Pseudorandom Encoder's Development Using Virtual Instrumentation

Dragan B. Denić[1], Miodrag Z. Arsić[2], Ivana S. Ranđelović[3], Goran S. Miljković[4]

Abstract – **A pseudorandom encoder as a new type of the absolute encoder with one code track coded by applying pseudorandom binary sequences together with new possibilities in its development which offers virtual instrumentation is considered in this paper. Here, a method for parallel reading of pseudorandom code using photodetector array is proposed. A problem of zero position adjustment at encoder installation is also considered and a concrete solution in accordance with requests of high technologies encoders is proposed. Then, two programs realized with software package LabVIEW 7.1 are presented and their front panels are shown. The first program simulates a code reading in encoder using sensor heads, while the second program simulates an electronic block of encoder operating. In the paper is pointed out advantage of computer using as auxiliary means in developing of optimal pseudorandom encoder solution.**

Keywords – **Position measurement, Pseudorandom encoder, Pseudorandom binary sequence, Virtual instrument, Zero position adjustment, LabVIEW.**

I. INTRODUCTION

The development of information technologies caused that virtual instruments are important part of measurement instruments. The possibility to customize the appearance and functional range of virtual instrument enables designers to apply complex procedures of their testing, [11].

The term Virtual Instrument (VI) is often used, but there is no official definition of its meaning. The truly virtual instruments (the software model of instrument) are designed and realized relatively seldom. They are usually used for an educational purpose only, or for modeling of some properties of real instruments, [11].

Generally, VI is usually a real measuring system based on a host PC, where the PC is used for set – up and control of measurement, data acquisition, data processing and displaying results. Both systems based on measuring separated modules and systems based on stand – alone measuring instruments controlled by PC or their conjunction are such designated. Advantages and disadvantages of such virtual instruments should be judged according to their application [11].

[1] Dragan B. Denić is with the Faculty of Electronic Engineering, University of Niš, Aleksandra Medvedeva 14, 18000 Niš, Serbia and Montenegro, E-mail: ddenic@elfak.ni.ac.yu

[2] Miodrag Z. Arsić is with the Faculty of Electronic Engineering, University of Niš, Aleksandra Medvedeva 14, 18000 Niš, Serbia and Montenegro, E-mail: marsic@elfak.ni.ac.yu

[3] Ivana S. Ranđelović is with the Faculty of Electronic Engineering, University of Niš, Aleksandra Medvedeva 14, 18000 Niš, Serbia and Montenegro, E-mail: rivana@elfak.ni.ac.yu

[4] Goran S. Miljković is with the Faculty of Electronic Engineering, University of Niš, Aleksandra Medvedeva 14, 18000 Niš, Serbia and Montenegro, E-mail: goranm@elfak.ni.ac.yu

The developments in encoder technology are consequently based on the permanent technical progress. As a main part of all control systems for positioning, absolute encoders provide measured information about sensor head position related to the measurement scale. Because each position is coded, the current position is defined apart from the previous position. This is the basic quality of the absolute encoders and hence proceeds their main feature that after the power is turned on, an information about the current position of movable system is instantly obtained.

The pseudorandom positional encoders are latest development trend in position measurement new methods at industrial movable systems. Pseudorandom encoders' development requests producing of code tracks which is very unpractical because during research in developing series of solutions different code reading methods are applied, [3, 4, 5, 6]. Each of applied methods uses a different number of reading heads, so computer have a great part in analysis of signals from sensor heads, by which expensive realizations of experimental systems would be evaded. In the paper computer is applied as auxiliary means for movable system simulation that is for measurement signals getting from sensor heads.

II. PARALLEL CODE READING OF PSEUDORANDOM CODE AND ITS USAGE IN POSITION ENCODERS

The method of pseudorandom coding, which requires only one code track for absolute position determination, represents an attractive alternative to the classic measurement method. Its advantages are significant in the case of high-resolution position encoders and linear position encoders with very long code tracks. Coding is based on the "window property" of pseudorandom binary sequence (PRBS) $\{S(p) / p = 0, 1, ..., 2^n-2\}$. According to this, any n-bit code word $\{S(p+n-k) / k = n,...,1\}$ obtained by a window of width n $\{x(k) / k = n,...,1\}$ scanning the PRBS, is unique and may fully identify window's absolute position p relative to the beginning of sequence, [1, 2, 3, 4].

