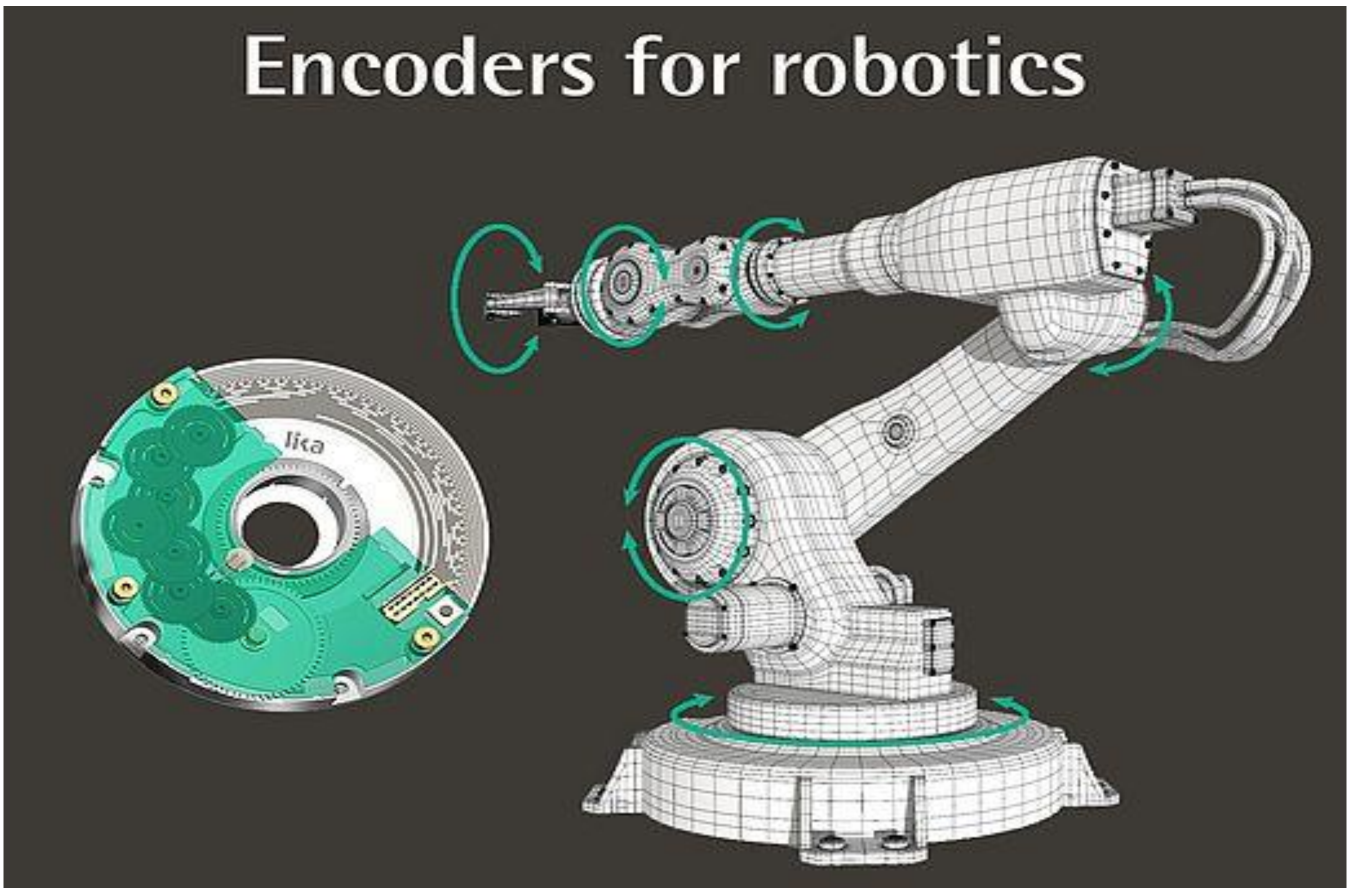
Encoders for robotics
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About the College

Basaveshwar Engineering College was started in the year 1963 offering bachelor degrees in Civil, Mechanical and Electrical Engineering. At present it offers degree programs in ten disciplines and ten post graduate programs including MBA & MCA. The College is a Government aided institution affiliated to Visveswaraiah Technological University (VTU), Belgaum in Karnataka and approved by All India Council for Technical Education (AICTE), New Delhi. Eight departments of the college have been recognized as Research Centers by VTU. Also five departments are recognized as QIP Centers for Ph.D programs by AICTE New Delhi. The college was granted autonomous Status by VTU and UGC in the year 2007. Since then the college has introduced Academic reforms by restructuring the curriculum keeping in view the technological developments and needs of the industry. The College has been selected under TEQIP phase II for scaling up PG and demand driven Research programs. Under this program new research laboratories and facilities have been created for the benefit of PG Students and research scholars to carry out high quality research work.

