Government Polytechnic Jalgaon

Academic Year 2020-21

Course Code

Control System And PLC

(22531)

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MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

GOVERNMENT POLYTECHNIC, JALGAON
(0018/1567)

Program Name and Code : ELECTRONICS & TELICOMMUNICATION
Course Name And Code : Control System And PLC (22531)
Academic Year : 2020-21
Semester : Fifth.

A MICRO PROJECT

On

Survey Of Servo System Used In Industrial Automation

Submitted on _____2020 by the group of 4 students.

Sr. No.	Roll No.	Name of student	Enrollment No.	Seat No.
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Certificate

This is to certify that Master Mr/Ms. **Prathamesh , Mohit , Mohish , Mandar** Roll No.**11, 23, 24, 25** Of **5th** Semester of Diploma in **E&TC.** Of Institute, **Government Polytechnic, Jalgaon (Code:0018/1567)** has completed the **Micro Project** satisfactorily in the Subject control system AND PLC (22531) for the Academic Year 2020- 2021 as prescribed in the curriculum.

Place**: Jalgaon** Enrollment No:-

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Date:-

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Seal of Institution

TITLE

Survey Of Servo System Used In Industrial Automation

Submitted by-:

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Under The Guidance Of:

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1. RATIONAL

A control system is a discipline that applies automatic control theory to design systems in such a way as to achieve a desired control of operation of the system. Control engineering has an essential role in a wide range of control systems. It seeks to understand physical systems, using mathematical modeling, in terms of inputs, outputs and various components with different behaviors. This course will facilitate students to use the different control systems used in various range of applications from simple home heating controller using a thermostat to a large Industrial control systems which are used for controlling processes or machines. The course introduces Control system and PLC which is adapted for the control of manufacturing processes.

2. COURSE OUTCOMES (COs)

- Identify different types of control systems.
- Determine the stability of the control system.
- Test the performance of various types of controllers.

Servo system -:

A servo controller is the heart of a servo system. A typical servo system consists of a motor, feedback device, and the controller. The control circuitry typically involves a motion controller, which generates the motion profile for the motor, and a motor drive which supplies power to the motor based on the commands from the motion controller. Servo systems are closed-loop systems which have some benefits over open-loop systems including the fact that they improve transient response times, reduce steady state errors and reduce system sensitivity to load parameters.

Servo system is one of the automatic control systems. It is used to control the rotation angle (or displacement) of the controlled object so that it can automatically, continuously and accurately re-enter the input command.It is usually a closed-loop control system with negative feedback, and in some cases open-loop control can be used to achieve its function.In practical applications, an automatic control system, such as a numerically controlled machine tool, generally adopts a mechanical position or an angle as a control object.

Servo system performance requirements

1. high displacement accuracy

Displacement accuracy: refers to the degree of compliance between the command pulse and the displacement of the machine table and the actual displacement of the command pulse converted into the table by the servo system.

2. good stability

Stability: The servo system can reach new or return to the original equilibrium state after a short adjustment process under the given input or external disturbance.

3. high positioning accuracy

Positioning accuracy: refers to the accuracy of the output can reproduce the input

4. fast response is good

5. wide speed range

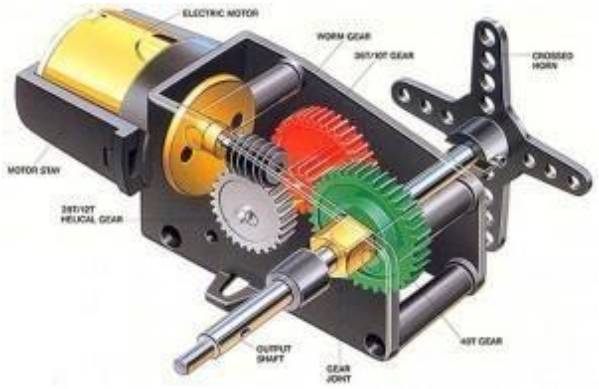
Speed regulation range: refers to the ratio of the maximum speed and the minimum speed that the mechanical device requires the motor to provide.

6. the system reliability is good .

7. low speed and large torque .

servo motor

The servo motor is most commonly used for high technology devices in the industrial application like automation technology. It is a self contained electrical device, that rotate parts of a machine with high efficiency and great precision. The output shaft of this motor can be moved to a particular angle. Servo motors are mainly used in home electronics, toys, cars, airplanes, etc.This article discusses about what is a servo motor, servo motor working, servo motor types and its applications.



Servo Motor

Types of Servo Motor

Servo motors are classified into different types based on their application, such as AC servo motor, DC servo motor, brushless DC servo motor, positional rotation, continuous rotation and linear servo motor etc. Typical servo motors comprise of three wires namely, power control and ground. The shape and size of these motors depend on their applications. RC servo motor is the most common type of servo motor used in hobby applications, robotics due to their simplicity, affordability and reliability of control by microprocessors.