Pseudorandom binary sequences (PRBS) are long known, and in the field of telecommunication theory are used for finding the scope, scrambling, error detection, modulation, synchronization, etc. They are generated with a shift register of length n and a corresponding feedback. With the right choice of that feedback, the PRBS of maximal length 2^n-1 are obtained, which are also known in literature as PN sequences or M-sequences, [8].

For realizing of true pseudorandom absolute encoder, it is needed to apply any kind of parallel code reading method and in order to avoid a need for initial movement. A usage of n particular detectors is unacceptable to encoders with high measurement resolution. It is problem to dispose those n

detectors on such little space [7, 8, 9, 10]. One of the possibilities is applying of integrated photodetector arrays for pseudorandom code reading. Integrated photodetector arrays are available on the market with different intervals between photodetectors. Those intervals are 13µm, 10µm, 7µm and smalller. It should use a large number of photodetectors in order to increase absolute position measurement precision [7, 8, 9, 10].

III. New algorithm with reduced processing time

For entirely clearing of operation principle of pseudorandom positional encoder with parallel code reading, an algorithm of pseudorandom encoder electronic block is shown in Fig. 1a, which is detailed described in [8, 10].

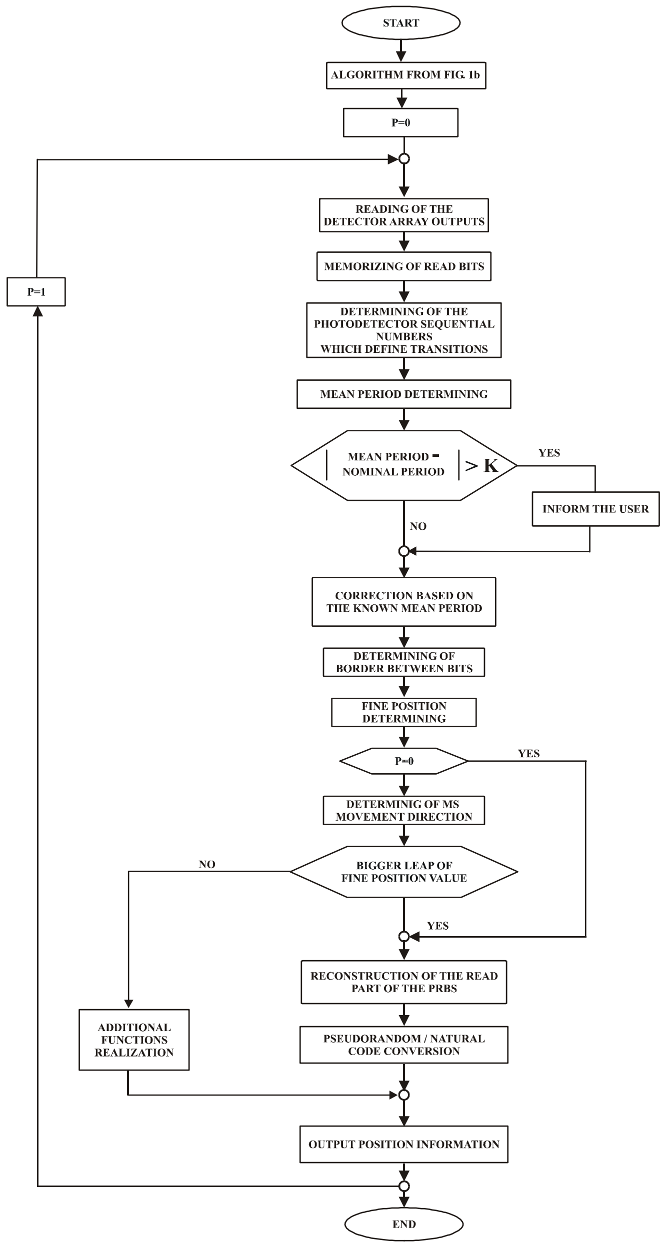

Fig. 1a. Algorithm of the proposed solution

This algorithm is product of many testing algorithms presented in references [8, 11]. For momentary position determining of movable system for case of code reading with linear photodetector array, first have to define method of rough and fine position determining. The algorithm shown in Fig. 1a defines fine position determining based on knowing sequential numbers of photodetectors which define transitions, then defines a moment of rough position determining so as method of movable system direction determining based on fine positions changes. It is easy come to information about movable system momentary position if is information about rough and fine position known. Because errors are occurred in code reading, algorithm defines method of error correction based on mean period calculating. When error is too much big, user is informed about that. In algorithm one pseudorandom to natural code converter is applied.

