

THE PROCESS AUTOMATION OF TEMPERATURE MEASUREMENT BY MEASURING FACILITY WHICH IS CONSISTS FROM AGILENT E8363B AND FREEZER/HEATING CHAMBER TNC-80

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Abstract. The vector network analyzer Agilent PNA series E8363B and freezer and heating chamber TNC-80 were used to measure electromagnetic parameters of natural and artificial substances under temperature influences. LabView 2016 software was used to the virtual instrument generation. This virtual instrument is needed for efficient electromagnetic parameter and temperature measurement automation. The virtual instrument framework and faceplate of the virtual instrument are shown. The present work involves an experimental study of the magnetic permeability of ferrites with hexagonal structure under temperature influences. It is show that there is a nonlinear influence of temperature on magnetic permeability of W-type ferrites.

1 Introduction

The temperature measurements of electromagnetic parameters of natural and artificial substances are very a laborious process if seen in the context of the major staff time. There are many factors which are affecting on the duration of the process. They are volume temperature gradient, the temperature range that is chosen for research, number of selected parameters of test samples, aggregate state (solid, crystal powder, or liquid) and chemical composition of the test samples, etc. The timing of the experiment shows that about 95% of the staff time is wasted. In that time the temperature increases or decreases to the set value.

There are huge amount freezer or heat measuring facilities which cost in the middle price range. These measuring facilities are not adapted to cooperate with peripheral facilities [1]. In particular there are the measuring facilities of high technological level. For example it is Agilent PNA series E8363B which will be regarded below in this article. These facilities are adapted to cooperate with peripheral facilities and have application software for these purposes. These facilities have the serial interface and cost in the high price range [2]. Standard features for the equivalents measuring facilities have not had special functions for such research. But they have a lot of upgrade opportunities. As a result

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the forward-looking task is to creation of fully automate measuring facilities for research effect of temperature on electromagnetic parameters of substances.

2 Hardware and software

The present work deals with the creation automate measuring facility to research effect of temperature on electromagnetic parameters of different substances. That facility based on vector network analyzer Agilent PNA series E8363B and freezer and heating chamber TNC-80 and personal computer. LabVIEW (National Instruments, 2016) is the software environment capable to creation virtual instrument framework. It is used for creation a virtual automate measuring facility.

To resolve the assigned task both NI LabVIEW 16 and software module NI LabVIEW Real Time 15 SP1, and drivers Agilent PNA series E8363B [3] were used. NI VISA 15.5, NI 4882_15 software drivers are open to access on the Company official website NI. Agilent 82357B USB/GPIB was used for connecting Agilent PNA series E8363B and personal computer. TESTA software and LAN interface were used for connecting freezer and heating chamber TNC-80 and personal computer.

Figure 1 shows a schematic diagram of automate measuring facility to research effect of temperature on electromagnetic parameters of different substances: 1 – Agilent PNA series E8363B; 2 – Agilent 82357B USB/GPIB cable; 3 – personal computer; 4 – Ethernet cable; 5 – freezer and heating chamber TNC-80.



Fig. 1. Schematic diagram of automate measuring facility based on Agilent PNA series E8363B.

Agilent PNA series E8363B vector network analyzer were used to measure S-parameters of measurement cell. It is a main part of automate measuring facility. The Agilent PNA series E8363B network analyzer technical characteristics are following: the authorized frequency bandwidth is from 10 MHz till 110 GHz, the dynamic range is from 110 dB till 0.006 dB.

The volume multimode rectangular cavity was used as measurement cell. The cavity perturbation techniques were used for the evaluation of magnetic permeability of experimental samples at SHF range. In this technique, a cavity was designed with a very small slot at the center of the broad/short wall of rectangular cavity in order to insert the sample material. A coaxial cable was used to connection Agilent PNA series E8363B vector network analyzer and measurement cell.

