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APPLICATION OF PSEUDORANDOM POSITION ENCODER FOR CRANE POSITIONING

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Abstract

The presented solution is based on application of developed pseudorandom linear encoder, with high reliability and flexibility, for crane positioning. Implementation of better solution for the crane displacement problem is achieved by applied encoder because position information from encoder is more reliable. The crane displacement problem is caused by geometrical deformities or irregularities of the crane paths and the crane, damages that are caused by the exploitation and by dynamical influences.

Keywords: pseudorandom position encoder, crane positioning, crane displacement problems.

INTRODUCTION

For positioning of various movable systems in precise automatic industrial machines, position measurement is very important. Angles and length have to be measured with a high accuracy and high reliability. Today it is achieved by digital positon transducers known as encoders. The optical encoder may be either rotary or linear and for commercially position, encoder may be incremental-type or absolute type, [1]. During the last years, very interesting for position measurements are pseudorandom binary sequences, also known as chain codes or shift register codes. Length (2^n-1) pseudorandom binary sequence generated by n-bit shift register and the corresponding feedback [2], is entered on the code track. On the basis of this code it is possible to realize pseudorandom linear encoder and to apply this solution to the crane positioning such as it is shown in [3]. The absolute position identification is based on the "window property" of pseudorandom binary sequences (PRBS) $\{S(p)/p=0,1,...,2^n-2\}$. Therefore any n-tuple $\{S(p+n-k)/k=n,...,1\}$ provided by a window $\{x(k)/k=n,...,1\}$ of width n scanning the PRBS, is unique and may fully identify window's absolute position p relative to the beginning of sequence, [3].

Cranes are machines with four-legged portal built to run back and forth on parallel rails, Fig.1, which can reach a more extensive area of a construction site.

Fig. 1. *Portal crane*

Many national standards, which define crane competence to work conditions, are established. From the point of view of usage for both the users and designers, crane displacement is very important problem. In this paper the use of pseudorandom absolute position encoder for crane positioning and prevention of crane displacement is proposed.

MEASUREMENT FOR CRANE DISPLACEMENT

The working crane loading leads to damage that causes construction damage or the loss of static stability and of function readiness. That is why many national standards define working crane conditions.

The crane displacement problem is caused by geometrical deformities or irregularities of the crane paths and the crane, damages that are caused by the exploitation and by dynamical influences. The technical standards define permitted angle of the displacement and side forces are provoked by it. The side forces are the bases for construction of the supporting structure, [3]. The portal reloading cranes can have much bigger displacement. In that case, these constructions have low rigidity and possibility to regulate the parallelism in construction and reduce displacement is not possible, [1]. The displacement shape of this crane at moving is shown at Fig. 2. Increasing the driving resistance of one portal side for the force ΔF causes the lag of this side portal for the length of ΔL.

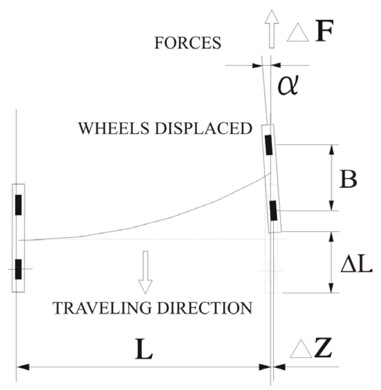

Fig. 2. *The displacement of the reloading portal crane*

$$\Delta L = \frac{L}{B} \cdot \Delta Z + \frac{\Delta F \cdot L^3}{3 \cdot E \cdot I_M} + \frac{\Delta F \cdot L^2 \cdot H_N}{G \cdot I_{ON}} \quad (1)$$

where L is range of lifts, H_N height of the portal leg, E and G modulus of elasticity and sliding, I_M the moment of inertia of the main carrier of the crane, I_{ON} the moment of inertia of the portal leg, B wheel spacing of the portal.

The classical mechanical solutions for prevention of the displacement require the high rigidity of the construction. Achieving parallel control of absolute information of the position of the both sides of the crane is very important. There are some technical solutions for the parallel control which is made based on the absolute information of position of the both sides of the crane. The first technical solution for parallel control is done by using “electrical shaft” where the motor speed is corrected by using phase’s differences of the angle speed of the electrical field of both sides of the crane. Then the classical absolute linear encoders are applied for parallel control of absolute positions of the left and the right crane side. Because of generated enormous number of quantization steps for real path length of the crane, application of pseudorandom absolute position encoder [4, 5, 6] proposed in this paper.

A good features of an absolute encoder and almost as simple as an incremental encoder is pseudorandom absolute encoder, Fig.3, with one synchronisation and one pseudorandom code track.

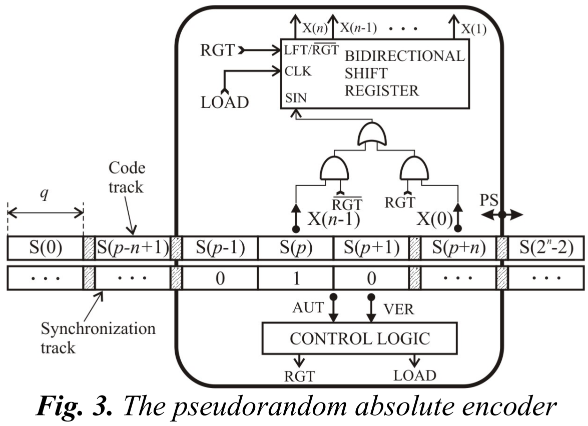

Fig. 3. *The pseudorandom absolute encoder*

This position encoder uses read bits from sensor heads $X(n\text{-}1)$ and $X(0)$, depending on the direction of movement, and send them to the shift register in order to form a n-bit code word [7]. Only one bit is being read for each new position of the movable system and entered into the mentioned shift register. After the initial movement that corresponds to space width of n bits, forming of the code word, which corresponds to the current position of the movable system, will be done. For each of the following positions a new bit is being read, and along with (n-1) bits of the previous code word, an output code word of the new position is obtained. Evidently, there is a necessity of initial moving after the first power-up, meaning that the movable system (MS) crosses a distance equivalent to space width of n code bits, so that the first valid output n-bit code could be formed.