IV. Determining of momentary position with direct adjusted zero position

It comes to the unmatchings in the starting positions when installs an absolute encoder on movable system shaft. One of the leader factory in the world for production of new encoder generation, Stegmann, presented on the market a great choice of the incremental and absolute encoders with different mechanical interface, resolution and with the new electronic features which are in the scope of the regular standards, [11,12]. If at installation of encoder CA6S on shaft of the movable system exists an umatching in the starting positions, directly adjusting of the starting position is done by pressing a taster. More precisely, encoder installation is done and then movable system is placed in own zero position. After this by simple pressing on taster, output position information of encoder is put at value zero. With respect to mode of classic encoder functioning, this solution is probably based on correction parameters memorizing which figurate in main algorithm.

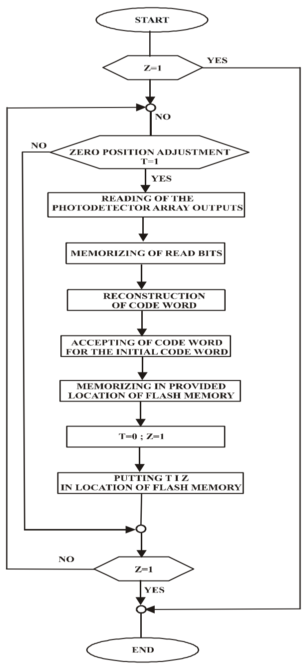

Fig. 1b. Algorithm of the proposed solution

Considering that direct zero adjustment will be soon a general request for any encoder, here is discussed a possibility of realizing such function at absolute pseudorandom encoder which is suggested here. By pressing the pushbutton at zero position of movable system, current output position information is accepted as a correction parameter and automatically a value of output position information becomes zero. Algorithm from Fig. 1a would be modified so as directly behind block “current position information“ would be a block “position information correction“. Of course, instead a first block (“algorithm from Fig.1b”) would be block which represents accomplishing of defining function above mentioned correction parameter and it’s storing in determined location of flash memory. It should know that a solution of this function requests execution of some arithmetical operations, for which unfortunately significant time is needed. Of course, this is in opposite with basic concept in this paper, and that is maximal possible decreasing of execution time of whole algorithm, in order to commercial real absolute pseudorandom encoder realization, [11].

The direct zero adjustment procedure itself is shown in algorithm, Fig. 1b. Proposed solution is based on fact that direct zero position adjustment is performed only one time at encoder installing. In algorithm from Fig. 1b, a direct zero position adjustment is done for parameter values “Z=0“, while “T=1“means that pushbutton is pressed. Parameters *T* and *Z* are put in flash memory of encoder itself, and then permanently storing of these parameters is done. That means at encoder restarting parameters *T* and *Z* stay memorized in flash memory of encoder itself so in all situations skip algorithm from Fig.1b. Therewith measurement time doesn’t increase. If direct zero position adjustment isn’t performed then pushbutton is pressed (“T=1“), reading of the detector array outputs is performed, adoption of code word for initial code word. This code word is stored in flash memory and also parameters “Z=1“, and “T=0“. When direct zero position adjustment is done then proceeds to steps executing which are presented with algorithm in Fig. 1a. The additional operation is eliminated by this, that is correction of each read value, [11]. After storing of code word in flash memory, which is stored as initial code word, code conversion pseudorandom/natural is performed, according to the algorithm which is shown in Fig. 1a and 1b. There aren’t modifications in algorithm functioning. The first block whose execution function is presented in Fig. 1b is performed only one time during direct zero adjustment procedure. In followed permanent algorithm functioning this block doesn’t more in function and according to this doesn’t influence to algorithm functioning. Such solution which, according to this description, looks as ideal approach is only one more proof of great possibilities of pseudorandom encoders in relation to many requests which will become standard in future, [11].

