

Software for Automated Measuring Pattern Diagrams of Wide Frequency Bands Antennas with Integrated Receivers

Dragan Obradović¹, Igor Stančić², Aleksandar Kopta³, Zoran Mičić⁴ and Predrag Manojlović⁵

Abstract – In this paper is described software and method for automated measuring antennas and antennas systems in wide frequency band. This software can be used with all antennas types and antennas with integrated microwave receivers with analog or digital output. It is also shown results of measuring the horn antennas system with the integrated microwave receivers in frequency range from 15 to 19 GHz.

Keywords –Antennas, Antenna measurement, Measurement software, Integrated microwave receivers

I. INTRODUCTION

The measuring instruments for a long time have the capability of connection with PC computers. This capability helps to create very complex measuring methods which significantly accelerate and simplify measuring, especially if are used a lot of calibration data [1]. The PC computers are usually connected with the instruments over GPIB (IEEE488.2), RS232, USB or Ethernet interfaces.

It is usual to develop or adopt software for each measuring methods [2]. There are many commercial software applications that can be used in the measuring automation like LabView from National Instruments [3][4], Matlab from Mathworks [5] or OpenLab from Agilent [6]. Implementation of the measuring methods with commercial software applications should be developed in the development environment of that applications. If used instruments or equipments are not supported by the commercial applications, it should be developed. When commercial applications are used, it must be also paid for licensing. In some cases is more convenient to develop complete measuring software in the standard development environment, especially if there are many devices in the measuring methods which are custom

¹Dragan Obradović is with the IMTEL Komunikacije, Bul. Mihajla Pupina 165b, 11070 Belgrade, Serbia, E-mail: obrad@insimtel.com.

²Igor Stančić is with the IMTEL Komunikacije, Bul. Mihajla Pupina 165b, 11070 Novi Beograd, Serbia, E-mail: stanco@insimtel.com.

³Aleksandar Kopta is with the IMTEL Komunikacije, Bul. Mihajla Pupina 165b, 11070 Novi Beograd, Serbia, E-mail: kopta@insimtel.com

⁴Zoran Mičić is with the IMTEL Komunikacije, Bul. Mihajla Pupina 165b, 11070 Novi Beograd, Serbia, E-mail: zoran@insimtel.com

⁵Predrag Manojlović is with the IMTEL Komunikacije, Bul. Mihajla Pupina 165b, 11070 Novi Beograd, Serbia, E-mail: pedja@insimtel.com

designed and if they are not supported by commercial applications.

This paper will show the developed software and method for automated measuring antennas and antennas systems with integrated microwave receivers in wide frequency band.

II. MEASURING METHOD

The measuring method which is shown on Fig. 1. can be used for measuring antenna patterns on a number of frequencies in the cases where received signal can be measured directly on the antennas or if antenna is integrated with receiver which has the analog output.

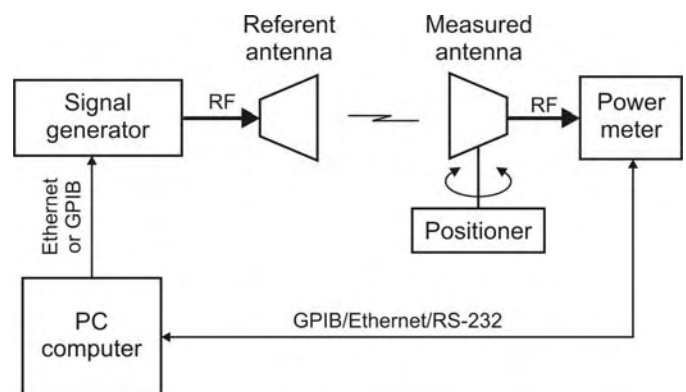


Fig. 1. Automated method for measuring antenna radiation pattern

The measured antenna is on the positioner which has capability of manual fine angle settings. The output of the antenna or integrated receiver is connected to the power meter which is connected to the computer with measuring software. Transmitting referent antenna is connected to the RF signal generator which is also connected to the computer with measuring software. For each angle of the measured antenna, the measuring software sends commands to the signal generator to set desired signal frequencies. For each set frequency, received level from measured antenna is read and stored to the database.

When the antenna radiation pattern with integrated receiver is measured at multiple frequencies in the case when the receiver output is in digital form, the measuring method which can be used is shown on the block diagram in Fig. 2.