The freezer and heating chamber TNC-80 is the second part of automate measuring facility. The freezer and heating chamber TNC-80 technical characteristics are following: the range of operating temperatures is from $-70\text{ }^{\circ}\text{C}$ to $+150\text{ }^{\circ}\text{C}$ with the maximum deviation by $\pm 0.5\text{ }^{\circ}\text{C}$ [4]. This chamber has two technological gaps to input measurement cell which is connected with Agilent PNA series E8363B vector network analyzer.

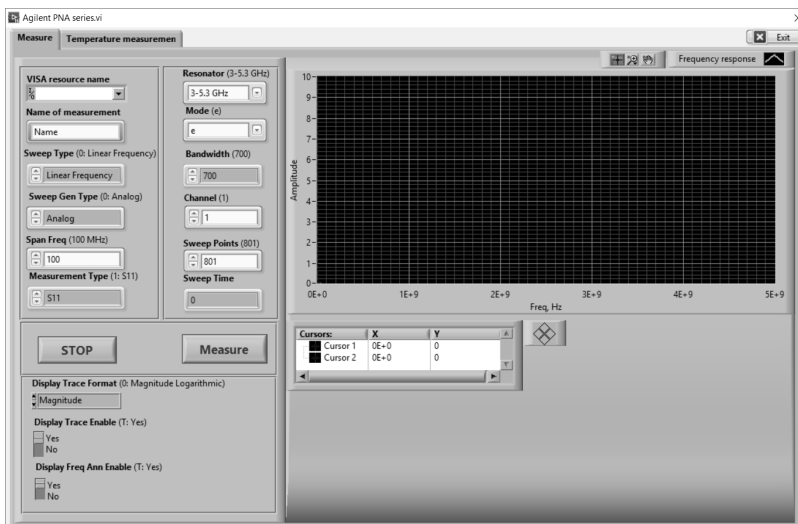
The proper system software was installed on a personal computer. Also it was install TESTA software at same computer. The interaction between personal computer (3) and Agilent PNA series E8363B (1) accessed via an Agilent 82357B USB/GPIB cable (2). The

interaction between personal computer (3) and freezer and heating chamber TNC-80 (5) accessed via an Ethernet cable (4).

TESTA software was used for gathering temperature data. The current chamber TNC-80 temperature and other current session data write to the file. This file is recorded into the TESTA program directory in real time procession every 5 seconds.

Before starting the measuring procedure it is necessary to perform the actions described below. Start TESTA program. Set the function heating and cooling chamber process program. Start Virtual Instrument program (Figure 2). Download file path TESTA into Virtual Instrument program. Connect to the Agilent 82357B via VISA resource name Agilent. The measurement points set up in the window «Temperature measurement».

a)



b)

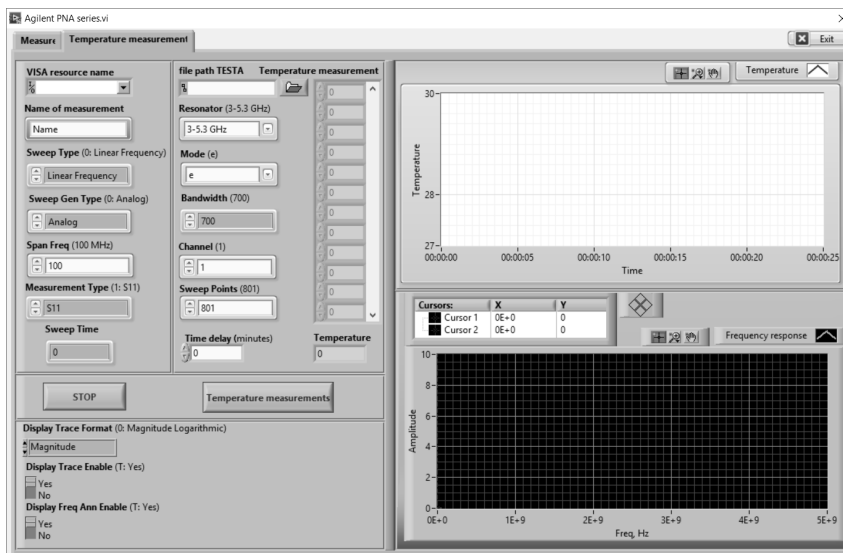


Fig. 2. Agilent PNA series E8363B Virtual Instrument program interface.

