

ВИМІРЮВАННЯ НЕЕЛЕКТРИЧНИХ ВЕЛИЧИН

VIRTUAL DEVICE FOR MEASURING THE IMMITANCE

ВІРТУАЛЬНИЙ ПРИСТРІЙ ДЛЯ ВИМІРЮВАННЯ ІМІТАНСУ

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Анотація. Розроблено віртуальний пристрій для оцінювання вмісту домішок важких металів у овочах. Його перевагами є висока точність, легкість у впровадженні та експлуатації, гнучкість програмного забезпечення. З його допомогою імітансним методом здійснено контроль показників якості овочевого соку щодо вмісту зазначених металів. Віртуальний пристрій створено у середовищі LabVIEW. До складу пристрою входить ємнісний перетворювач (кондуктометрична комірка, заповнена досліджуваною рідиною – овочевим соком із різними добавками), блок NI USB-6009, під'єднаний до комп'ютера за допомогою інтерфейсу full-speed USB. Автономний вимірювальний прилад NI USB 6009 має аналогові входи та виходи для генерування та збирання вимірюваних даних. Для формування певного значення імітансу генерували фізичний тестовий сигнал у вигляді змінної напруги, зчитували комплексні напруги та розраховували шукану величину. У програмі використано окремі елементи DAQ-задачі та цикл While Loop with Stop Button.

Здійснено дослідження активних і реактивних компонентів електропровідності зразків морквяного соку із різним вмістом іонів міді. Отримані експериментальні дані оброблено за допомогою засобів зазначеної платформи. Вони збігаються з даними вимірювань за допомогою традиційних RLC-метрів.

Змінюючи програмний код створеного віртуального пристрою, можна розширити спектр досліджень, охоплюючи інші овочеві соки.

Ключові слова: електропровідність, імітанс, кондуктометрична комірка, віртуальний інструмент.

Abstract. A virtual device for assessing the presence of heavy metals in vegetables is developed within the LabVIEW systems engineering software. The quality of vegetable juice with heavy metals contamination is studied in the immitance-measuring way. Device consists of the capacitive transducer (a conductivity cell filled with investigated fluid – vegetable juice with various additives), USB-6009 unit, connected to a computer with the full-speed USB interface. This stand-alone unit equipped with analog inputs and outputs generates the alternating voltage and collects the measured data and measures and computes then integrated voltages as well as immitance. To generate the input signal, the program uses the separate elements of the Data Acquisition section and the Stop Button loop.

The studies of active and reactive components of electrical conductivity of carrot juice samples with different content of copper ions are conducted. The obtained results coincide with the measurement results carried out with help of RLS-meter. Altering the program code of the created virtual device, we get an opportunity with the high exactness, easiness in implementation and operation to diversify easily the series of immitance measurements for the other vegetable juices.

Key words: Electrical conductivity, Immitance, Conductometric cell, Virtual instrument.

Introduction

The most actual problem for the modern world is the production of the safe products. Content of impurities and contaminants in the products has to be minimal, in particular content of the heavy metals such as mercury, copper, zinc, arsenic, cadmium that are toxic. They exhibit devastating impact on the health of the consumer, and their content in foods, including vegetables, must be controlled. Therefore, is important to develop an effective measuring instruments for control, storage and transmitting data on the content of heavy metals by developing appropriate virtual devices.

Disadvantages

To assess the quantity of heavy metals in vegetables, a number of physical and chemical methods are developed [1]. Each of them is inherent in its own specifics, positive and negative sides. In particular, atomic absorption methods that are able to measure the content of metals in the substance require complex preparation of samples. Photometric methods are also used to determine the small concentrations of heavy metals in vegetables; unfortunately these methods need previous calibration. Radiometric methods based on the measurement of α - and γ - radiation, cause by the

ionization of atoms and molecules of the analyzed substance under the action of incident radiation. Herein, the accuracy depends on the probability of meter operation, the suitability of the apparatus, adsorption, and so on.

Goal of the work

Aim of the current issue is creating the virtual device for determination of the contamination of heavy metals in vegetable juice by measuring and computing its immitance.