This measuring method is similar like previously described, except that output of the integrated receiver is in digital format [8][9]. In some cases receiving frequency channel should be set by measuring software computer.

In both shown methods is used azimuth positioner with manual angle setting. The described methods can be used for

controlled positioner with some modification in the measuring software.

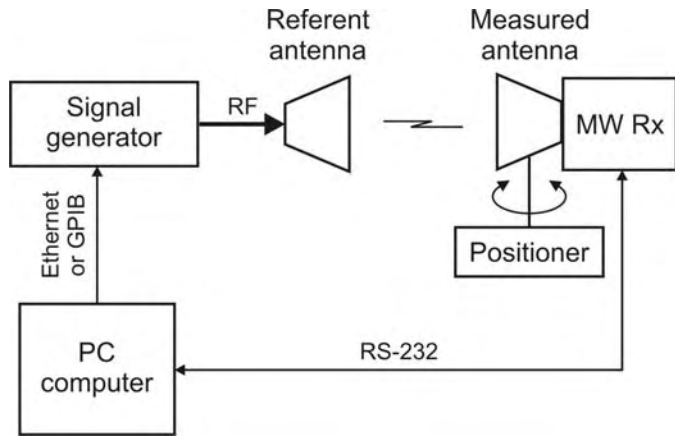


Fig. 2. Automated method for measuring radiation pattern of antenna with integrated receiver with output in digital format

III. SOFTWARE ORGANIZATION

On Fig. 3 are show components of the developed software for automated measuring antenna radiation pattern. The Components are same and for other methods.

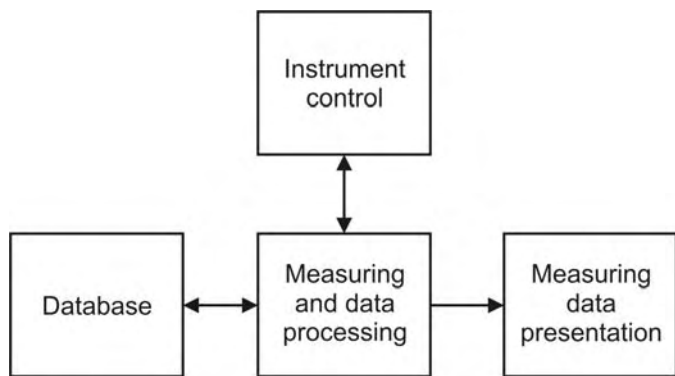


Fig. 3. The components of the software for automated measuring

The instruments control component is realized like class library where is for each type of instrument is created separately abstract class. The software for some measuring method can use any available instrument which is supported by library class and software developing can be focused on measuring method not on controlling and connecting with the instruments.

The results of measuring are stored in database for later processing and presentation. For the database can be used Access file format or database servers like MS SQL or MySQL. It is usually for each measuring method to use two database tables. The first is used for storage data about measuring conditions, and the second to storage measured data.

The presentation component is used to show raw or processed measuring data in desired form. The measured data from database can be shown in graphical form or exported to Excel or other file format for later analysis or using. In this stage of software development, it is used external software

application Gnuplot [11] for drawing many types of graphics. Command and data files for Gnuplot are creating by the measuring software.

IV. INSTRUMENT CONTROL LIBRARY

Source code for instrument control is separated from software for measuring methods into library, which can be used for different measuring applications [12]. The basic request in design of this library was that the programming classes for instruments be grouped by type and function of the instrument, not by type of connection. The library was developed in C# programming language for .NET Framework [13] like dynamic library DLL file.

In Fig. 4 is shown part of the class diagram for this library. All instrument classes are inherited from abstract class Instrument which has methods Open() and Close() for opening and closing connection to instruments. Those methods are implemented in inherited classes and depend from instrument type and connection type. All classes inherited from the class Instrument have attribute InstConnection which describe type and parameter for connection to the instrument.

