

# DEVELOPMENT OF THE SOFTWARE FOR THE ACCELERATING FIELDS IN LINEAR STRUCTURES MEASUREMENT

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## Abstract

The software which allows controlling the whole installation to measure electric fields in the linear structures has been developed. The installation consists of linear structure, step motor drive, motor controller, a probe which moves on the string through the structure to perturb the field to use the perturbation measuring method, network vector analyzer and the PC. The software interface is user-friendly, user only needs to write down the length of the structure, a desired step of the probe and push the start button. As a result user can obtain the picture of electric field on the structure axis. It is possible to choose between two measuring methods: by S11 or by S21.

## METHOD DESCRIPTION

Information about electrical field amplitude and phase distribution along the axis of the accelerating or deflecting section can be obtained from the measurements, based on non resonant perturbation theory. According to this theory, change of the complex reflection coefficient on the entrance of the structure, when the small perturbing body is in the structure, is proportional to the square of the electric field amplitude in the point where perturbing body is placed:

$$\Delta S_{11} = S_{11}^{pb} - S_{11}^0 = CE^2, \quad (1)$$

where  $S_{11}^{pb}$  – is a complex coefficient of the reflection on the structure entrance with perturbing body,

$S_{11}^0$  – is a complex coefficient of the reflection on the structure entrance with perturbing body,

$E$  – is a complex amplitude of the electrical field in the point of the perturbing body *комплексная амплитуда напряженности электрического поля в точке размещения тела,*

$C$  – is a complex coefficient.

RF field is perturbed by the probe moving along the structure axis. For the accelerating structure with a longitudinal field, the probe geometry is a needle. And for the deflecting structure with a transverse field – it is a flat disk.

Using the measurement results, it becomes possible to calculate reflecting coefficient change  $\Delta S_{11}^{(n)} = S_{11}^{pb(n)} - S_{11}^0$  (where  $n$  – it is a cell number) and find the ratio between complex amplitudes of electric field in the centers of the neighbor cells.

$$\frac{E_{n+1}}{E_n} = \left[ \frac{\Delta S_{11}^{(n+1)}}{\Delta S_{11}^{(n)}} \right]^{\frac{1}{2}}. \quad (2)$$

Let the complex amplitude in the first cell is equal  $E_1 = 1$ , i.e. its amplitude is equal 1 and phase is equal 0. Then we get following expressions for the complex amplitudes in the cells centers

$$E_{n+1} = E_n \left[ \frac{\Delta S_{11}^{(n+1)}}{\Delta S_{11}^{(n)}} \right]^{\frac{1}{2}}, \quad (3)$$

$$E_1 = 1.$$

So, as a result of the reflecting coefficients measurements we get the following data:

$S_{11}^0 = a^{(0)} + jb^{(0)}$  – a complex reflection coefficient with the probe outside the structure ( $j$ -is the imaginary unit),

$S_{11}^{pb(n)} = a^{(n)} + jb^{(n)}$  – a complex reflection coefficient with the probe inside the center of the  $n$ -cell.

Using the measurement results we can calculate the reflection coefficient change

$$\Delta S_{11}^{(n)} = S_{11}^{pb(n)} - S_{11}^0 = CE_n^2 = C|E_n|^2 \exp(j2\varphi_n)$$

, where  $|E_n|^2$  – is a square of electric field amplitude in the middle of the  $n$ -cell,  $\varphi_n$  – is a starting phase of electric field amplitude in the middle of the  $n$ -cell.

## THE INSTALLATION CONSISTANCE

The installation consists of the followings components:

- Directly the measured structure with the thread with probe.
- Step-motor, which controls the thread moving.
- Controller, which is connecting the step-motor with the computer.
- Network analyzer, which is measuring the reflection coefficient and the structure frequency in the defined time moments. It is also connected PC.
- PC with the describing software.

## THE INTERFACE

The software is developed in the Lab VIEW, which allows creating the comfortable and intuitive interface. On the Fig. 1 is presented the main window, in which displays

the main data: time, date, the structure name. Also it is possible to plot the field distribution, using previously measured and saved data array, while pushing the “Load from Disk” button.

After pushing the «New Measurement» button, user is prompted to input the measurement parameters (see Fig.2). In the case of required data precision it is possible to choose one of two types of measurement:

- «Regular measurement step». In this case it is required to input the probe step value. The data from analyzer will be read after the each step. This method allows obtaining the smooth field distribution, but the measuring time will be long.
- «Set coordinates manually». The probe is stopping only in previously defined coordinates that allows measuring faster in cases when, for example, it requires to make sure about zero field value in coupling cells centers or in field distribution uniformity in the accelerating cell centers.

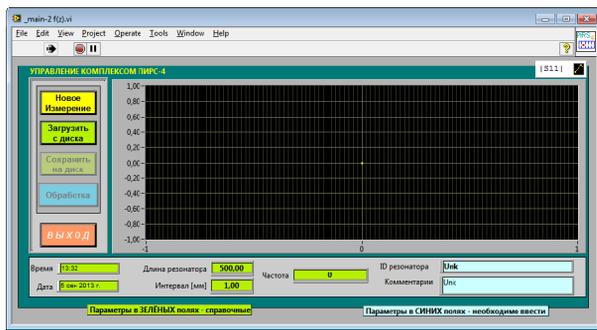


Figure1: Program main window.