Immitance measurements with help of LabVIEW system-design platform

We conducted an experiment on the detection of heavy metals in vegetable juice. The electrical measurement scheme we used during the experiment consists of a capacitive transducer (conductivity cell filled with vegetable juice with various additives), an RLC meter, a unit for processing results and control. RLS-meter in the asynchronous mode sends a test signal of a sinusoidal shape to a capacitive transducer. In response to the test signal on the RLS-meter, the characteristics of the investigated model liquid (components of the juice's electrical conductivity) are obtained.

As a result of the experiment described in the preceding paragraph, a series of consecutive data that reflects the physical parameters (complex voltages of the active and reactive components) is proportional to the immitance.

The content of copper ions in carrot juice was monitored. The change of active G and reactive conductivities in the frequency range from 50 Hz to 100 kHz depending on the composition of substances by means of capacitive sensors was estimated.

Let's formulate briefly the basic principles of the current study [2, 3]. As an input test signal, we send a sinusoidal signal. In asynchronous mode, we receive an output signal. Then for the converter the output conductivity is given by the ratio:

$$G_{out} = \frac{1}{z_{out}} = j\omega C_x + \frac{1}{R_x}, \quad (1)$$

where R_x is an active component of resistance and C_x is the capacity of capacitor electrolytic cell. The frequency of the test signal directly affects the conductivity. Capacitance of the capacitor of the conductivity of the conductivity electrolytic cell C_x is defined as:

$$C_x = \epsilon_p \epsilon_0 \frac{S}{l}, \quad (2)$$

where ϵ_p is the dielectric permittivity of the solution; ϵ_0 is the dielectric vacuum permeability; l is the distance between the graphite electrodes, S is the area of electrodes. The readout of the device at the i^{th} frequency is as follows:

$$N_G = k_A \frac{1}{R}, \quad (3)$$

$$N_B = k_A \omega C, \quad (4)$$

where N_G is the active component of conductivity; N_B is the reactive component of conductivity; k_A is the conversion factor of ADC.

However, the described method of measuring with help of RLC-meter is not sufficiently flexible. In addition, the RLC-meter and the test signal generator are quite dimensional. LabVIEW system-design platform and development environment for a visual programming language from National Instruments [4] provides the support for automated systems for research in the similar cases. Its environment is multifunctional and can assure: exchange of information with external measuring and control devices; analysis and processing of received information; collection, storage and transmission of information; operation with virtual instruments, etc. In the LabVIEW environment, particular virtual devices can be created that simulate the certain functions of the measurement, control and operation.

So, the mentioned platform with NI USB 6009 unit was applied for creation the virtual device aiming the monitoring of the content of heavy metals in vegetable juice. Two windows (Front Panel and Block Diagram) have been used. Then there were added the particular block diagram codes for graphic simulating the functions to control the front panel objects. The designed virtual device for measuring the immitance of juices contains several primary block diagram objects – terminals, functions, and wires (Fig. 1).

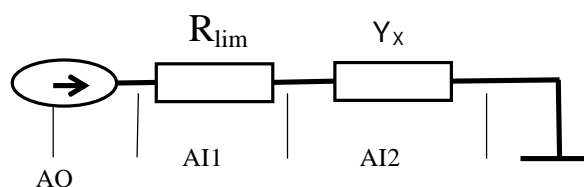


Figure 1. Diagram of measuring the immitance of juice: AO, AI are the inputs and outputs of the NI USB 6009 respectively

Since the nominal value of carrot immitance has a dimension of one thousandth of Ohms, it is necessary the implementation of R_{lim} in the electric circuit to avoid overload and to take into account the approximate values of the measured immitance. As well it needs to consider the technical characteristics of the NI USB 6009 unit. To compute the immitance of carrot juice, it is provided the measuring the complex voltages $U1$ and $U2$ on the analogue inputs AI1 AI2 of the NI USB 6009. To compute the immitance it is needed to follow the next steps: 1) Generation of the test signal; 2) Reading of complex voltages; 3) Calculation of immitance (see the Fig. 2).

