

SIMPLY IMPEDANCE MEASURING SYSTEM

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ABSTRACT

This paper deals with the simple impedance measuring system. The whole system contains two basic measuring devices, generator and oscilloscope. Measurement itself is based on the Agilent VEE Pro 6.2 graphical programming language which means, that the measurement is fully automatic.

1 INTRODUCTION

The main aim of whole article and work behind is to create simple automatic measuring system of the impedance, which means measuring module and also phase of unknown impedance over frequency range from 10 Hz up to 50 MHz or more. Secondly the system has to be built by simple measuring devices which are easily accessible. Impedance can be generally calculate from

$$Z = \frac{U}{I}, \quad (1)$$

if we know voltage U , current I and also the relationship between them, which means the phase shift between the voltage and current. This situation is given in fig. 1a. This idea was designed and produced on PCB. The scheme design is given in fig. 1b. For this system were used generator and two channel oscilloscope. First channel measured voltage on the resistor R at A and B points.

From this value was calculated current. Second channel measured voltage U_2 at the point B. Oscilloscope measured RMS values of voltage and phase shift, these values were put into the equation (1) and unknown impedance Z was calculated. This system was quite good but it had problems with grounding and with interferences which were unacceptable for automatic measuring. These problems produced a lot of mistakes. According with these problems, measuring system was redesign. New system has the same configuration which is given in fig. 1b. But In this case the oscilloscope measures only voltages in points A and B

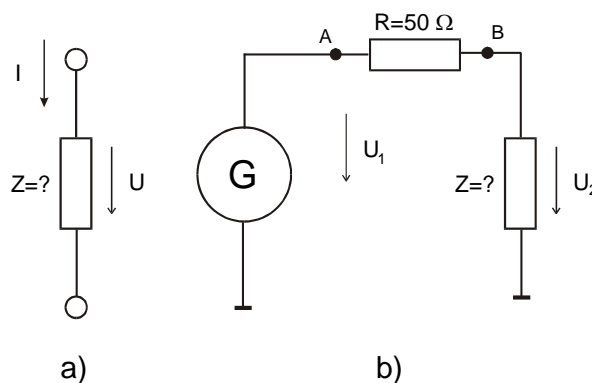


Fig. 1: Principle of the used method

and also their phase shift. The measurement is described by this equation:

$$\frac{U_2}{U_1} = \frac{Z}{R + Z}. \quad (2)$$

Meaning of all variables is explained by Fig. 1b. After several very simple mathematics operations could be obtained equation for the unknown impedance Z :

$$Z = \frac{R \cdot U_2}{U_1 - U_2}, \quad (3)$$

where U_1 , U_2 , and Z are complex variables. The phase shift between voltages could be added to one of them with the relevant sign.

2 MEASUREMENT HARDWARE REALIZATION

There were chosen Agilent 33220A as a generator of test signal and Agilent 54621A (oscilloscope) as a detector of the test signals on both of itself ports. Generator has a frequency range up to 20 MHz and an oscilloscope up to 60 MHz so the whole measurement system has a frequency range from 10 Hz up to 20 MHz. The whole measuring setup is given in fig. 2. In front of the oscilloscope is a small metal box with PCB which can be cold an adaptor. On this PCB are realized two 10:1 oscilloscopic probes. Each probe contains capacity compensated divider which was tuned to optimal conditions. This solution gives better behaviour at higher frequency range. The adaptor has five connectors. Two of them are for the two channels of the oscilloscope and these connectors are directly switched into the oscilloscope. Owing to this solution there could not appear any mistakes, probes are near the connected points of these two BNC connectors. There is also BNC female connector which is for input signal from generator, SMA connector for the reference impedance which is mainly 50 ohms Radial resistor (type R404605) and also connector N for unknown impedance connection. Reference resistor Radial (R in fig. 1b.) can be replaced by any other resistor with SMA connector and suitable value of resistance.