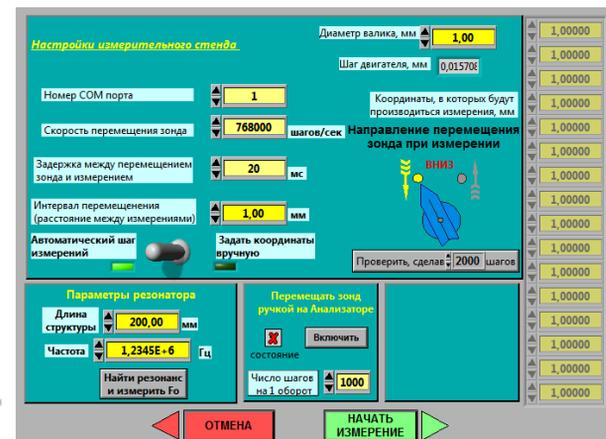


Figure 2: “New measurement” window.

After the measure type selecting, step motor parameter setting and the structure resonant frequency measure, the program proceeds to the main measurements (see Fig.3). In this window the momentum picture of the complex reflecting coefficient and the progress line are displayed. Also it is possible to select the possibility of probe returning in the initial coordinate after measurement end.

When the measurement is done, it is possible to save the obtained data array (real and imaginary parts of reflecting coefficient in the each coordinate). Then this ar-

ray is proceeding in postprocessor (see Fig. 4). There is a possibility to view the field amplitude and phase along the axis and also to find the cells centers.

The postprocessor allows recalculating of the thermal drift influence. It needs specification of points, where the plot was placed outside the structure before and after measurement.

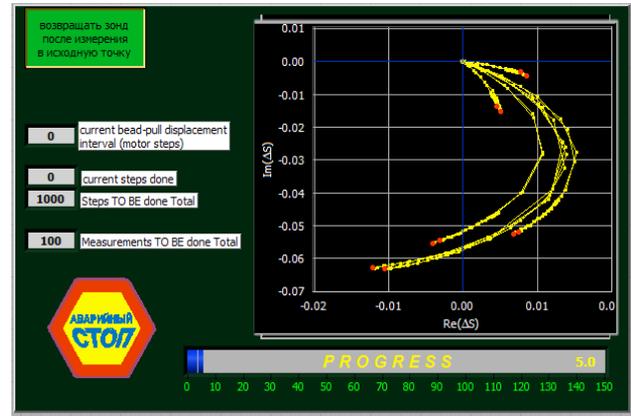


Figure 3: Measurement process.

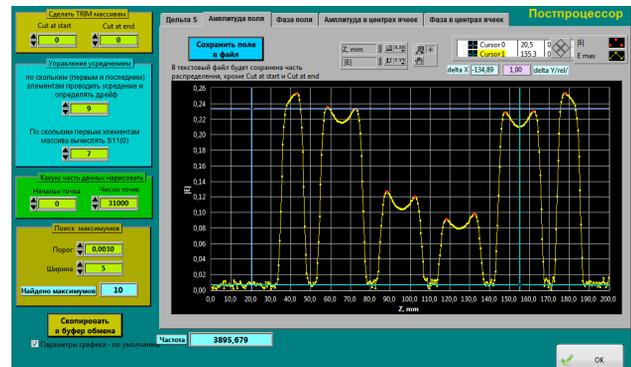


Figure 4: Postprocessor.

## THE PROGRAM PART

The measuring complex operating and treatment of the obtaining results program algorithm allows measuring of the electromagnetic fields distribution as by the change of the reflection coefficient and the shift of the resonant frequency. Both methods have their own features and well complement each other. The first of these algorithms is

based on mathematical apparatus, shown above. Justification of second is well known [3].

The used code is graphical (see Fig.5), that's why it always easy to add new functions or to delete excess.

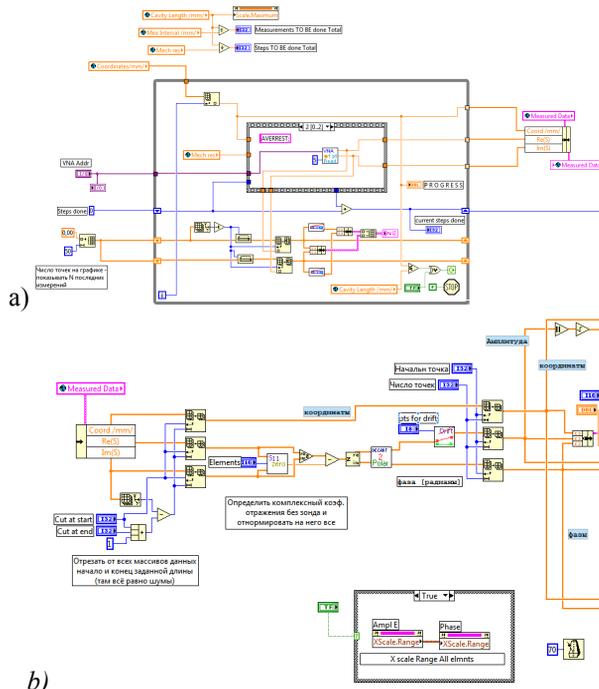


Figure 5: The part of the graphical code, describes the measurement (a) ad postprocessor (b) processes.

## CONCLUSION

This article describes the theory on which is based the work of the program for the accelerating or deflecting linear structure electric field axis distribution measurement. The principle of program operating and its interface is described.

At the moment, purchased, configured and successfully tested all the components of the measuring unit.

## REFERENCES

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