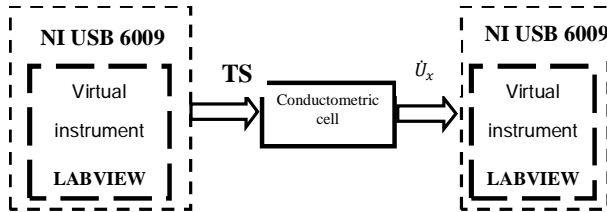


Figure 2. Block-scheme for measuring the immitance of juice:

TS – test signal, \dot{U}_x – complex voltage

According to specifications, the NI USB 6009 block generates a maximum voltage of 5 V and a maximum current of 5 mA. NI USB 6009 block is designed to generate DC voltage. According to the method of immitance measurement, the test signal is a sinusoid. Therefore, it is suggested to use the while loop cycle to generate variable voltage. The NI USB 6009 block is managed through the DAQ task software. The frequency of the test sinusoidal signal is set indirectly through the interval and the number of points. Since the NI USB 6009 does not generate an alternating voltage, there are applied DAQ elements and the Loop cycle with Stop Button. The DAQ task for generating and collecting data is selected from the functions palette in the block diagram window. To start the DAQ task, we have received / generated the signals and chosen the type of measurements that is the voltage (Fig. 3). The window's options are: input range, data acquisition mode (N measurements or continuous mode), frequency of measurements.

Creating a test signal. This program demonstrates how to perform continuous analog output tasks on the NI USB- 6009 and also incorporates the model of operation that is associated with software timed analog output. Continuous software timed analog output means that analog channel is updated only once for every iteration

of the program's while loop. It is important to remember that these devices allow a maximum update rate of 150 samples per second on each channel; therefore the main program's while loop can iterate no faster than once every 6 ms.

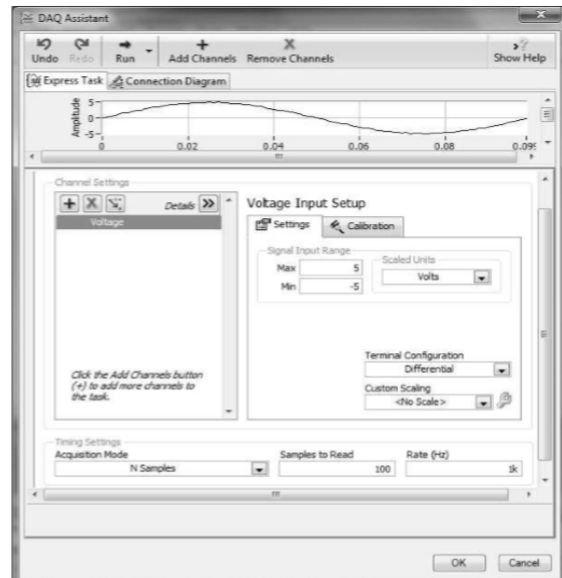


Figure 3. Configuring the device with help of DAQ Assistant

The output voltage range of such devices is within range of 0–5 V. This program outputs the sine waves with a DC offset and allows select the number of points per cycle. It would be observed that increasing the points per cycle is able to enhance the resolution of the output waveform, but also to diminish its frequency. Approximate period of the output waveform is equal to the points per cycle times the output rate.