1) DC Servo Motor

The motor which is used as a DC servo motor generally have a separate DC source in the field of winding & armature winding. The control can be archived either by controlling the armature current or field current. Field control includes some particular advantages over armature control. In the same way armature control includes some advantages over field control. Based on the applications the control should be applied to the DC servo motor. DC servo motor provides very accurate and also fast respond to start or stop command signals due to the low armature inductive reactance. DC servo motors are used in similar equipments and computerized numerically controlled machines.

DC Servo Motor

2) AC Servo Motor

AC servo motor is an AC motor that includes encoder is used with controllers for giving closed loop control and feedback. This motor can be placed to high accuracy and also controlled precisely as compulsory for the applications. Frequently these motors have higher designs of tolerance or better bearings and some simple designs also use higher voltages in order to accomplish greater torque. Applications of an AC motor mainly involve in automation, robotics, CNC machinery, and other applications a high level of precision and needful versatility.

AC Servo Motor

3) Positional Rotation Servo Motor

Positional rotation servo motor is a most common type of servo motor. The shaft's o/p rotates in about 180o. It includes physical stops located in the gear mechanism to stop turning outside these limits to guard the rotation sensor. These common servos involve in radio controlled water, radio controlled cars, aircraft, robots, toys and many other applications.

4) Continuous Rotation Servo Motor

Continuous rotation servo motor is quite related to the common positional rotation servo motor, but it can go in any direction indefinitely. The control signal, rather than set the static position of the servo, is understood as the speed and direction of rotation. The range of potential commands sources the servo to rotate clockwise or anticlockwise as preferred, at changing speed, depending on the command signal. This type of motor is used in a radar dish if you are riding one on a robot or you can use one as a drive motor on a mobile robot.

Continuous Rotation Servo Motor

5) Linear Servo Motor

Linear servo motor is also similar the positional rotation servo motor is discussed above, but with an extra gears to alter the o/p from circular to back-and-forth. These servo motors are not simple to find, but sometimes you can find them at hobby stores where they are used as actuators in higher model airplanes.

Linear Servo Motor

Servo Motor Working Principle

A unique design for servo motors are proposed in controlling the robotics and for control applications. They are basically used to adjust the speed control at high torques and accurate positioning. Parts required are motor position sensor and a highly developed controller. These motors can be categorized according the servo motor controlled by servomechanism. If DC motor is controlled using this mechanism, then it is named as a DC servo motor. Servo motors are available in power ratings from fraction of a watt to 100 watts.The rotor of a servo motor is designed longer in length and smaller in diameter so that it has low inertia.

Servo Motor Working

Servo Motors Characteristics

The servo motors have their own characteristics like other types of motors, which are voltage, current, operating speed, torque, control pulse, resolution and pulse and weight.

Power Supply Voltage and Current :

The power supply voltage and current values are specified for each type of servo motors and depend on the application. The common RC servo motors powered from supplies in the range of 4 – 6 V and 100 mA - 2 A .

Operating Speed :

Operating speed of a servo motor is defined as the time required for the shaft to reach a specified position. Common servos have operating speeds in the range of 0,05 to 0,2 s/60 degree.

Torque :

Typical values of torques of servo motors are in the range of 0,5 to 10 kg/cm.

Control Pulse :

Control pulse is referred to the type of pulse used to position the shaft. Two main types of control pulses used in RC applications: center position in 1-2 ms and 1,25-1,75 ms.

Resolution :

It defines the precision with which the shaft is positioned when it receives an external command signal. Typical servo motors have resolutions in the range from 1 degree to 10 degree.

Size and Weight :

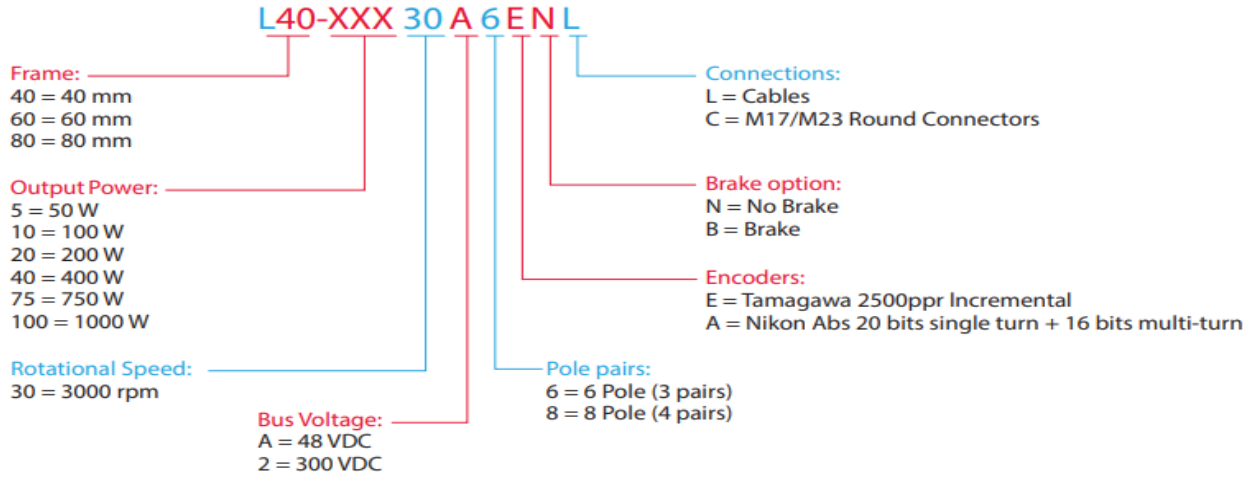
This characteristic is important in the mechanic design of projects. Typical RC servo motors have a weight range between 15 and 200g.