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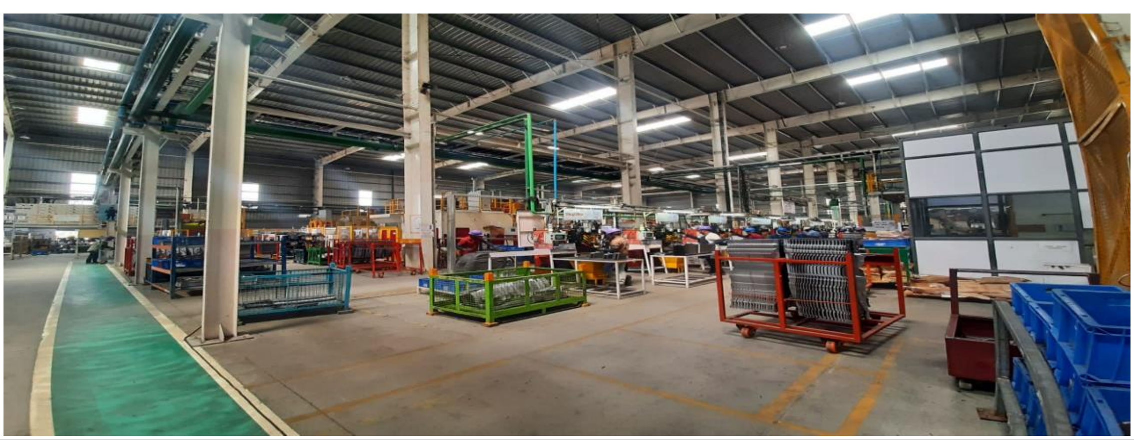
About the organization

Headquartered in Haryana, India, JBM Ogihara Automotive India Lmt. was founded by a pool of live wire professionals having several years of combined technical and corporate expertise in providing high quality, cost-effective and complete end-to-end solutions to its valued customers. All our team members are highly qualified in their respective fields and have years of industrial experience behind them.

JBM Ogihara is specialized in the manufacture of Japan machines and tools. As an Automotive company, we are known for our expertise in automated assembly lines, process automation, data acquisition and visual inspection. JBM Ogihara is one of the leading companies in manufacturing the automotive car components for reputed companies like Maruti, Toyota.



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1. Introduction to Encoders

Encoders are a fundamental component of modern technology and play a crucial role in various fields, from computer science to artificial intelligence. At its core, an encoder is a sophisticated algorithm or model that transforms raw input data into a compressed and meaningful representation, often in the form of a numerical code or vector.

In the realm of natural language processing, encoders have revolutionized the way machines understand and process human language. They can translate text into numerical embedding's, capturing intricate semantic and syntactic relationships between words and sentences. These representations have enabled breakthroughs in machine translation, sentiment analysis, and question-answering systems.

Similarly, in the domain of computer vision, encoders excel at extracting valuable information from images, converting pixels into compact feature vectors. This capability has significantly advanced image recognition, object detection, and even autonomous vehicles.

Moreover, encoders have revolutionized recommendation systems, where they efficiently summarize user preferences, enabling personalized content suggestions for online platforms.

In this ever-evolving landscape of artificial intelligence and data science, encoders continue to be at the forefront of innovation. Their ability to learn and represent complex patterns empowers us to tackle previously insurmountable challenges. As we delve deeper into the realm of encoders, we discover an exciting world of possibilities, where raw data metamorphoses into knowledge, leading us towards a future of unprecedented technological achievements. Thus these encoders can be used in Robots to control its speed and position.

