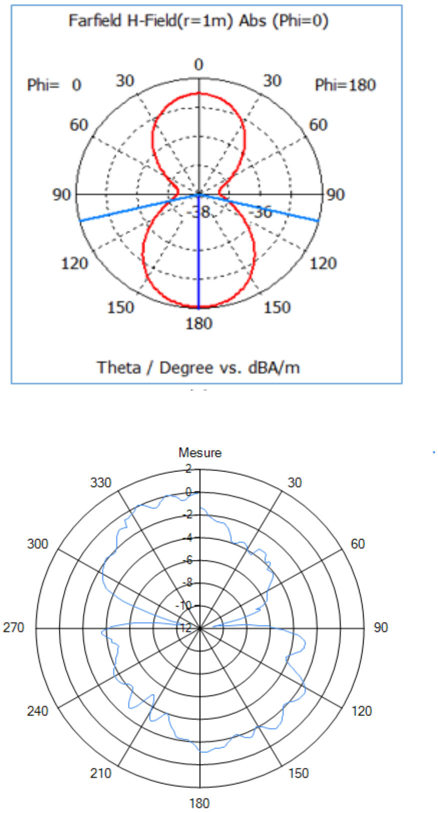

Fig 13. Comparison between simulations and real measurement results.

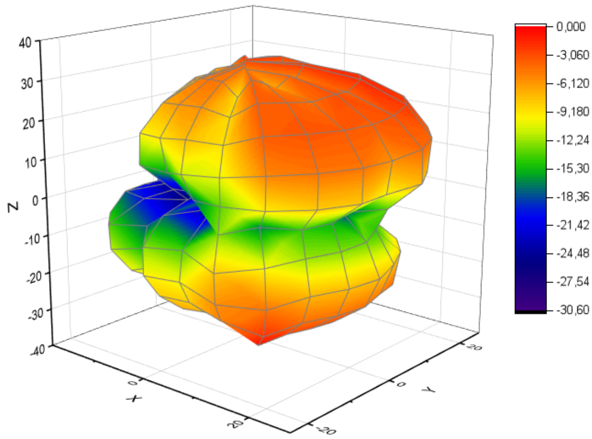

Fig 14. 3D radiation pattern.

Conclusion

Substantially, a simple software tool has been developed for the measurement of the antenna radiation pattern. Under those circumstances, the developed tool can plot the antenna radiation pattern in real time and save the data to an Excel file, making it suitable for laboratory testing and research.

Additionally, with this tool, we are able to verify the accuracy of the radiation pattern of commercial antennas and antennas developed for reasons of scientific research. It can also be used for quick identification of the radiation pattern of antennas used in wireless systems.

***Authors**: PhD Student. Anis Jouini, Sys'Com Research Laboratory, National Engineering School of Tunis, University Tunis El-Manar Tunis, Tunisia.*
E-mail: Jouinianis53@gmail.com;
PhD Student. Azer Hasnaoui, Sys'Com Research Laboratory, National Engineering School of Tunis, University Tunis El-Manar Tunis, Tunisia.
E-mail: hasnaoui.azer@gmail.com;
Professor Fethi Mejri, Sys'Com Research Laboratory, National Engineering School of Tunis, University Tunis El-Manar Tunis, Tunisia.
E-mail: fethi_mejri@laposte.net,
Professor Adnane Cherif, Research Unite of Processing and Analysis of Electrical and Energetic Systems, Faculty of Sciences of Tunis, University Tunis El-Manar
Tunis, Tunisia.
E-mail :adnane.cher@fst.rnu.tn
Professor Salem Hasnaoui, Sys'Com Research Laboratory, National Engineering School of Tunis, University Tunis El-Manar Tunis, Tunisia..
E-mail : Salem.Hasnaoui@enit.rnu.tn

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