

AUTOMATING MEASUREMENT OF RADIATION PATTERN IN LABVIEW

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This paper deals with augmentation of original control software programmed in LabVIEW, made for controlling the movable antenna mast, for the purpose of automating the measurement process of antenna radiation pattern in an anechoic chamber. Introduction of this paper contains information about the anechoic chamber and radiation pattern measurements in general. Next parts of the paper describe the original software developed for controllable mast and how this software was augmented for automated measurements purposes.

K e y w o r d s: process automation, LabVIEW, antenna radiation pattern, anechoic chamber

1 INTRODUCTION

Antenna is a device made to radiate energy from connected system into the free space and vice versa [1, 2]. Since real antennas don't radiate evenly in all directions, it's necessary to know how the total radiated energy is distributed in their surrounding area. The parameter describing this energy distribution in all directions from antenna is called spatial radiation pattern [1, 2, 3]. Example of such spatial radiation pattern is in Figure 1.

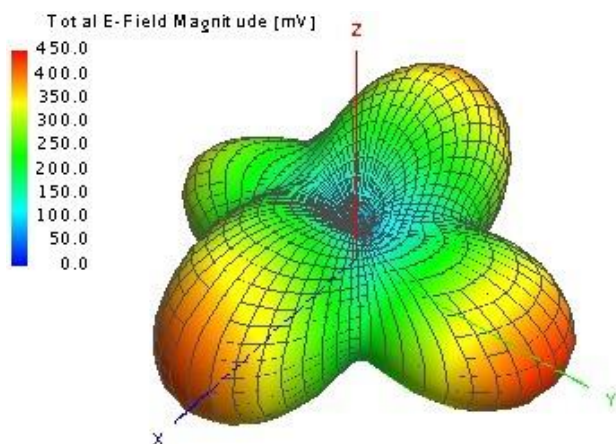


Figure 1: Example of antenna spatial radiation pattern

Radiation pattern is usually measured in an anechoic chamber [1, 2]. It is a closed area containing only the most essential equipment which needs to be inside, for example antennas, masts and cables. Signal generator, spectral analyser and other equipment is placed outside the chamber. Anechoic chamber has two basic purposes. First one is to isolate from any outside electromagnetic radiation that could interfere with measurements. The second one is to absorb radiation on its inner walls, so no echoes are created inside the chamber, thus eliminating another significant source of error.

Spatial radiation pattern is measured at Faculty of aeronautics TUKE in the anechoic chamber by placing analysed antenna, or aircraft model with mounted antenna, onto controllable antenna mast. This custom mast, marked MSU01, was developed and constructed by ZTS VVÚ Košice and has ability to move both in rotation

and elevation. The analysed antenna is connected to spectral analyser and is irradiated by another antenna inside anechoic chamber, which is connected to signal generator. Analysed antenna is then positioned by controllable mast to obtain its spatial radiation pattern. Setup at Faculty of aeronautics TUKE is displayed in Figure 2.

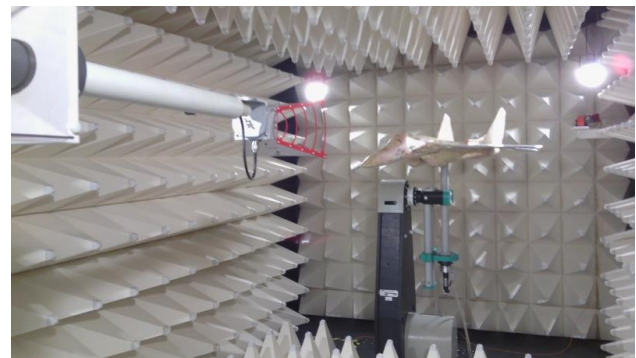


Figure 2: Inside of anechoic chamber

2 ORIGINAL CONTROL SOFTWARE

To control the MSU01 movable antenna mast, ZTS VVÚ Košice developed a control software implemented in LabVIEW. This software has all the important functionality, like setting absolute position of mast, changing movement speed, axis selection, homing function, error reporting and so on. Preview of this complex software is in Figure 3 and in Figure 4. LabVIEW Block diagram of original software is not shown due to possible copyright infringement.