At the end, two programs are presented realized by using software package LabVIEW 7.1, [13], which simulate a reading from sensor heads at pseudorandom positional encoder, so as electronic block operating of such encoder, and their front panels are shown in Fig. 2 and 3, respectively. The simulation begins with program starting which simulates code reading on first computer. Within this program a route of system moving is proposed, PSBS type that is its length, number of photodetectors which read a code, so as a moment by which is initial state defined, and at the end output information is stored in database which is later used by other program. An electronic block software realization of tested pseudorandom positional encoder represents the second program which accepts information from database and gives series of positions on output. This program determines rough and fine positions and then based on that determines output positions so as information about correctness of positions and about moving direction. A selection of zero position from which code conversion would be done later is achieved by pressing the ‘STOP’ taster.

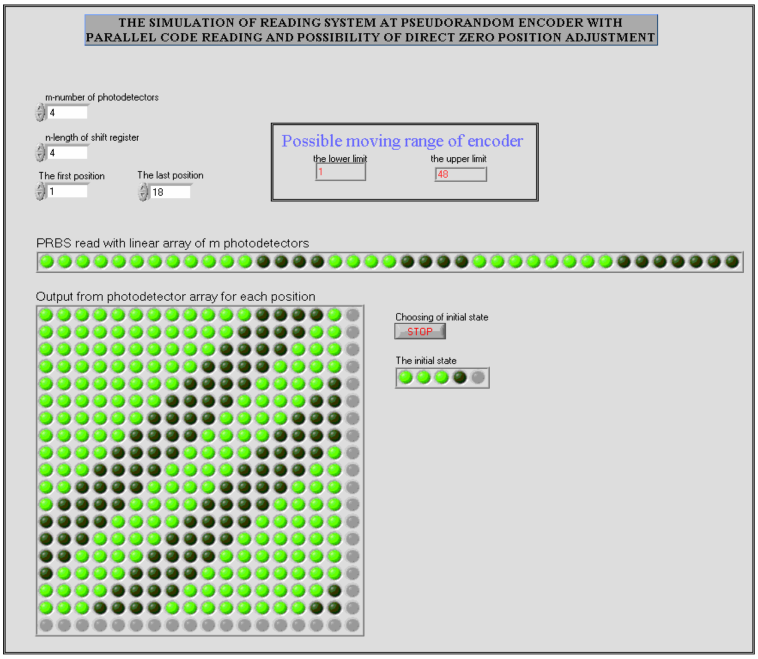

Fig. 2. Front panel of simulated reading system at pseudorandom encoder with parallel code reading and possibility of direct zero adjustment

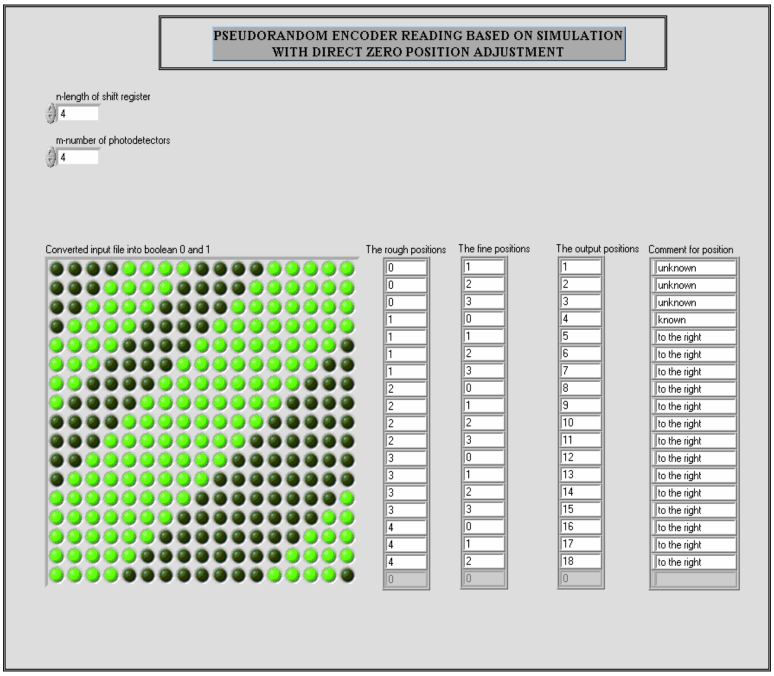

Fig. 3. Front panel of pseudorandom encoder with direct zero adjustment electronic block simulation

