NEKI ASPEKTI KORIŠĆENJA NOVIH ELEKTRONSKIH PLATFORMI U REALIZACIJI SISTEMA ZA PRIMENU OBNOVLJIVIH IZVORA ELEKTRIČNE ENERGIJE

SOME ASPECTS OF THE USE OF NEW ELECTRONIC PLATFORMS IN THE IMPLEMENTATION OF THE SYSTEM FOR THE APPLICATION OF RENEWABLE ELECTRICITY SOURCES

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Na inostranom, kao i na domaćem tržištu, pojava novih, ekonomski prihvatljivijih, elektronskih platformi doživljava veliku ekspanziju zadnjih godina. Primenljivost tih platformi i rešenja baziranih na istim se svakodnevno sve više dokazuje u različitim aspektima korišćenja. Jedan od potencijalnih domena primene svakako je i domen upotrebe tih rešenja u realizaciji sistema koji za osnovu imaju korišćenje obnovljivih izvora električne energije. Iako ove elektronske platforme poseduju široku dostupnost komponenti, prihvatljivu cenu i vrlo uprošćen način korišćenja, postoje neka određena vrlo važna pitanja i problemi sa kojima se tokom projektovanja i implementacije realizatori mogu susresti. U skladu sa navedenim u radu će se akcenat baciti upravo na ova manje poznata i često zanemarena pitanja, te će biti diskutovano o potencijalnim problemima koji se javljaju i mogu javljati u domenu merne sigurnosti, standardizacije i srodnim oblastima.

Ključne reči: *elektronska platforma; merna nesigurnost; mikrokontroler; otvoreni kod; standardizacija*

On the foreign market, as well as on the domestic market, the emergence of new, more economically viable, electronic platforms has been experiencing great expansion in recent years. The applicability of these platforms and solutions based on them are increasingly being proven every day in various aspects of usage. One of the potential domains of application is also the domain of using these solutions in the realization of the systems that are based on the use of renewable electricity sources. Although these electronic platforms have a wide availability of components, an acceptable price and a very simplified way of using, there are some very important issues and problems that can be encountered during design and implementation by developers. In accordance with the above, in the paper, the focus will be exactly on these less-known and often neglected issues, and it will be discussed about potential problems that can occur in the domain of measurement uncertainty, standardization, and related fields.

Key words: *electronic platform; measurement uncertainty; microcontroller; open-source; standardization*

1 Introduction

The First Industrial Revolution was characterized as the period of mechanization conditioned by the invention and understanding of all potentials of the steam engine. By adopting potentials of the application of electricity, the possibility of industrialization and mass production was open, which is characterized as the Second Industrial Revolution. Directly from the previous one, the Third Industrial Revolution was created as an era of automation and the use of modern electronic devices and information-communication technologies. The enormous growth that came from the Third Industrial Revolution pushed the humanity in the sphere of what many today called the

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Fourth Industrial Revolution, based on extensive digitalization and interconnection of various devices, their interoperability, with the increasing diversity, speed and volume of data generated.

Significant progress in the field of production and industry development has also led to the development and improvement of measurement systems, measuring devices and greater development of metrology as a special and very important part of every industrial process. It can be conditionally said that the various improvements in the metrology were realized in two areas of work. In the first field of work, efforts were directed to proceduralization and to the standardization of the measurement process, while in the second field of work various technical and technological improvements were made to different aspects of the measurement processes themselves. As a direct consequence of that approach, certain uniformity in the implementation of various measuring processes in different aspects of modern industry has been reached, including the realization of measurement processes in the segment of the use of renewable electricity sources. Instruments used in the realization of measurement processes also get significant improvements. In addition to analogue instruments, a large number of digital instruments are introduced and began to use. The instruments themselves are realized with greater reliability and accuracy and measuring segments for which they are intended are increased.