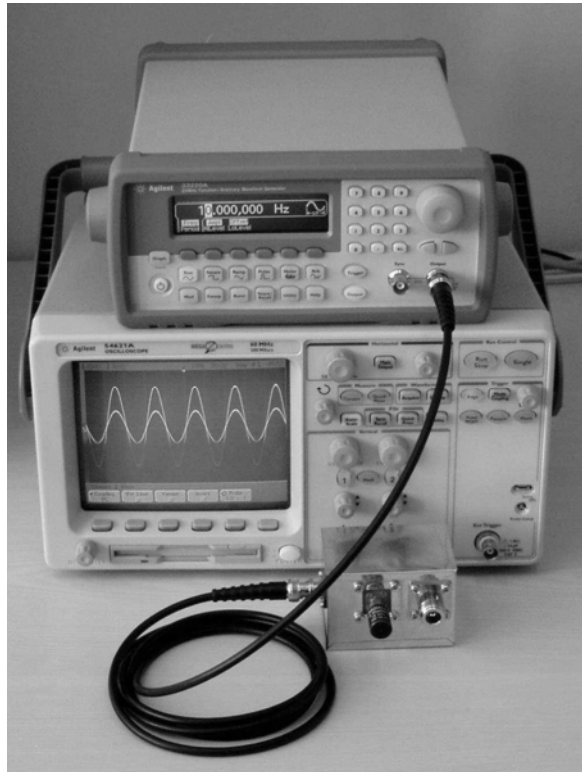


Fig. 2: *Measurement setup*

3 SOFTWARE

As was said the whole measurement is fully automatic and controlled through the GPIB bus. The commanding software was done in the Agilent VEE Pro 6.2 graphical programming language. The user interface is given in fig. 3. There are some boxes with options like generated power level, frequency range, measuring points per decade, value of reference

impedance, save path and description of measuring. The main part of this interface occupied large chart where are represented the measured data. This chart has two lines: dark one represents module of the impedance in ohms and light one represents phase of the impedance