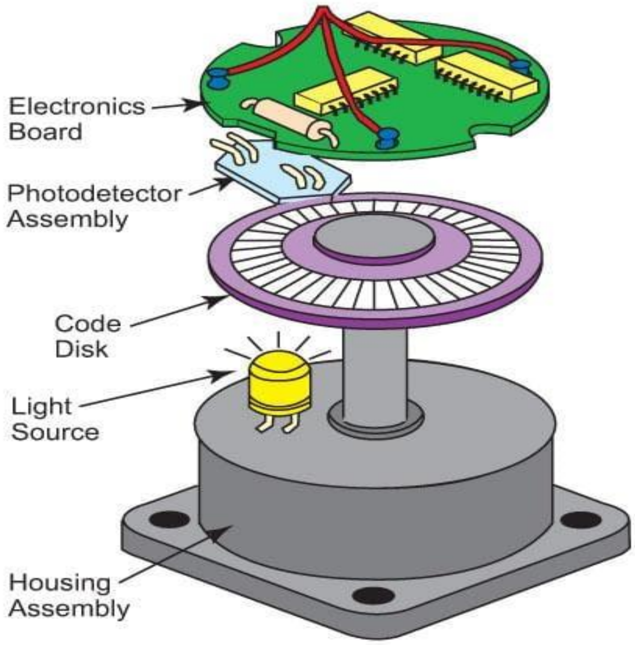

Fig no 1.1: Encoder

Encoders are devices integrated into servo motors in robots to provide feedback about the motor's position, speed, and direction. They consist of a sensor that tracks the motor's rotation and sends signals back to the control system, allowing for precise control and accurate positioning of the motor. This feedback loop enables the robot to maintain its desired position and make adjustments in real-time, enhancing its overall performance and stability in various applications.

2. Design of Encoders in Servo motor

The design of encoders in servomotors involves careful consideration of various factors to ensure accurate and reliable position and speed feedback. While the specific design may vary depending on the application and the motor's requirements, here are the key elements and considerations typically involved in the design of encoders in servomotors:

Encoder Type: There are different types of encoders used in servomotors, including optical, magnetic, and capacitive encoders. Each type has its advantages and limitations in terms of resolution, reliability, cost, and environmental robustness. The selection of the encoder type depends on factors like the required resolution, speed, and the environment in which the motor operates.

Resolution: The resolution of the encoder determines the accuracy of position and speed measurement. Higher resolution encoders provide finer increments of feedback, enabling more precise control. The encoder's resolution is determined by the number of slots, pulses, or lines per revolution on the encoder disc or sensor.

Quadrature Encoding: Many encoders in servomotors use quadrature encoding, where two output channels (A and B) produce out-of-phase signals. This method allows the motor controller to determine both the direction and speed of rotation by analyzing the phase relationship between the A and B channels.

Index Pulse: Some encoders also include an index pulse, which occurs once per revolution. The index pulse provides a reference point, enabling the motor controller to determine the motor's absolute position, ensuring that position information is not lost during power-up or in case of any errors.

Signal Interface: The encoder must have an appropriate signal interface to communicate with the motor controller or drive system. Common signal interfaces include incremental quadrature signals (A, B, and index), analog signals, or digital communication protocols like SSI (Synchronous Serial Interface) or BiSS (Bidirectional Serial Synchronous Protocol).

Environmental Considerations: Encoders in servomotors may operate in harsh environments, including high temperatures, vibration, and dust. Therefore, the design should take into account the required environmental robustness and protection to ensure reliable operation.

Electrical Noise Immunity: To maintain accurate feedback, encoders must be designed to minimize susceptibility to electrical noise or interference, which can affect the quality of the encoder signals and the motor control system's performance.

Integration with Servomotor: The mechanical design of the encoder must allow for easy integration with the servomotor's shaft. It should provide a secure and accurate coupling to the motor shaft to ensure that any movement of the motor is accurately translated to the encoder's output.

Calibration and Compensation: During the design process, calibration and compensation techniques may be implemented to account for any encoder errors or variations, ensuring accurate and consistent feedback.