The remaining empty fields are given by operator during experiment. They are not mandatory. The contents of empty fields are given by the Agilent PNA series E8363B measurement conditions.

After pushed on button «Measure/Temperature measurements» the measurement system starts operating in the stand-alone mode. It monitors the current temperature in the chamber and records the electromagnetic parameters of measurement cell when the temperature reaches a set value. The results of measurement save into folder which was creation by Virtual Instrument program. This folder and Virtual Instrument program are stored in the same directory.

Since the chamber port interacts with TESTA program, the main difficulty is the direct interaction between Virtual Instrument program and the temperature sensors.

A block diagram of the Virtual Instrument program is demonstrated in Figure 3.

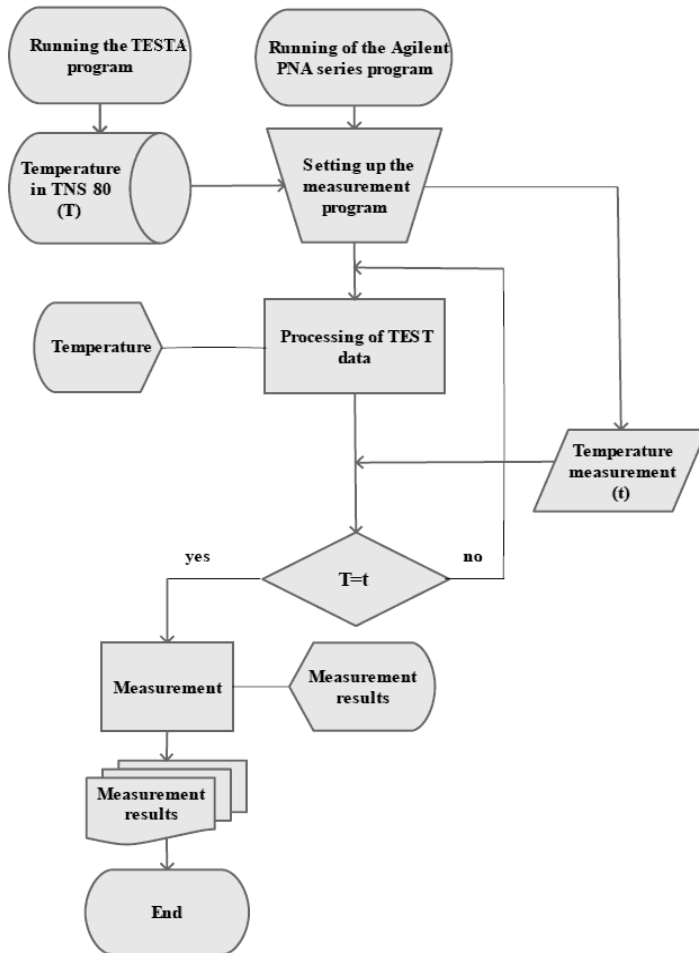


Fig. 3. A block diagram of the Virtual Instrument program for temperature measurements.

A block diagram shows the software algorithm, when the Virtual Instrument program is worked according Figure 2b. The essential difference between Figure 2a and Figure 2b is that a Figure 2b is necessary to set temperature measurement points. Running a program according Figure 2a (Setting up the measurement program) is an amplitude frequency response measurement. The amplitude frequency response saves to a local folder.

3 Results and discussion

To establish correct functioning of the Virtual Instrument program it is necessary to measure the effect of temperature on the magnetic permeability of W-type hexaferrite powder [5]. The hexaferrite powder was put into quartz tube with inner diameter 2 mm. After that the quartz tube was put into rectangular cavity. After that the rectangular cavity with test sample was put into chamber. The measuring point was equal 7.29 GHz. The measurements were carried out under conditions of temperature from 230 K till 315 K. Temperature correction coefficient of frequency was defined before measure. It was equal $17.45 \times 10^{-6} \text{ K}^{-1}$. It was used to calculate of magnetic permeability of test sample. The measurements were carried out every 10 K.