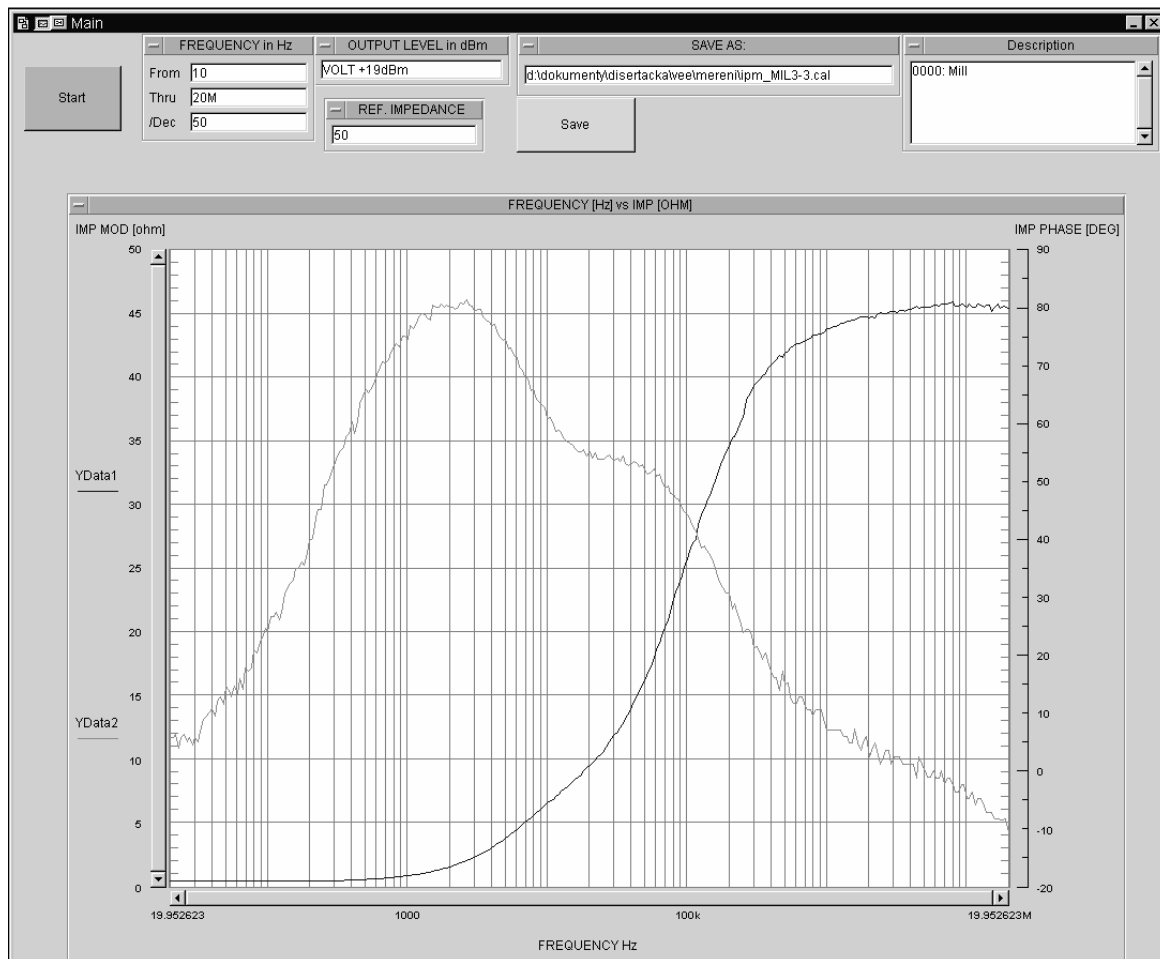


Fig. 3: User interface built in Agilent VEE Pro

in degrees. Program, which simple example is given in fig. 4, firstly resets both devices and loads into them setup of whole measuring. The measuring itself continues sequentially on each frequency. The generator setups the frequency and oscilloscope setups time scale according with generating frequency and also setups vertical scale on default values for both channels. After that there is measured peak-to-peak voltage of channel 1. This value is used for vertical setup of both channels. Next step is to obtain a peak-to-peak voltage value for second channel where is measured voltage U_2 . The peak-to-peak value is again used for vertical setup of channel 2. Now scale procedure has done and both curves are on oscilloscope's screen maximally magnified. For making this setup, the oscilloscope offers automatic function called "auto scale", but this function does not work with low voltage signals, so there was necessary to produce manual function for scaling. After this whole setup there are measured data: voltages and frequencies of both channels and phase shift between channels. These data are saved to the text file with the calculated impedance data, the example of output file is given in tab. 1. Generated file can be easily opened by Microsoft Excel. File has two parts: Header which contains information about measured devices like type, serial number and description of measured device or just a user's note which can be added there for better orientation in results. In fig. 4 is given an example of several programming commands

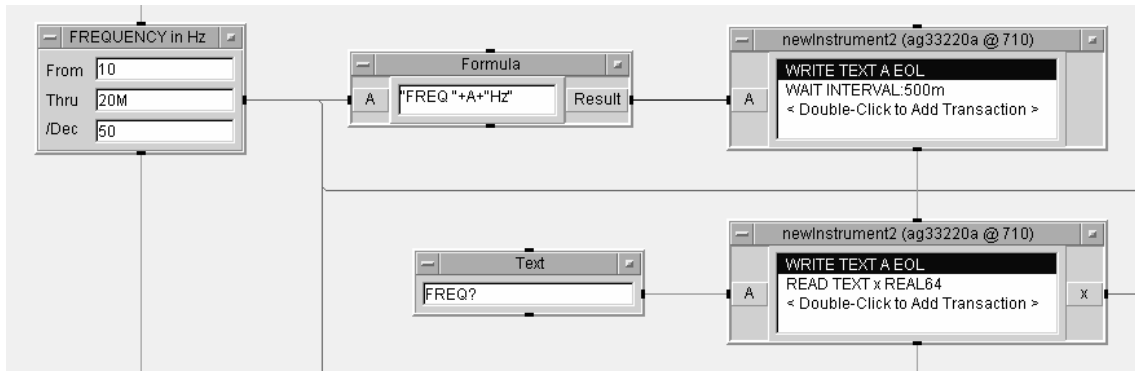


Fig. 4: Example of Agilent VEE Pro 6.2 programming technique

from Agilent VEE Pro development environment. There are shown only simple blocks. The programming is very similar to LabVIEW. Each block can have five ports and programming consists in connecting each block to another by air wire. For better orientation in amount of wires has each wire different colour according to character of data signal (string, char, int 32, real 64 and so on). The Agilent VEE Pro development environment allows also converting between these types, adding conditions for ramifying of the program. By these tools and boxes programmer can make a very sophisticated program with many features and options. One measuring on one frequency takes about two seconds. This duration is caused by oscilloscope. In program there have to be added waiting commands because oscilloscope has data ready on its output after several time. The whole measuring takes about 15 minutes without any other personal influence, everything is fully automatic.

| Agilent Technologies,33220A,MY44001686,2,00-2,00-22-2 | | |
|---|----------|------------|
| AGILENT TECHNOLOGIES,54621A,MY40000177,A,01,20 | | |
| Description | | |
| FREQ:GEN | MOD, IMP | PHASE, IPM |
| 10 | 0,401819 | 2,540245 |
| 10,47129 | 0,403265 | 2,540318 |
| 10,96478 | 0,387749 | 2,539536 |
| 11,48154 | 0,402026 | 2,540256 |
| 12,02264 | 0,404336 | 3,810546 |
| 12,58925 | 0,399903 | 1,905114 |
| 13,18257 | 0,403233 | 3,185471 |
| 13,80384 | 0,387608 | 1,904649 |
| 14,4544 | 0,403356 | 4,445541 |
| 15,13561 | 0,403312 | 3,810468 |
| 15,84893 | 0,402882 | 3,175369 |
| 16,59587 | 0,402416 | 4,445458 |