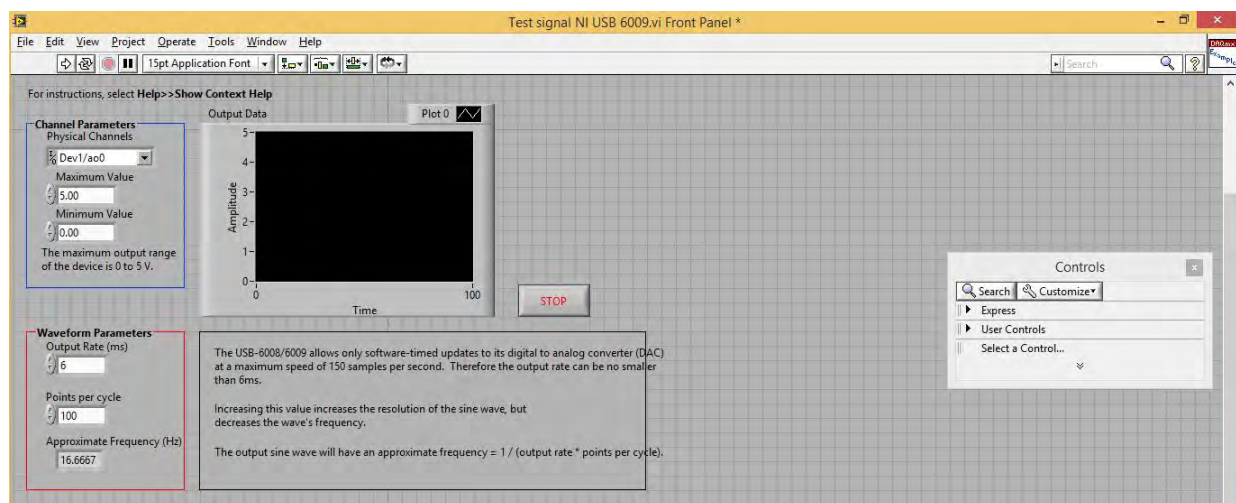


Figure 4. Test signal of virtual device on the base of NI USB- 6009 unit

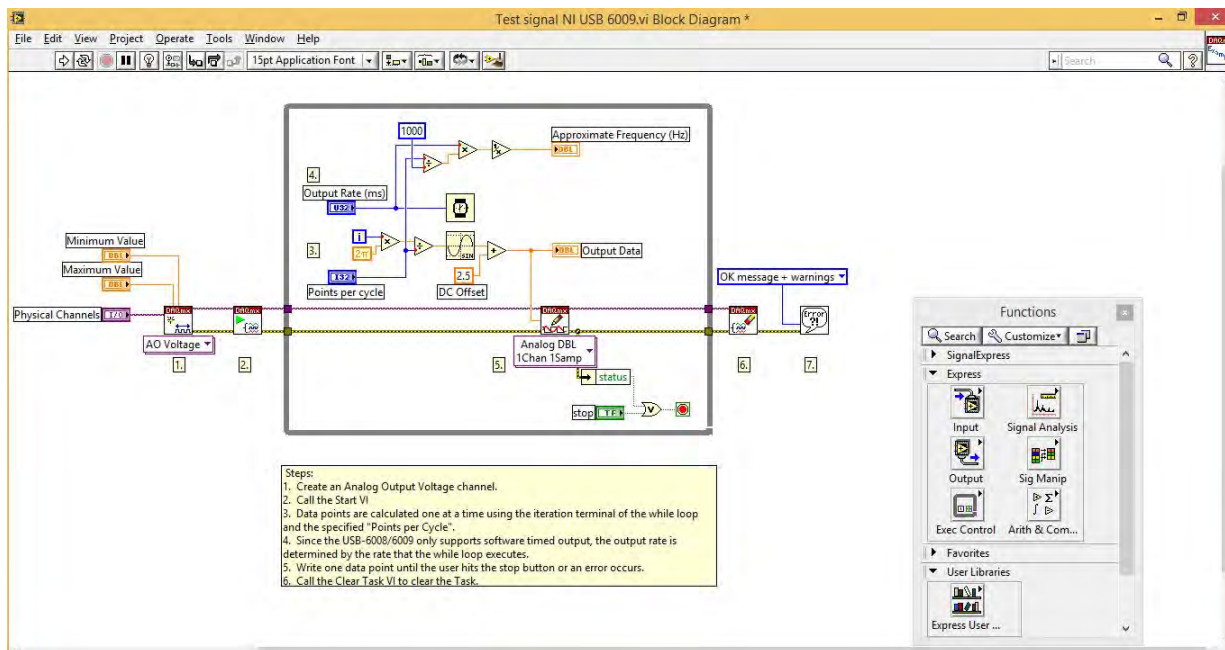


Figure 5. Block diagram of created virtual device

Execute Code for the created virtual device:
 1. Open the Test Signal. 2. Configure front panel controls: namely Physical channel, Maximum value, Minimum value, Output rate, Points per cycle. 3. Run the device.

Example of imittance measurement with help of the virtual device

active and reactive components of electrical conductivity of carrot juice samples with different content of copper have envisaged liaison between ion content and imittance value. By altering the program code of the virtual device, it can be provided the opportunity to diversify the imittance measurements for the other vegetable juices.



Figure 6. Virtual device for measuring the contamination of the heavy metals in the juice

Conclusions

Virtual device for measuring the contamination of heavy metals in the juice is developed in the imittance-measuring way. Device consists of the capacitive transducer with the studied vegetable juice, NI USB-6009 unit, connected to a computer with the LabVIEW platform software. The conducted studies of

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