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EXAMINATION OF THE POTENTIAL FOR CONTROLLING THE TRACTOR'S DRIVE WHEEL'S TURNING ANGLE WITH ENCODERS

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Abstract. This article analyzes the operating principles of encoders used to convert linear and rotary motion into digital signals. Particular attention is given to the working mechanisms of optical and magnetic encoders, as well as the structural and functional features of incremental and absolute encoders. The main advantages of incremental encoders include simple design, high resolution, and low cost, while their primary limitation is the relative measurement principle and the loss of positional information when power is interrupted. The study also examines the structure of coding disks, encoding methods based on Gray and Barker codes, and the advantages of absolute encoders in high-precision control systems. The comparative analysis demonstrates the practical significance of encoder technologies in modern industrial automation and motion control applications.

Keywords: encoder, incremental encoder, absolute encoder, optical encoder, magnetic encoder, coding disk, Gray code, Barker code, rotation angle, digital signal.

Encoders can be used to convert linear or rotary motion into a binary digital signal. An encoder is a device whose shaft is connected to the rotating shaft of the object being measured, providing electronic control of the object's rotation angle. Based on their operating principle, encoders are classified as optical or magnetic.

encoder shaft is equipped with a disk with interrupt windows around its perimeter. An LED and phototransistor are positioned opposite these windows, generating an output signal in the form of a sequence of rectangular pulses with a frequency proportional to both the number of interrupt windows and the disk/shaft rotation speed. The number of pulses represents the angle of rotation. Optical encoders are available as incremental and absolute encoders.

Incremental encoders They have an interrupt disk with multiple windows of equal size on the main radius and two readout optocouplers , which allows recording both the rotation angle and the direction of shaft rotation. A single interrupt window and a corresponding optocouplers are located on the secondary radius of the disk , determining the initial position (the reference point).

The advantage of incremental encoders is their simple design and, consequently, low cost, with high resolution and high operating frequency.

The main disadvantages are that incremental encoders produce a relative reading of the rotation angle, information about which is not saved when rotation stops.

incremental encoders are designed for industrial applications in mechanical engineering, rolling mills, shipbuilding, textile and footwear industries, and elsewhere. Key parameters for these encoders include rotation angle resolution, the ability to operate at high frequencies, and a high degree of protection to withstand harsh environmental conditions.

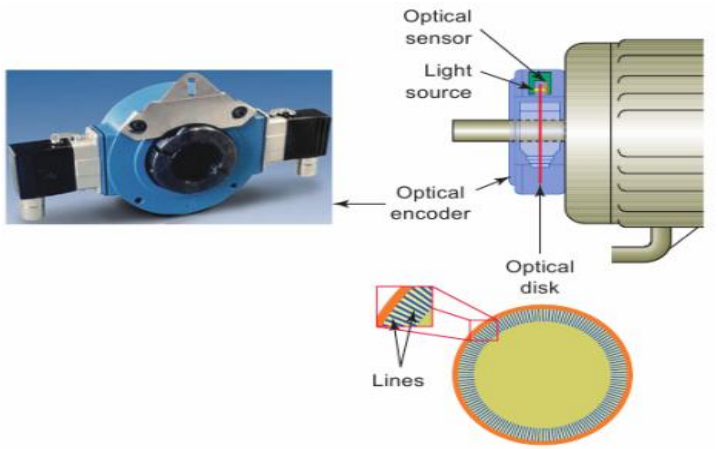


Fig. 1. The main components of an incremental encoder are:

A rotating disk (encoding disk) with lines or slots; a light source; and an optical sensor (receiver) (Fig. 1). The rotating disk with slots interrupts the light beam to the optical sensor. An electronic circuit connected to the output of the optical sensor counts the beam interruptions and generates digital output pulses for the encoder .