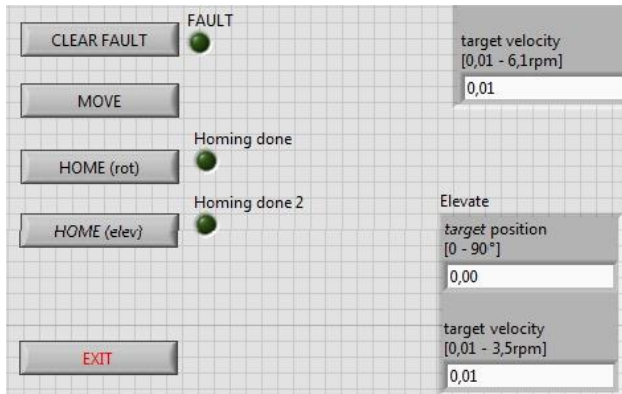


Figure 3: Preview of software interface (centre of Fig. 4)

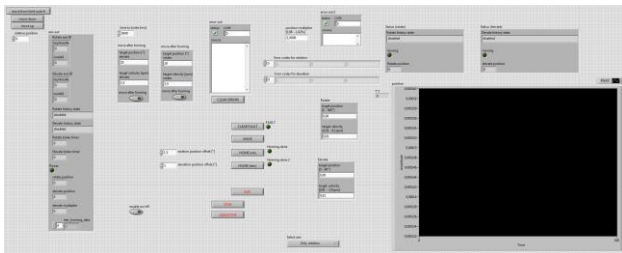


Figure 4: Preview of software interface, overall view

Although this original control software is sophisticated, it does not feature any option for automated measurements. To measure the complete spatial radiation pattern with original control software, the following steps had to be made:

1. Set up signal generator
2. Set up spectral analyser
3. Set mast position through software
4. Read value from spectral analyser
5. Write this value down, together with current elevation and rotation status

To obtain the spatial radiation pattern with accuracy of 5° , steps 3, 4 and 5 need to be repeated overall 2701 times, which takes huge amount of time. Software functionality had to be therefore extended by means of process automation.

3 AUGMENTATION OF ORIGINAL SOFTWARE

As the original control software has been programmed in LabVIEW, altering its functionality is possible. The main goal was to automate spatial radiation pattern measurements. The secondary goal was to create such data file from measurements, which would be compatible with FEKO software import function, for graphical viewing of results. To achieve these goals, LabVIEW programming environment had to be studied [4, 5, 6]. Basic idea was to implement these steps:

1. Connect to spectral analyser, set it up
2. Move the mast to desired position

3. Read value from spectral analyser
4. Write this value, together with current mast position information, to data file
5. Repeat steps 2,3 and 4 for all positions

Augmentation of the original software by these steps was made by applying reverse engineering, implementing communication with spectral analyser and creating a new program procedure. The resulting LabVIEW front panel is shown in Figure 5.

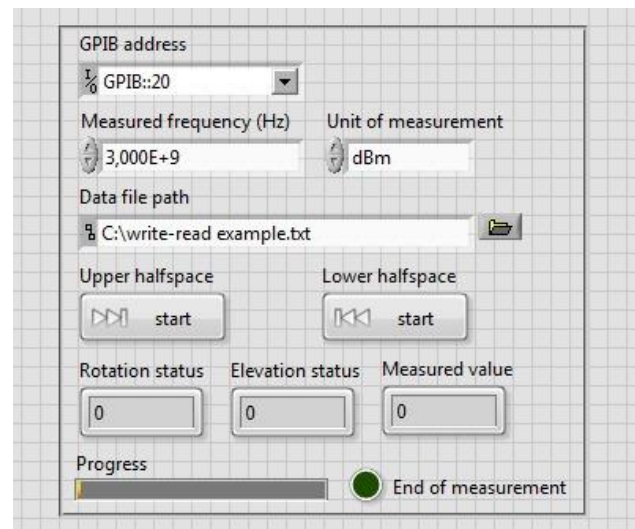


Figure 5: Front panel of created program procedure

Design of two half spaces, as can be seen in figure above, is due to physical limitation of mast possibilities. The mast of MSU01 can operate only in 90° in elevation. For complete spatial radiation pattern, elevation of 180° is necessary.

Before running the new program procedure, by clicking on „start“ button, frequency and unit of measurement must be set, as well as data file path. GPIB address of spectral analyser remains constant. Manual setup of signal generator is also required.

By hitting „start“ button the following happens:

1. Spectral analyser is initialised and configured
2. Data file is opened
3. All statuses are set to default states
4. Mast is moved to starting position
5. Series of 10 measurements at single position is made
6. Mean value of this series is written to data file, together with current position of mast
7. Mast is moved 5° in rotation
8. Step 5 and 6 repeat

9. After measuring the whole rotation range of 360°, mast moves 5° in elevation and another round of measurements in rotation begins
10. When all steps are complete, access to data file is closed, communication with spectral analyser is closed, indicator „End of measurement“ is lit up and other statuses are set to default

Running both half space procedures, by hitting the second „start“ button after the first half space measurement is finished, provides complete spatial radiation pattern. Procedures for upper and lower half space do vary only in few details.