In the case of high-resolution encoders, mentioned distance of initial movement is very small. However, this is still a pseudorandom absolute encoder's disadvantage. The use of two reading heads can be used to check the code reading errors as well as to operate in a single-head mode if one reading head is damaged. After forming of pseudorandom code word, it is necessary to convert it into the natural code [8, 9] and also can be implemented a procedure of checking pseudorandom code reading correctness, [10].

THE MEASUREMENT SYSTEM FOR POSITIONING AND PREVENTING OF CRANE DISPLACEMENT

The system for crane displacement measurement is presented in Fig. 4. The signals from two encoders are sent to the input ports of the microprocessor unit. Two measurement systems are applied and provide parallelism in crane moving and in that way prevent crane displacement. Pseudorandom binary code is used in this measurement system with two reading heads for synchronisation track and two reading heads for code track. Synchronisation track is used for direction determination and defining of moment of pseudorandom code reading.

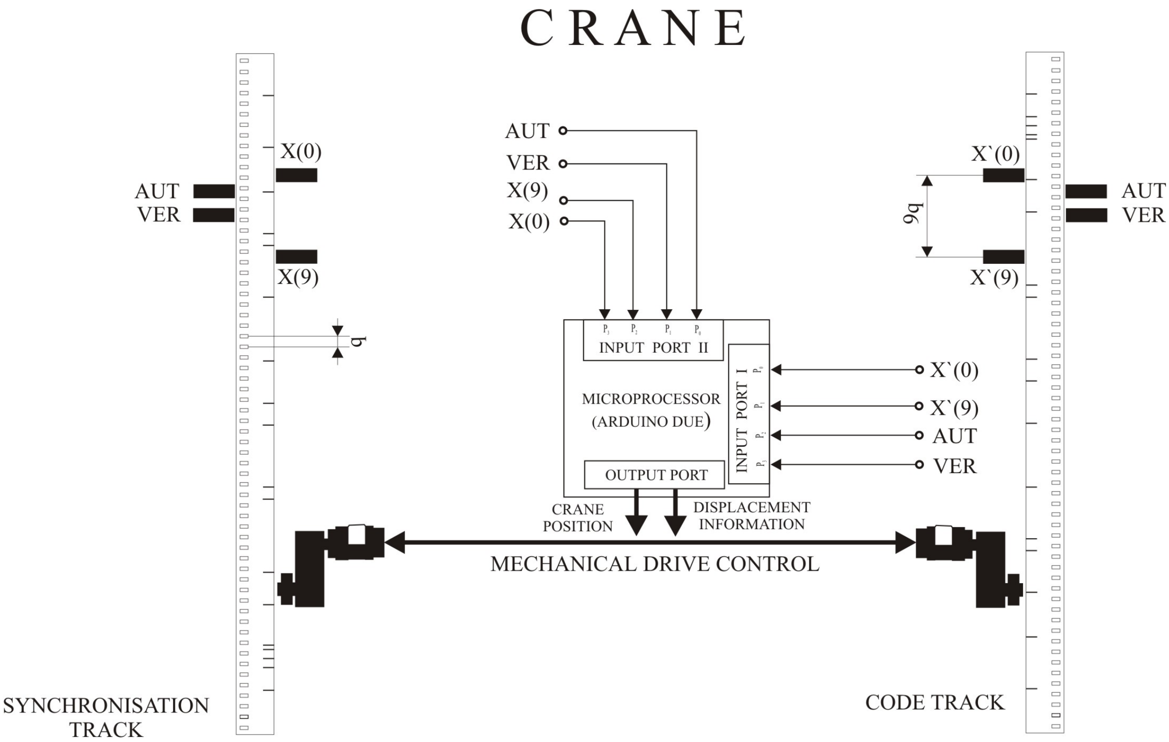

Fig. 4. *The measurement system based on microprocessor for positioning and preventing of crane displacement*

An example of a 10-bit pseudorandom binary code is considered, which is read with two reading heads, $X(9)$ and $X(0)$, at the distance 9q. Reading heads *AUT* and *VER* provides reading code synchronisation and determination of the moving direction. All functions of this system are realized with microprocessor Arduino Due, where in working algorithm are compared absolute position information of both sides of crane, calculated crane displacement and determined certain correction parameters. Pseudorandom binary code is not suitable for direct application in digital electronics, and so pseudorandom/ natural code conversion must be implemented. Sources of errors in pseudorandom absolute encoder are quantization error (due to digitalization), assembly errors, structural limitations (code track deformations due to loading), manufacturing tolerances (inaccurately imprinted code patterns, positioning of code reading sensors) and ambient influences (temperature, vibration, contamination, light noise, humidity).

The proposed system is an intelligent, programmable, and reliable due to implemented procedure for code reading error detection. Two reading heads, *X*(9) and *X*(0), can form two code words which should be on the same distance, and this fact enables implementation of procedure for checking of the code reading correctness.

CONCLUSION

This paper shows a concept and realized solution for crane positioning using pseudorandom absolute position encoders. On the basic of experimental results of the developed encoder functioning, discussion about possibility of its application for crane positioning is given. The proposed solution for crane positioning provides a precise and high reliable position information and crane displacement problem prevention.

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