In recent years, metrological procedures have increasingly included the use of modern information and communication technologies (ICT) and modern measurement approaches are starting to be realized much more through computer-based measurements. Nowadays, those tendencies have a wider meaning and the interpretation was transferred to a completely different level due to the appearance of the Fourth Industrial Revolution or as it often referred as The Industry 4.0 which includes wider use of ICT through smart, connected technologies [1]. The segment of the use of sustainable sources of electricity has also not remained immune to these events on the whole, including the part relating to metrology.

In the following sections of this paper will be presented some aspects of the use of modern technologies in the field of renewable sources of electricity, from the perspective of the metrological processes. It will only point out the potential problems that can occur during the implementation of the mentioned technologies without entering into deeper analysis due to the limitation of the discussion in the paper itself.

2 Conversion of Existing Traditional Solutions

As is known, no measurement can be realized with absolute accuracy. Therefore, the following formulation is used in the measurement result display:

$$Y = y \pm U \tag{1}$$

where is Y - the result, y - measured value and U - uncertainty [2].

There are numerous ways for expression of measurement uncertainty, but one of the mostly used and accepted is ISO method known as GUM method [3] which is consisted of five major phases. In the first phase all relevant components of measurement uncertainty are identified and in the second phase, standard uncertainties u_i are calculated for those identified components. After these phases, in the third phase, combined uncertainty is calculated as:

$$u_c = \sqrt{\sum u_i^2} \tag{2}$$

and then in the fourth phase, expanded uncertainty is calculated as:

$$U_i = k \cdot u_c \tag{3}$$

where is k - coverage factor which defines the confidence of the measurement [4].

Using all previous calculations, the final measurement result can be expressed as it described in (1) which represents the final stage of the mentioned GUM method.

As said above, the tendency of modern systems is reflected in the implementation of systems using ICT with all benefits that bring modern possibilities in the form of using various devices and

their interconnectedness. In previous statements, it is seen that the complexity of the measurement uncertainty calculation process is directly proportional to the number of measuring components. An additional factor is that every component has its own characteristics related to the uncertainty. According to that, it is expected that some certain issues can be occurred in modern systems related to their participation in measurement processes.

Those expectations will be explained in the following example which represents one potential system that can be used for monitoring structural damages on objects. This system is practically realized in the laboratory for rock and soil mechanics for the scientific and educational purposes, but it is representative for this paper because it can be used for structured health monitoring on wind turbines [5].

One of the possible solutions for monitoring structural damages is the use of enough number of independent analog or digital comparators because every comparator has a known sensitivity [6]. We could read manually data from every single comparator and all data can be properly analyzed because for each comparator there is exact information about uncertainty and measured value. This will be a solution in more traditional manner.

Common modern approach is based on the use of Linear Variable Differential Transformers (LVDTs) which can measure linear displacements. For further analysis, one system based on the LVDTs will be used which abstraction is shown in Figure 1.

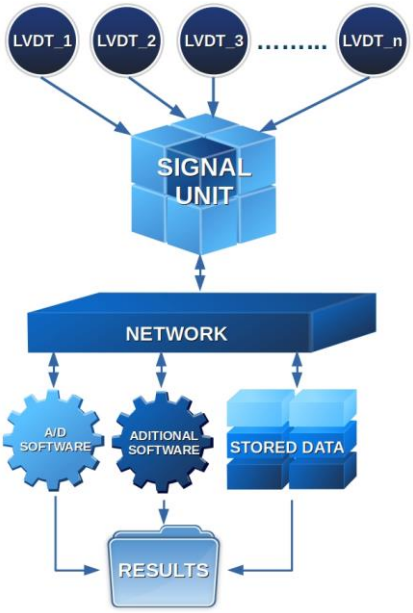

Figure 1 - Schematic representation of the measurement system based on LVDTs

As shown in the mentioned Figure 1, the measurement process is realized directly by a large number of LVDTs (labeled in the figure as LVDT_number). Furthermore, these LVDTs are connected to a special platform (labeled in the figure as Signal Unit) which provides two main operations. The first purpose of this platform is providing signal conditioning and the second one is providing data acquisition. This platform has its own specialized software that is located partly within the platform itself, and partly on the appropriate computer that is connected to the platform. There are some additional activities provided by the system using additional software which is included on the appropriate server. Also, in this case, the data gathered from the measurement processes are stored on the same server for the purpose of achieving later insights into the various aspects of the measurement process. All devices are interconnected via appropriate computer network and in this particular case, all devices are on the same Ethernet network.