Overall, the design of encoders in servomotors is a crucial aspect of achieving high-precision motion control. Proper selection of encoder type, resolution, and signal interface, combined with considerations for environmental robustness and noise immunity, are essential for ensuring the motor's reliable and accurate performance in various application

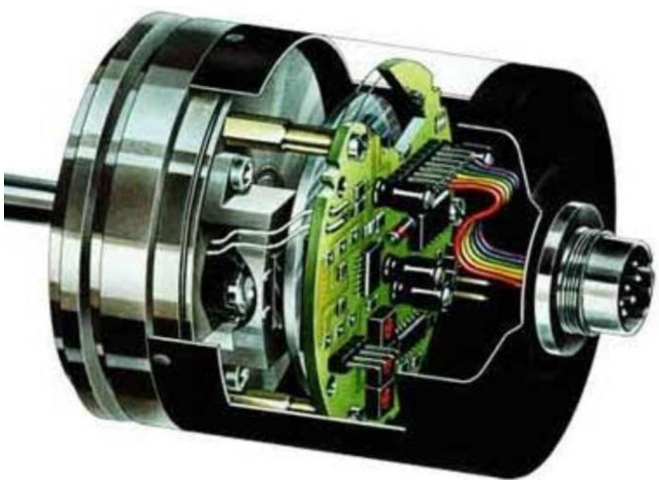


Fig no 2.1: Overview of Encoder in Servo motor

3. Types of Encoders

1. Incremental Encoder
2. Absolute Encoder

Incremental Encoder

An incremental encoder is a type of position sensor that provides relative and continuous feedback on the motion or position of a rotating shaft. It generates electrical pulses or signals as the shaft rotates, but it does not provide information about the absolute position. Instead, it measures changes in position from a reference point, typically referred to as the "index pulse," which occurs once per revolution. The encoder's output is in the form of pulse counts, and by analyzing the pulses' frequency and direction, the system can calculate the relative position, speed, and direction of the rotating shaft. Incremental encoders are commonly used in various applications, including servomotors, robotics, CNC machines, and automation systems.

Absolute Encoder

An absolute encoder is a type of position encoder that provides unique and unambiguous position information for a rotating shaft or object. Unlike incremental encoders, which generate pulses that indicate relative movement, absolute encoders produce a binary or digital code that represents the exact position of the encoder's shaft at any given moment, even after a power cycle or system restart.

The key characteristic of an absolute encoder is that it has a separate output for each possible shaft position, and each output represents a unique binary or digital code. This means that the encoder can determine its position without the need for additional reference points or initialization procedures.

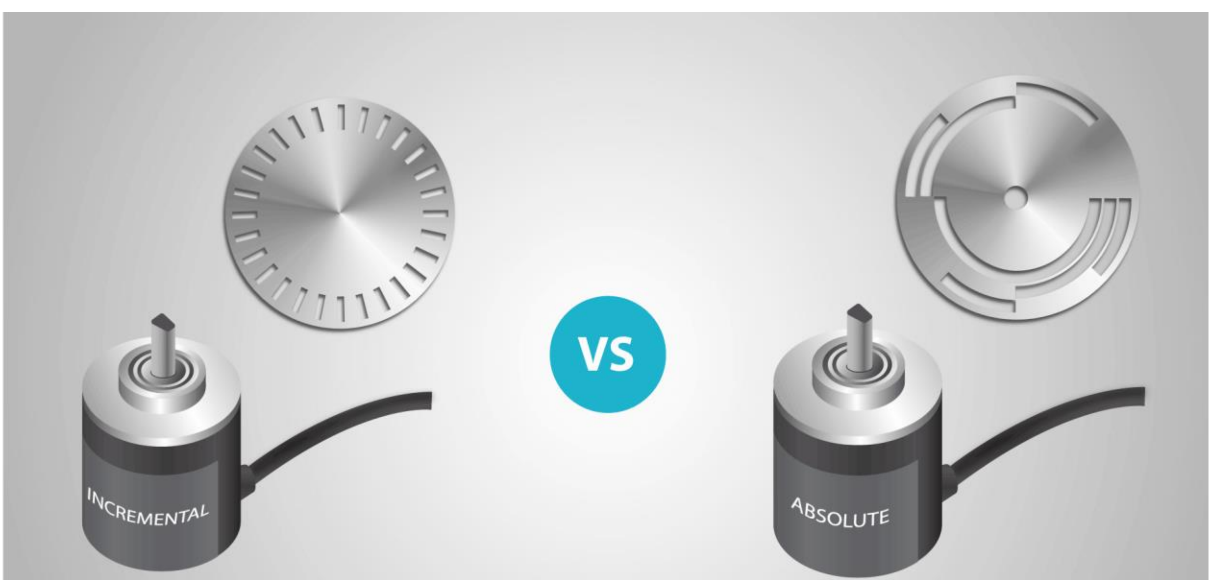

Fig no 3.1 : Incremental and Absolute type of Encoder

4. Input and Output for Encoders in Servo motor

In servo motors, the encoders serve as feedback devices, providing information about the motor's position and speed to the motor controller or drive system. The encoder takes the motor's rotational movement as input and generates electrical signals as output, which convey position and speed data. Let's delve into the inputs and outputs of encoders in servo motors:

Input

Motor Shaft Rotation: The primary input to the encoder is the rotational movement of the motor shaft. As the servo motor rotates, the encoder's sensor (e.g., a disc with slots or patterns, or optical/magnetic sensors) detects these movements.

Output

Position Feedback: The encoder generates electrical pulses or digital codes that represent the motor's current position. The number of pulses or code steps corresponds to the motor's angular position, providing precise position feedback to the motor controller.

Speed Feedback: By analyzing the frequency or timing of the pulses generated by the encoder, the motor controller can deduce the motor's rotational speed. The speed feedback allows the controller to regulate and maintain the motor's speed at the desired level.

Direction of Rotation: In encoders with quadrature encoding (A and B channels), the phase relationship between the A and B signals determines the direction of the motor's rotation. The controller uses this information to control the motor's direction during position and speed adjustments.

Index Pulse (Optional): Some encoders include an index pulse, which occurs once per revolution. The index pulse provides a reference point or a unique marker that allows the motor controller to determine the motor's absolute position. This is particularly useful for multi-turn absolute encoders.

The outputs from the encoder are sent to the motor controller or drive system, which continuously analyzes the position and speed feedback to adjust the motor's operation and maintain precise control over its movements. The motor controller compares the desired position or speed (set point) with the feedback from the encoder. Based on this comparison, it calculates an error signal and generates appropriate control signals to adjust the motor's power and direction, effectively bringing the motor closer to the desired position and speed.

The continuous feedback loop, facilitated by the encoder, ensures that the servo motor operates with high precision and accuracy, making it suitable for applications requiring precise motion control.

5. Working Principle of Encoders in Servo Motor

The working of encoders in servo motors involves a closed-loop control system, where the encoder provides feedback on the motor's position and speed, allowing the motor controller to continuously adjust and maintain the desired position or speed. Let's dive into the working of encoders in servo motors step-by-step:

Encoder Setup: The encoder is typically mounted on the shaft of the servo motor. It consists of a disc with slots or patterns, or it may use optical or magnetic sensors to detect rotational movement. The number of slots or pulses on the disc determines the encoder's resolution, which affects the precision of the motor's control.

Signal Generation: As the servo motor shaft rotates, the encoder detects the changes in the slots or patterns on the disc or the variations in the magnetic fields. These movements generate electrical signals in the form of pulses.

Feedback Signal: The electrical pulses are sent as feedback to the motor controller or drive system. The frequency of the pulses corresponds to the motor's rotational speed, and the number of pulses provides information about the motor's position.

Comparison and Error Calculation: The motor controller compares the feedback signals from the encoder with the desired position or speed (set point). If there is any deviation between the two, an error signal is calculated, representing the difference between the actual and desired states.

PID Control: To minimize the error and achieve precise control, the motor controller uses a PID (Proportional-Integral-Derivative) control algorithm. The PID controller takes into account the magnitude and duration of the error to generate control signals for the motor.

Motor Adjustment: The control signals are sent to the motor's drive system, which adjusts the motor's operation based on the PID controller's output. The motor's power and direction are adjusted to bring the motor closer to the desired position or speed.

Continuous Feedback Loop: The process of feedback, error calculation, and motor adjustment occurs rapidly and continuously, creating a closed-loop control system. As the motor rotates, the encoder provides continuous feedback, allowing the motor controller to make real-time adjustments to maintain precise control over the motor's position and speed.

6. Application in Encoders

1. RFID (Radio Frequency Identification) Technology
2. Machine Learning and Natural Language Processing (NLP)
3. Image and Video Compression
4. Text Encoding
5. Cryptography
6. Digital Communication
7. Error Detection and Correction
8. Data Compression

7. Conclusion

Encoders in servo motors act as feedback devices, providing information about the motor's position and speed to the motor controller. This closed-loop control system enables servo motors to achieve high precision and accuracy in various applications, making them ideal for tasks that require precise motion control.