The complex magnetic permeability was calculated by following formulas:

$$\frac{\mu'}{\mu_0} = 1 - \frac{(l^2 + a^2 p^2) V_c \Delta\omega'}{a^2 p^2 V_s \omega_0}, \tag{1}$$

$$\frac{\mu''}{\mu_0} = \frac{(l^2 + a^2 p^2) V_c \Delta\omega''}{a^2 p^2 V_s \omega_0}, \tag{2}$$

where $\Delta\omega' = \omega - \omega_0$ is the shift of resonance frequency to left side, $\Delta\omega'' = (\delta\omega - \delta\omega_0)/2$ is the change in the half-width of the resonance line when the sample is placed in the cavity, V_c is the volume of the test sample, V_s is the volume of the cavity, p is the number of wave variations along cavity, a is the widthwise of the cavity, l is the lengthwise of the cavity.

Figure 4 shows the calculation results.

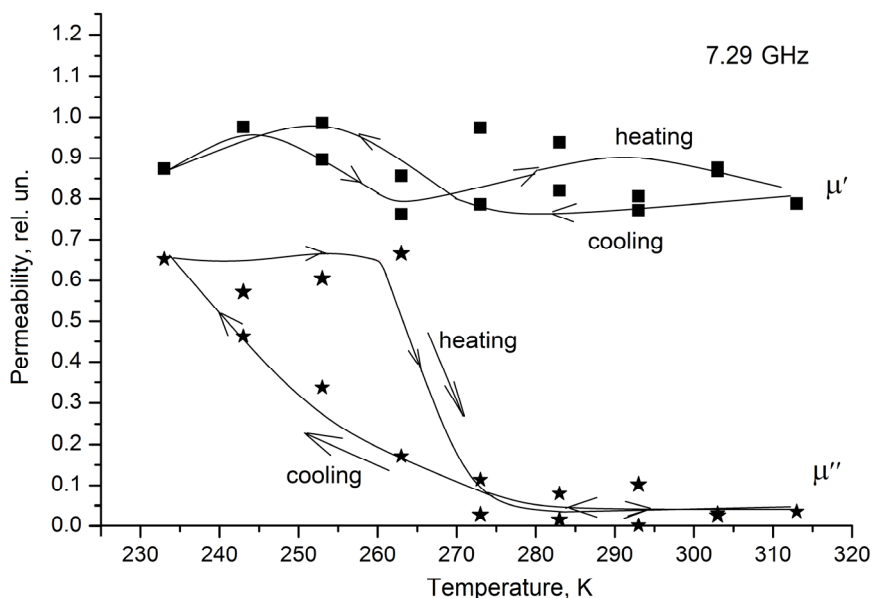


Fig. 4. Complex permeability of W-type hexaferrite powder.

In order to provide an interpretation of the magnetic permeability results, we will use a data from article [5]. This article shows, that W-type hexaferrite bulk sample have nonlinear temperature dependence of magnetic permeability. Note that the similar

dependence is observed in our experiment. Since we measured hexaferrite powder we saw that there is a correlation (though quite weak) between the bulk sample and the powder sample. Also we saw that there are the different shapes of the curves both cooling and heating.

4 Conclusions

Virtual Instrument program is very intuitive and easy to use. Even young researcher may operate by virtual automate measuring facility. There is the opportunity to modernize and improve this virtual automate measuring facility in the future. Firstly, there is the opportunity to connect other peripheral facilities. Secondly, there is the opportunity for remote control of measurement process.

The virtual automate measuring facility for research effect of temperature on electromagnetic parameters of substances is used on the Center Radiophysical measurements, diagnostics and research parameters of natural and artificial materials of Tomsk State University. There were plans to adaptation of this program to other measure equipments.

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