The output positions are decimal values which are obtained by summing of rough and fine positions binary values. Within developed solution one example for pseudorandom sequence is given with needed number of bits $n = 4$, number of photodetectors per one code bit $m = 4$, and proposed moving route is $(1-18)$, and read array of movable system momentary output positions is given in Fig. 3, in output list form, which of course can be printed.

V. CONCLUSION

Computer integrating within industry and other fields is caused by growth of electronics and microcomputer technology. In paper is shown advantage of computer using as auxiliary device in developing of optimal pseudorandom encoder solution. In the first part of the paper pseudorandom encoder with parallel code reading operating principles are explained, and then is presented a simulation of the particular parts of that encoder realized by software package LabVIEW 7.1. Simultaneously, a solution is suggested which on simple way enables direct zero position adjusting, at encoder mounting. After taster is pressed, written code word itself is adopted for started, or zero position and store in flash memory of encoder itself. Read code word is stored as initial code word and in relation to it code conversion pseudorandom/ natural is performed. On this way, anyone additional operation is eliminated, i.e. correction of each value of measured position, this is only possible way at classical absolute encoders.

REFERENCES

[1] M. Arsić, D. Denić, "Position measurements based upon the application of pseudorandom encoding", *Facta Universitatis, Ser. Electronics and Energetics*, no. 6, pp. 13-23, 1993.

[2] H. Khalfallah, E.M. Petriu, F.C.A. Groen, "Visual position recovery for an automated guided vehicle", *IEEE Trans. Instrum. and Meas.*, vol. 41, no. 6, pp. 906-910, 1992.

[3] M. Arsić, D. Denić, "Code convertor pseudorandom/natural applied at position encoders", *ETRAN, Ser. Elektronika*, pp. 164-167, 1995.

[4] D. Denić, M. Pešić, M. Arsić, “New algorithm of code conversion pseudorandom/natural”, *Proceedings ETAN,* volume II, pp. 39-44, Belgrade, 1993.

[5] E.M. Petriu, J.S. Basran, "On the position measurement of automated guided vehicles using pseudorandom encoding", *IEEE Trans. Instrum. and Meas.*, vol. 38, no. 3, pp. 799-803, 1989.

[6] M. Arsić, D. Denić, "New pseudorandom code reading method applied to position encoders", *Electronic letters* no. 10, vol. 29, pp. 893-894, 1993.

[7] D. Denić, I. Ranđelović, M. Arsić, “Absolute position measurement using the method of pseudorandom code parallel reading”, *ICEST 2003 Conference Proceedings,* pp. 394-397, Sofia, Bulgaria, 2003.

[8] D. Denić, I. Ranđelović, M. Rančić, “High-resolution pseudorandom encoder with parallel code reading”, *ISSN 1392-1215 Electronics and electrical engineering* Nr 7(56), pp. 9-14, Kaunas, Litvania, 2004.

[9] D. Denić, I. Ranđelović, J. Đorđević, G. Miljković, "New type of linear and angular displacement transducer based on pseudorandom encoding", *ICEST 2005 Conference Proceedings,* pp. 394-397, Niš, Serbia and Montenegro, 2005.

[10] D. Denić, I. Ranđelović, "New type of position encoder with possibility of direct zero position adjustment", *IDAACS 2005 Conference Proceedings,* pp. 299-305, Sofia, Bulgaria, 2005.

[11] M. Florezyk, W. Winiecki, "The parametric method for functional testing of virtual instruments", *IDAACS 2005 Conference Proceedings,* pp. 310-315, Sofia, Bulgaria, 2005.

[12] http://www.stegmann.com

[13] LabVIEW, User's Manual, National Corporation, USA, 2004