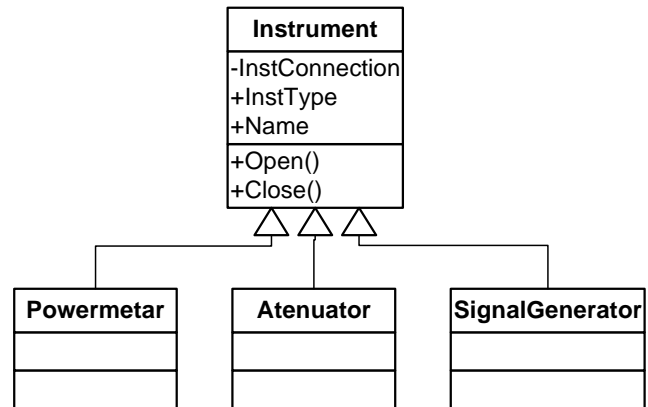


Fig. 4. The abstract class Instrument and inherited classes for instrument types

The classes for particular instrument type by function have methods which are specified for that instrument type. Implementations of those methods are in inherited classes for each instrument model. In Fig. 5. is shown the class diagram for microwave signal generators. For each models the structure SigGenSpec has characteristics of the particular instrument model (e.g. operating frequency and output levels ranges, etc.) and measuring software can read operating range for selected instrument model.

When measuring software is developed it will be made reference to base class for instrument type, not for particular instrument model. It is also possible to list available instrument models, and with static method of the base class it is possible to create object of the selected instrument model. In this example with signal generator, static method CreateSigGen() is defined for this purpose. In this way is possible to change DLL instrument library with new one which support new instrument model without changing and compiling existing measuring software.

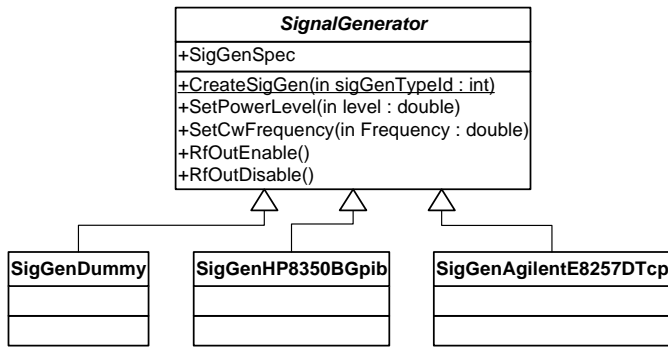


Fig. 5. The abstract class *SignalGenerator* and inherited classes for different instrument models

Not all instrument models should have connection to the real equipment. For example, the class *SigGenDummy* is virtual instrument and it is very useful during measuring software development.

V. SOFTWARE REALIZATION

Software for automated antenna radiation pattern measuring is realized like Windows form application which is executed under .NET Framework. Complete software was written in programming language C#. Measuring software application supports measuring for different methods. For each measuring methods were developed different customized windows forms. The software makes possible setup parameters for each measuring and choice of measuring instrument models. Configuration data are stored in XML files. Forms for application configuration are same for all measuring methods. Fig. 6 shows the windows form for selection and configuration instruments.

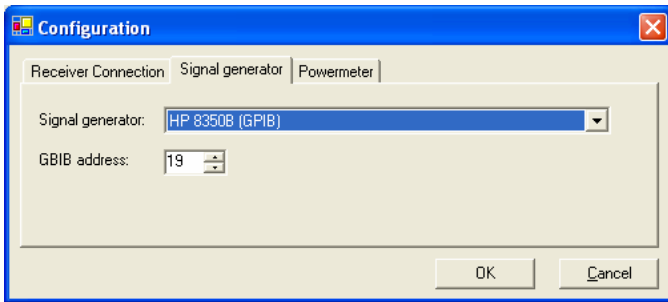


Fig. 6. Windows form for selection and configuration instruments

In the shown software, it is used local .mdb Access format file. Measured data in the antenna radiation pattern measuring method are stored into two database tables *MeasAngle* and *MeasAngleResults*. In *MeasAngle* table are saved general data about measuring like frequency range and step, time of start measuring, comment, etc. Unique ID of measuring will be got from field *IdMeasAngle* in this table after the record is saved. The second table *MeasAngleResults* is used for storage measured data with ID of measuring.

Software module for executing antenna radiation pattern measuring with integrated receivers with digital outputs is realized to use in advanced defined states. In Fig. 7. are shown

diagram with transitions between states. For simplicity, in this diagram are not shown transitions to error states.