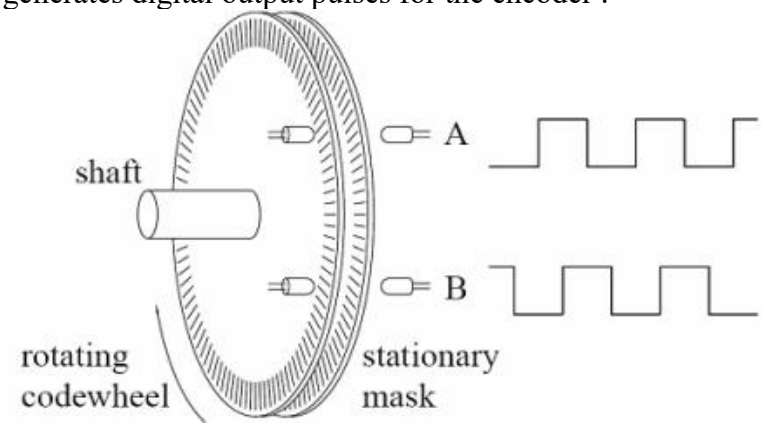
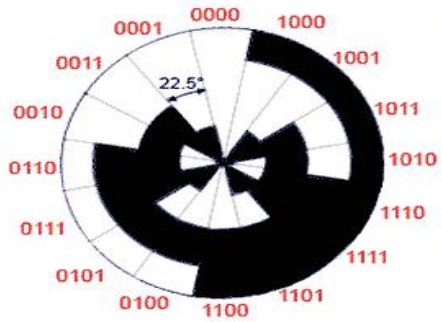


Fig. 2. Generalized principle of construction of an incremental encoder .

The coding disk is A device for converting shaft angular displacement values into digital form. A geometric image of a digital code is applied to the coding disk . The code's digits are printed on a concentric track, with the least significant digits located closer to the periphery.

Depending on the code reading method (contact, photoelectric, electromagnetic, inductive, electrostatic, etc.), the geometric image of the code can be composed of sections that are electrically conductive and electrically insulated , transparent and opaque, magnetic and non-magnetic, etc. The general appearance of a 4-digit coding disk with a coding table is shown in Fig. 2. To encode the angular rotation according to Fig. 2, four light sources and a photoelectric sensor installed opposite each other are required . At the outputs of the photo sensors, parallel codes are formed corresponding to the angle of rotation of the wheel (shaft), which can be easily converted by a microcontroller into decimal or a convenient visual form for operator reading.

The disadvantage of a 4-bit incremental encoder is its large conversion error and relatively narrow range of rotation angle control (only 32 $^{\circ}$). Another disadvantage is the occurrence of errors when crossing the boundaries of individual discrete sections, when some digits can be read on one side of the boundary, and some on the other (due to inaccurate installation of removable devices or due to non-simultaneous reading of the code during disk rotation).



Decimal	Gray Code
0	0000
1	0001
2	0011
3	0010
4	0110
5	0111
6	0101
7	0100
8	1100
9;	1101
10	1111
11	1110
12	1010
13	1011
14	1001
15	1000

Fig. 3. General view of the coding disk encoding the F -code (Barker code) and the reflex code (Gray code)

Encoding disks with binary code variants that eliminate the above-mentioned errors are predominantly used. These codes include the so-called F -code (Barker code) and the reflex code (Gray code) , which are formed by the subsequent encoding disk (Fig. 3). A single encoder cannot indicate the direction of rotation. To determine the direction of rotation of a shaft or wheel, a second "source-receiver" pair must be added, 90 ° out of phase with the first. Some optical rotary encoders use a reflective encoding disk. This disk alternates between sections that absorb and reflect light, and the light source and receiver are located on one side of the disk. A unique feature of these encoders is that, with only one light source and receiver, the pulse sequence from the sensor allows one to determine how many steps the disk has rotated relative to its previous position.

Note that any system that detects the relative rotation of the disk, but cannot measure its absolute angular position, is an incremental sensor.

The best option among the encoders considered is the absolute encoder (Fig. 4). It has an interrupt disk with concentric windows at different radii, whose relative sizes are determined by a binary code, and which are read simultaneously, giving a coded output signal for each angular position (Gray code, binary code...).

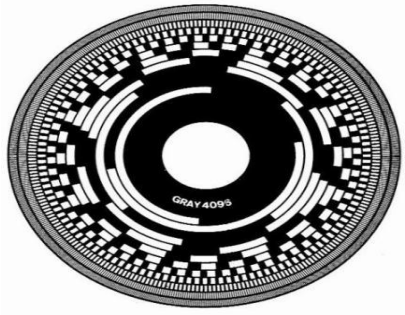


Fig. 4. General view of the coding disk , Gray code and binary code.

This encoding method makes it possible to obtain data on the instantaneous position of the shaft, the position of the wheels without a digital counter or returning to the initial position, since the output is a multi-bit coded word.

Encoders are usually manufactured in a “hole” version and important elements of their design are special couplings that allow compensation for motor shaft play.

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