The procedure for the upper half space is debated in the next few lines in a bit more detailed way, by describing its LabVIEW block diagram. As will be seen, it is mostly composed as a series of subVIs and FOR loops of defined numbers of repetition. These specific numbers were chosen to correspond to 5° movement, which provides sufficient accuracy.

One of the first steps is to initiate and configure the spectral analyser. For this purpose, a subVI was created, shown in Figure 6. Its inputs are „GPIO address“, „Measured frequency“ and „Unit of measurement“ from Figure 5. This subVI consists of blocks from Rohde&Schwarz for the spectral analyser connected to each other, so analyser is set to chosen single frequency, together with 4% frequency span to display data on spectral analyser for fast check.

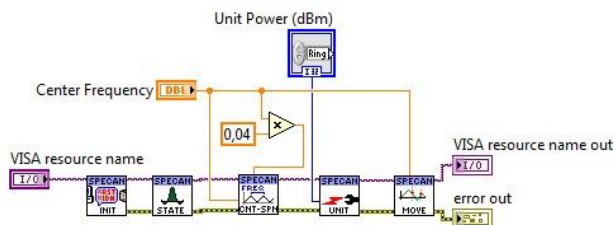


Figure 6: Spectral analyser initialisation

Moving the mast to its starting position is made by single FOR loop with „MOVE“ block created by the original software developers and a time delay. As can be seen in Figure 7, the starting position is set to 360° in rotation and 90° in elevation. Number „2“ defines movement in both rotation and elevation. Time delay assures that next steps won't start before movement is finished.

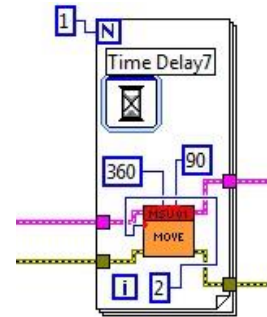


Figure 7: Initial position of mast

The main part of procedure is presented in Figure 8. It consists of nested loops of subVI and „MOVE“ blocks, creating proper movement, measurement and recording of data.

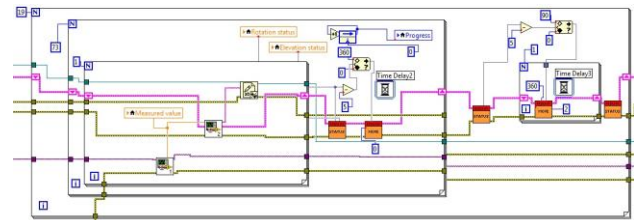


Figure 8: Main part of the procedure

Important component of this procedure is the measurement itself. It is made as a series of 10 individual measurements, which are then averaged.

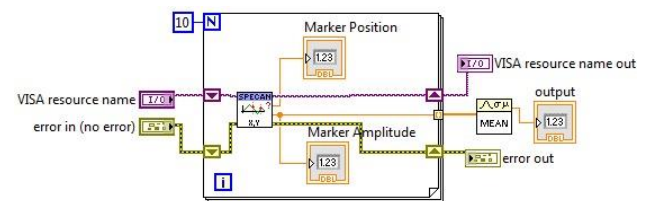


Figure 9: Measuring with spectral analyser

Then this single data output enters subVI for data file creation, together with MSU01 data output, from which the current position is read. An example of the created data file can be seen in Figure 11. The first column contains information about position in rotation, the second in elevation and the third column contains data from the spectral analyser.

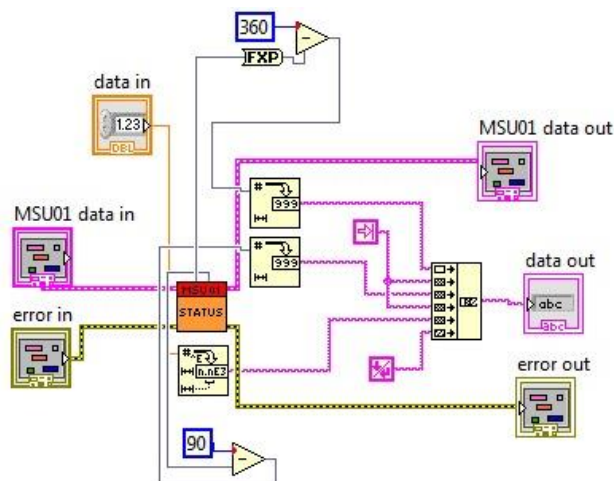


Figure 10: Creation of a data file

meranie.txt - Poznámkový blok

| Súbor | Úpravy | Formát | Zobrazit | Pomocník |
|-------|--------|---------------|----------|----------|
| 0 | 0 | -49.440446E+0 | | |
| 5 | 0 | -49.032054E+0 | | |
| 10 | 0 | -48.185237E+0 | | |
| 15 | 0 | -47.667566E+0 | | |
| 20 | 0 | -47.635417E+0 | | |
| 25 | 0 | -48.137739E+0 | | |

Figure 11: Example of the created data file

Movement in rotation is made by reading current rotation position by „STATUS“ block, subtracting 5° from it and this new position is set as input to „MOVE“ block, which moves the mast to this new position. It is shown in Figure 12, together with progress bar addition.