This approach provides more benefits than the previous more traditional approach. Some of the key benefits are that the entire measurement process is much easier to manage, there is a much higher level of automatization with the great possibility of expansion, data flow identification is

easier, there is a possibility of various insights and much other. But, among all these benefits, there is one issue that must be considered.

Determining the measurement uncertainty, and therefore the reliability of the measurement, is now becoming a very complex process and in some segments, it can be some kind of challenge. The measurement process may be simplified from the user side, but from the standpoint of measuring uncertainty, which sometimes may be hardly noticeable to the average user, the measurement process has reached a greater degree of complexity.

If we look at the aforementioned GUM method and its five phases from which it is composed, we can see that last three result from the first two phases because the first two phases speak about the identification of all relevant factors that make measurement uncertainty and calculation of partial measurement uncertainties. For LVDTs there are mostly provided enough information about these factors and measurement uncertainty at all by the vendor of the equipment, but LVDTs are only one part of the described solution. The uncertainties that are entered into the entire measurement process by the platform to which LVDTs are connected must not be ignored. Some uncertainties in the measurement process can also be realized by the use of appropriate software solutions. Additionally, an additional source of measurement uncertainty can be the network itself that connects devices, since it also combines in itself the appropriate sources of measurement uncertainty.

As can be seen from the previously exposed, there are now a larger number of possible sources of measurement uncertainty, and the process of determining what source of measurement uncertainty and how much it affects the measurement process itself becomes rather complex. Consequently, it becomes extremely difficult to determine partial measurement uncertainties which result in the difficulty in determining the combined and expanded measurement uncertainty. In accordance with the presented expectations, it is also expected a certain complexity in determining the measurement results.

3 Virtual Instrumentation Issues

Computer can be taken as a source of measurement uncertainty, however, since virtual instruments substantially represent a software solution, the problem of determining the measurement uncertainty of virtual instrumentation mainly will be in determining the measurement uncertainty of the software itself, respecting the propagation of all measurement uncertainties related to all phases preceding the work of the software itself. The application of appropriate analytical procedures gives appropriate results but in a very limited domain of work. In other words, the more complex an algorithm for the realization of a virtual instrument, the more difficult it is to apply an analytical approach to determining measurement uncertainty [7], so it does not make an adequate and universal solution to the problem of determining the measurement uncertainty of the virtual instrument.

One of the possible solutions to overcome these problems could be based on the use of the Monte Carlo method, which is often applied in situations where it is extremely complex or impossible to apply any of the other approaches. The Monte Carlo method for the basic uses the generation of a large number of random values for which a repeating of the calculation procedure is performed according to certain laws (algorithms) in order to find a unique form that can be displayed as a numerical result.

It is probable that, after a certain number of iterations, the Monte Carlo method will give certain results based on which it will be possible in some way to determine the measurement uncertainty, but here it should point out a large number of iterations needed to obtain adequate values, that is, those values that can be claimed to be suitable for further use when interpreting the measurement results. In some cases, the number of iterations may range up to several thousand, even up to several tens of thousands. This number of iterations can be a problem in the application since it takes time for their execution, which can be especially emphasized if the measurement uncertainty is determined in the measurement procedure itself [8].

From the previous considerations, we come to the conclusion that there are some difficulties in determining the "universal" measurement uncertainty of a virtual instrument applicable to any segment of the use of a virtual instrument in measurement processes as opposed to "classical"

measuring instruments in which, for example, we can rely on the values of expanded measurement uncertainty defined by the vendor itself.