Tab. 1: Output filestructure

4 CONCLUSIONS AND RESULTS

The result of measuring RADIAL R404605, 50 Ω resistor is given in fig. 5. Dark line represents module of impedance and light one is phase of impedance. Worse results on higher frequency range which are caused by probes. The accuracy of measured module of impedance is quite good. Measuring fault did not exceed $\pm 2 \Omega$ in abso-

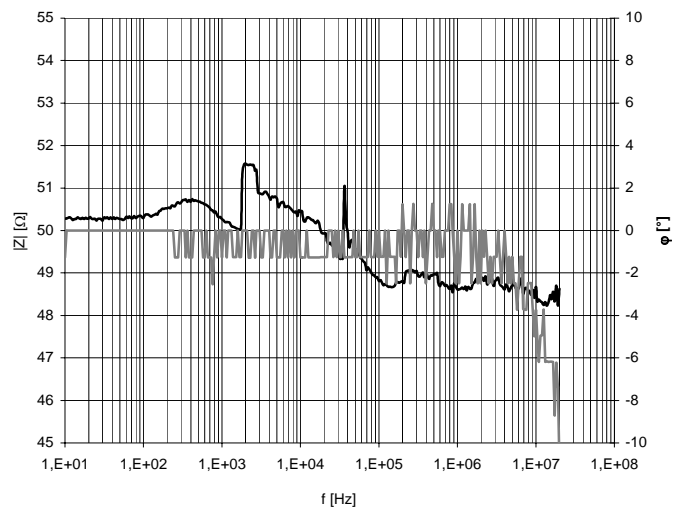


Fig. 5: Impedance of 50 Ω RADIAL resistor

lute range. Fig. 6 represents a measuring of variable impedance over the frequency range. The dark line represents data for measurement setup with oscilloscope and light dashed one represents data got from impedance meter. There is mistake on low frequencies which was produced by reference resistor. By using reference resistor with lower value of impedance e.g.

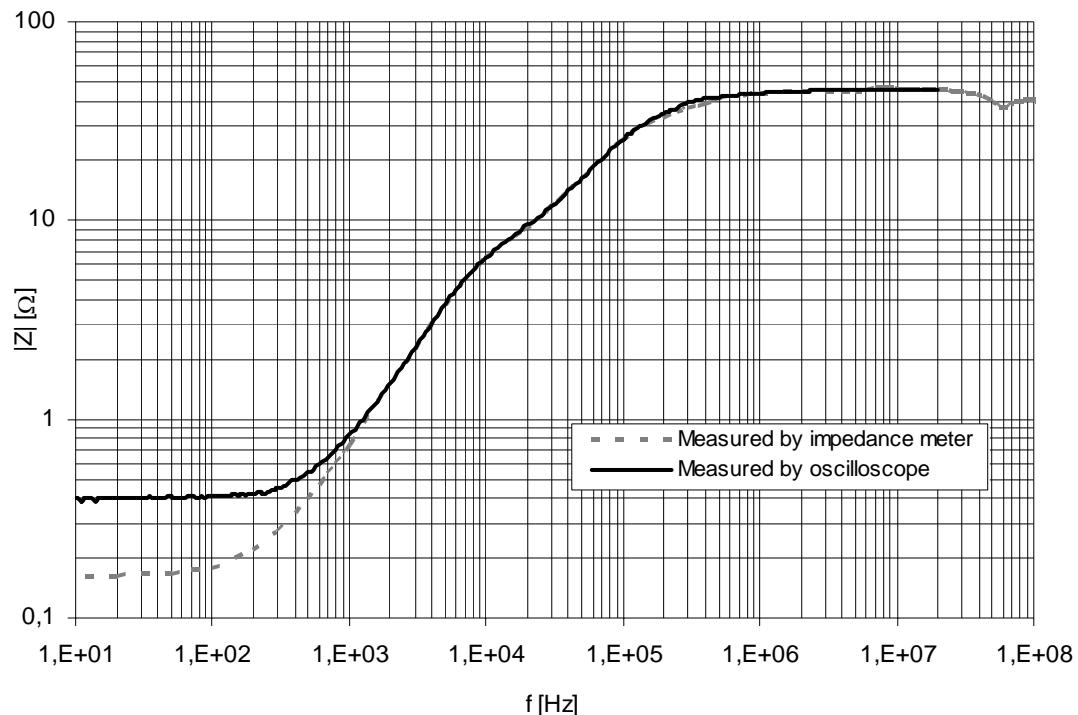


Fig. 6: Comparison of the variable impedance measured data

10 or 1 Ω is possible to obtain better results in this area. This project will be used in the further author's Ph.D. work not for accuracy measurements but for a quick check measuring over a wide frequency range.

ACKNOWLEDGEMENTS

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