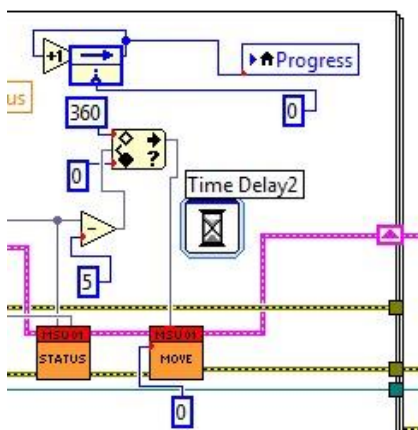


Figure 12: Rotation (centre of Pic. 8)

The movement in elevation is programmed very similarly, as can be seen in Figure 13. This part also includes return in rotation back to 360°. Although 0° and 360° are the same position, it needs to be done this way, so entanglement of antenna cable around mast is avoided.

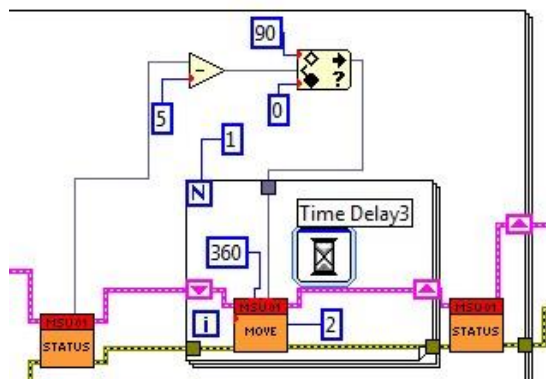


Figure 13: Elevation (right side of Pic. 8)

After running all FOR loops and thus measuring spatial radiation pattern with 5° accuracy, procedure continues to set all statuses to the default state and „End of measurement“ indicator is lit up.

4 TIME SAVINGS

Several tests were made in order to determine time savings achieved by the realised process automation. Measurement for one half space with automated software takes approximately three hours to complete. As there are two half spaces, this sums up to six hours. Taking preparation of measurement, instruments set up, lunch break for staff and other time consuming processes into account, one whole spatial radiation pattern measurement takes about one workday to complete.

As time required for the whole spatial pattern measurement without automation was expected to be much greater than one workday, simple assumptions and estimations were made in order to gain approximate time required for single measurement without automation.

Time required for a specific action was measured, first for automated control software and then for human operator performing the same action. This action was creation of data file of ten lines. Each line consisted of current mast position and current electric field strength, gained as average of ten values read from the spectral analyser. Both times were recorded.

Automated system achieved time of one minute and two seconds. Human operator completed the same task in twenty-three minutes and thirteen seconds. Time of the automated system can be rounded to one minute, time of human operator, adding margin for possible errors due to monotonous activity, to twenty-five minutes.

By direct correlation of mentioned findings, it is possible to assume that the time required for measuring of the spatial radiation pattern without automated control software would be approximately twenty-five workdays.

5 CONCLUSIONS

Augmentation of original control software was successful. Both goals, automating the measurement of

spatial radiation pattern and creation of FEKO compatible data file, were accomplished. Huge time saving were achieved. One spatial pattern measurement takes one workday, instead of approximately twenty-five workdays without automation. Future work includes optimising time delays in procedures and reduction of acceleration and deceleration time of mast motor, in order to achieve even greater time savings.

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BIBLIOGRAPHY

- [1] MACNAMARA, T.: Introduction to Antenna Placement and Installation, 2010, ISBN 978-0470019818
- [2] STUTZMAN, L.; THIELE, G.: Antenna Theory and Design, 2012, ISBN 978-0470576649
- [3] ORFANIDIS, S.: Electromagnetic Waves and Antennas, 2013,
URL: <www.ece.rutgers.edu/~orfanidi/ewa>
- [4] LARSEN, R.: LabVIEW for Engineers, 2011, ISBN 978-0136094296
- [5] STAMPS, D.: Learn LabVIEW 2012 Fast, 2013, ISBN 978-1585038503
- [6] ESSICK, J.: Hands-On Introduction to LabVIEW for Scientists and Engineers, 2012, ISBN 978-0199925155

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