4 Using of Open Source Based Solutions

Until a few years back, the concept of open source has largely been linked to principles related to the world of software [9]. Today, the open source concept turns into something more and begins to be represented in a much wider sense, so there are whole ecosystems developed on the open source basics. In recent years, there has been an increase in hardware solutions (mini computers, microcontrollers) based on the open source concepts, whether they related only to parts of software solutions that can be implemented on that hardware, or to the hardware and the environment on the whole. Some of the most well-known hardware systems based on the open source concepts are shown in Figure 2.

a) b) c)

Figure 2 - Some of actual projects that includes open source:
a) Arduino Uno Rev3 SMD [10], b) Raspberry Pi 4 Model B [11], c) ROCKPro64 [12]

These open source electronic platforms have become extremely popular in recent years among many users thanks to an extremely large community that develops new solutions jointly and improves existing, openness, highly affordable prices and a well-balanced relationship between price and performances. Today, described trends are not limited only to homemade solutions which are primarily intended for education or testing purposes. Many companies have in their portfolios solutions based on the mentioned hardware and many of those solutions are already incorporated in the real time industry processes. It is realistic to expect that the field of application of renewable sources of electricity does not remain immune to the application of such solutions in the wider area of work and their introduction in the regular application instead of some sporadic cases.

Despite many positive features related to this approach, it must be pointed to two identified issues that should be resolved in the near future in order for such solutions to be adequately applied.

Vendors which solutions are based on the use of these platforms must provide enough information about the accuracy of the final product. That practically means that vendors must engage additional resources to provide a series of tests in aim of product characteristics confirmation. Also, vendors must expand R&D departments and provide similar actions which again require the engagement of larger financial resources so the final product maybe will not be competitive with the price on the very dynamic market. As the direct consequence major of these products has no certifications or standardization which are required for using in most of the industrial appliances. It can be said that currently mentioned solutions are limited for use in so-alled "gray zone".

Due to such circumstances, unfortunately, despite the quality of such approaches, due to the problem of the proving some of the stated aspects of quality, vendors of open source based products are still more oriented to the educational area than to productive area.

5 Conclusion

In the previous chapters, three possible situations that may be encountered in modern methods of measurement instruments realization were considered with a special emphasis on the aspect of an application in the field of renewable sources of electricity. First is considered the situation when a more traditional measurement process is moved to a more modern oriented one. Then a very popular aspect of virtualization in measurement instrumentation is discussed. In the end, the segment of the open source solution application was briefly analyzed. As was shown previously, each segment

generates a large number of benefits in modern measurement procedures, but this does not mean that there are no some side effects. On the contrary, every application of new procedures based on new techniques or technologies is realized with a certain dose of the unknown, as is pointed out in the previous lines without going into a more comprehensive, deeper analysis and without presented solutions for the concrete overcoming of the mentioned problems. The goal was only to point out the potential barriers that can arise if each process is considered in the domain of measurement uncertainty.

It is believed that, in the near future, the knowledge about presented aspects will be of crucial importance, since it will be rarely met partially, but it is quite certain that modern systems will in some way include all presented solutions. Almost certainly, it can be said that in the measurement instrumentation of the future inclusion of computers and microcontrollers will grow rapidly, as well as many other devices (specifically smart ones) with the necessity of some kind of network connectivity between all those devices. Some parts of the measuring instrumentation will be realized on open source principles, and also it is very possible to expect complete open source measuring instruments. Certainly, in order to simplify, personalize and reduce costs, virtualization will become an essential factor in this domain. In order to understand and master the certain complexity of this instrumentation of the future, it will be needed to take a step towards in aim of understanding and overcoming certain features of its parts, partly done in this paper.

Which will be final answers to some of the questions considered in the presented work is not yet known, it can only be speculated with some potential possibilities. It is certain that some aspects of measurement uncertainty will have to be redefined in the near future by all interested parties, from standardization organizations to vendors, in order to respond to the modern concepts that are partly are already presented now and that will occur in the future, in order to adequately respond to challenges of the future. In accordance with some already valid, basic principles, the final solutions will certainly be applicable to the field of the use of renewable sources of electricity.

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