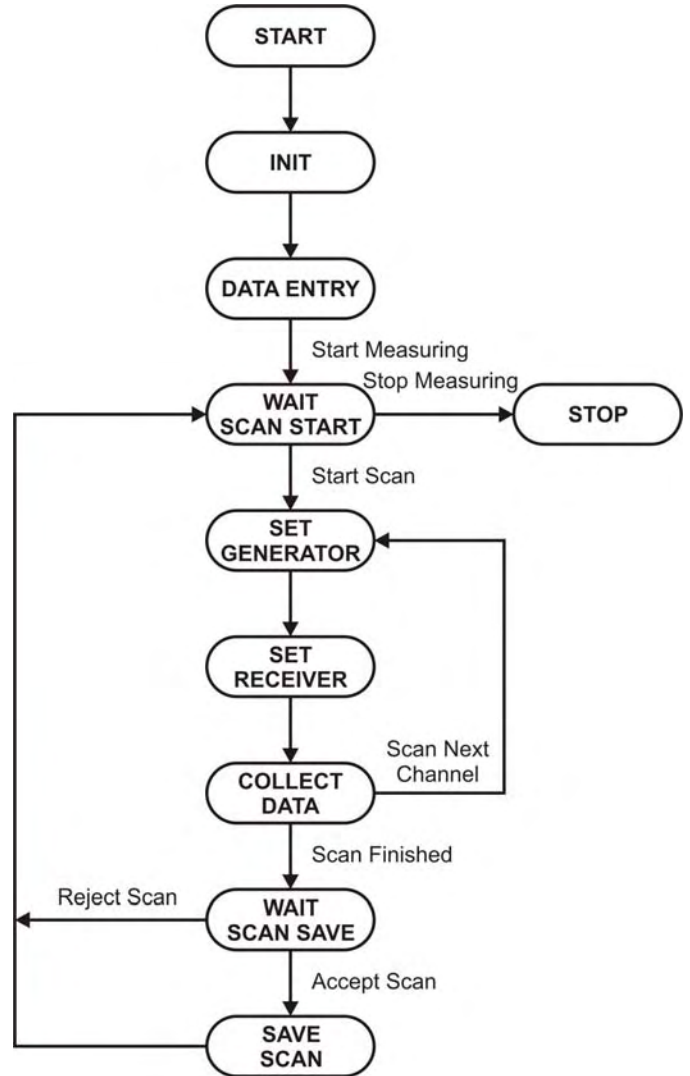


Fig. 7. Diagram states of the software modul for antenna radiation pattern measuring with integrated receivers with digital outputs

When the software module is started initialization of the communications with instruments and receiver and opening database will be done. In the state *DATA ENTRY*, user can enter measuring parameters (frequency range and step, comment, etc.). When user press button to start with measuring, application is in the state *WAIT SCAN START* where application wait for user to setup antenna positioner on required angle. When user press button to continue measuring, the application in the state *SET GENERATOR* setup signal generator on needed frequency, and in the state *SET RECEIVER* setups receiver on needed frequency channel. In the state *COLLECT DATA* collects data from the receiver. Signal generator frequency and receiver channel are incremented while boundary frequency is not reached. Then the application goes to the state *WAIT SCAN SAVE*, where wait for user to accept this measuring which is shown in the form and save records to database. If measuring data are accepted, the next state is *WAIT SCAN* when user needs to change antenna angle.

On Fig. 8. are shown windows forms for antenna radiation pattern measuring.

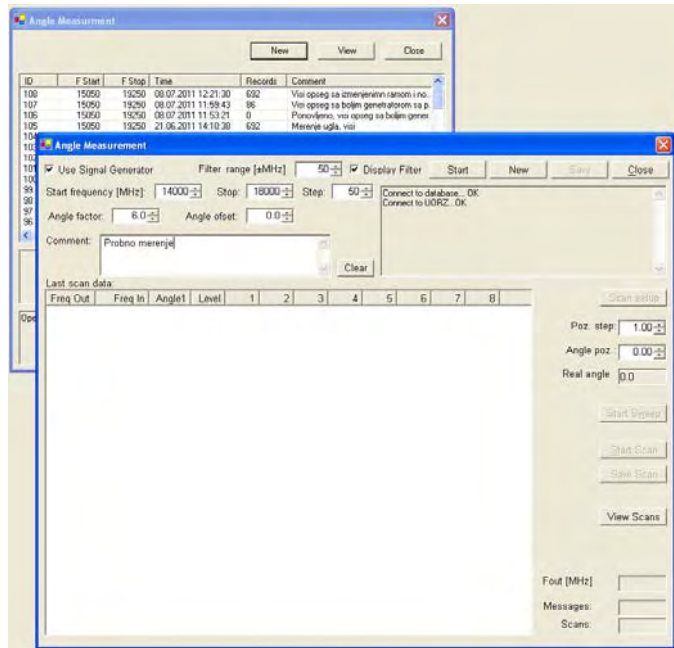


Fig. 8. Windows forms for antenna radiation pattern measuring

VI. MEASURED DATA PRESENTATION

Measured data from the database can be presented in tabular and graphical forms. Because there are large number of measured data, tabular view is not always suitable. The application supports export measured data to Excel and CSV file formats for analysis or representing in other programs.

Graphical views of the measured results are more convenient. Orthogonal, polar and 3D graphical views are supported for representing antenna radiation patterns. In Fig. 9. is shown 3D radiation pattern diagram for horn antenna which are measured on 46 different frequencies in ranges from 15 to 19.5 GHz with step from 100 MHz and with angle step from 22.5°. On this diagram is easy to observe some irregularities in antenna radiation patterns on some frequencies.

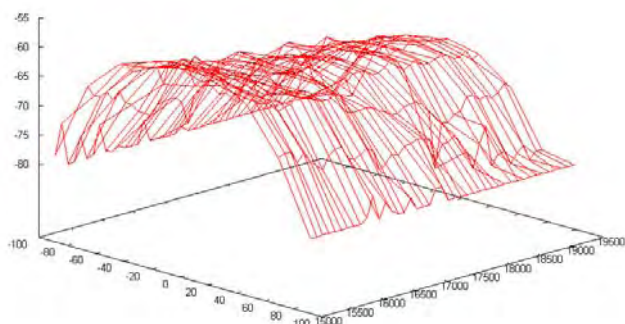


Fig. 9. Example of 3D antenna radiation pattern digram which depends from frequency

VII. CONCLUSION

Described method and software allow to make automated measuring of antenna radiation patterns on antenna with integrated receivers on desired number of frequencies. The software helps to make measurement for shorten time and to present on convenient way large amount of measured data. Different presentation types of he measured data can help to check for possible problems in realization of the tested antennas. The software also can be upgraded for supports for a new instruments types and models, for different kinds of integrated receivers and to support new measuring methods.

ACKNOWLEDGEMENT

This work was partially supported by the Ministry of Education and Science of the Republic of Serbia under Grant TR-32024.

REFERENCES

- [1] E. Krufft, P. Packebush, "Calibration ensures accuracy," IEEE Spectrum, vol. 37, no. 11, pp. 66-69, Nov. 2000.
- [2] Joseph P. Keithley, "Customization is key to future instrumentation", IEEE Spectrum, vol. 36, no. 1, pp. 94-95, Jan. 1999.
- [3] P. Ponce-Cruz, F. D. Ramírez-Figueroa, *Intelligent Control Systems with LabVIEW*, London: Springer, 2010.
- [4] www.ni.com
- [5] www.mathworks.com
- [6] www.agilent.com
- [7] M. Pirola, V. Teppati, V. Camarchia, "Microwave measurements Part I: Linear Measurements," IEEE Instrumentation and Measurement Magazine, vol. 10, Issue 2, pp. 14-19, Apr. 2007.
- [8] S. Jovanović, P. Manojlović, D. Obradović, N. Mitrović: "Wideband Receiver for Signal Detection in Frequency Range from 15 to 19 GHz", Proceedings of Papers XLV ICEST, Vol. 1, Ohrid, FYR Macedonia, 2010, pp. 545-548.
- [9] D. Obradović, S. Jovanović, N. Mitrović, Ž. Gajić: "Realization of IF signal processing for millimeter band signal detector system", 54. ETRAN, Conference Proceedings, pp. MT2.4-1-4, Donji Milanovac, Serbia, 2010.
- [10] Jovanović Siniša, Manojlović Predrag, Tasić Siniša, Obradović Dragan, Mitrović Nemanja, "Wideband receiver for signal detection in frequency range 11-15 GHz", TELFOR 2010, Conference Proceedings, Belgrade, Serbia, 2010.
- [11] T. Williams, C. Kelley, *Gnuplot 4.4 - An Interactive Plotting Program*, 2010.. Available: www.gnuplot.info
- [12] Dragan Obradović, Predrag Manojlović, Nemanja Mitrović, Siniša Jovanović, and Željko Bojović, "Software for automated measuring of the wideband microwave receivers", TELFOR 2010, Conference Proceedings, Belgrade, Serbia, 2010.
- [13] J. Albahari, B. Albahari, *C# 3.0 in a Nutshell. 3rd ed.*, Sebastopol: O'Reilly Media, 2007.