DC SERVO MOTOR SPECIFICATION

Spec. \ Model	FSK76-N075200	FSK76-N075300	FSK76-N075400	FSK76-N048100	FSK76-N048200	FSK76-N024100
Rated Output Power / W	200	300	400	100	200	100
Rated Torque/kg-cm	6.50	9.27	13.00	3.25	6.50	5.40
Rated Speed / rpm	3000	3000	3000	3000	3000	1800
Rated Current / A	3.30	4.80	6.50	2.30	4.60	4.90
Rated Voltage / V	75	75	75	48	48	24
Voltage Constant/ v/Krpm	22.62	23.33	23.33	15.20	14.80	11.75
Torque Constant / kg-cm	2.20	2.27	2.27	1.47	1.44	1.15
Static Friction Torque/kg-cm	0.50	0.60	0.75	0.50	0.60	0.50
Peak Current at Stall /A	16.00	18.50	26.40	40.00	52.00	46.00
Max. Rating Speed / rpm	4,000	4,000	4,000	4,000	4,000	2,500
Peak Torque at Stall /kg-cm	34.43	41.00	58.50	62.00	76.00	55.00
Mechanical Time Constant /ms	5.80	5.04	6.50	9.30	10.02	7.90
Electrical Time Constant/ ms	1.14	1.05	0.75	1.14	1.06	1.08
Weight / kg	2.10	2.40	2.80	2.10	2.40	2.10
Flange Size / mm	□ 76	□ 76	□ 76	□ 76	□ 76	□ 76
Housing Size / mm	ϕ 90 x 111	ϕ 90 x 126	ϕ 90 x 146	ϕ 90 x 111	ϕ 90 x 126	ϕ 90 x 111
Encoder / ppr	Magnetic or Optical type all available					
Brake	Y					
Driver	Y					

Servo Motors Specification:-

Feature	Frame 40				Frame 60				Frame 80			
Rated power W	50		100		200		400		750		1000	
Nominal DC Bus voltage	48	300	48	300	48	300	48	300	48	300	48	300
Min VDC for rated speed at peak torque*	46	112	44	99	46	179	46	173	46	211	NA	185
Rated torque Nm (in.lb)	0.16 (1.4)		0.32 (2.8)		0.64 (5.6)		1.27 (11.2)		2.39 (21.1)		NA	3.18 (28.1)
Rated speed RPM	3000											
Rated current A RMS/ Amplitude	1.5/2.1	0.7/0.9	3.5/5	1.4/2	6/8.4	1.5/2.1	11/15.5	2.9/4.1	16.5/23	3.9/5.5	NA	6.3/9
Peak torque Nm (in.lb)	0.48 (4.2)		0.96 (8.5)		1.92 (17)		3.81 (33.7)		7.17 (63.4)		NA	9.48 (84)
Peak current A RMS/ Amplitude	4.5/6.3	2.1/3	10.5/15	4.2/6	17.7/25	4.5/6.3	33/47	8.7/12.3	50/70	11.7/16.5	NA	18.9/26.7
Feedbacks	Tamagawa 2500ppr Incremental Encoder/ Nikon Abs 20 bits single turn + 16 Bits multi-turn** Note: The multi-turn option is activated by adding a battery rated 3.6V/ >1200 mAh to the ABS encoder											



Common Industrial Applications for Servo Motors

1. **Robotics:** A servo motor at every "joint" of a robot is used to actuate movements, giving the robot arm its precise angle.

2. **Conveyor Belts:** Servo motors move, stop, and start conveyor belts carrying product along to various stages, for example, in product packaging/bottling, and labeling.

3. **Camera Auto Focus:** A highly precise servo motor built into the camera corrects a camera's lens to sharpen out-of-focus images.

4. **Robotic Vehicle:** Commonly used in military applications and bomb detonation, servo motors control the wheels of the robotic vehicle, generating enough torque to move, stop, and start the vehicle smoothly as well as control its speed.

5. **Solar Tracking System:** Servo motors adjust the angle of solar panels throughout the day so that each panel continues to face the sun, harnessing maximum energy from sunup to sundown.

6. **Metal Cutting & Metal Forming Machines:** Servo motors provide precise motion control for milling machines, lathes, grinding, centering, punching, pressing, and bending in metal fabrication for such items as jar lids to automotive wheels.

7. **Antenna Positioning:** Servo motors are used on both the azimuth and elevation drive axis of antennas and telescopes such as those used by the National Radio Astronomy Observatory (NRAO).

8. **Woodworking/CNC:** Servo motors control woodturning mechanisms (lathes) that shape table legs and stair spindles, for example, as well as augering and drilling the holes necessary for assembling those products later in the process.

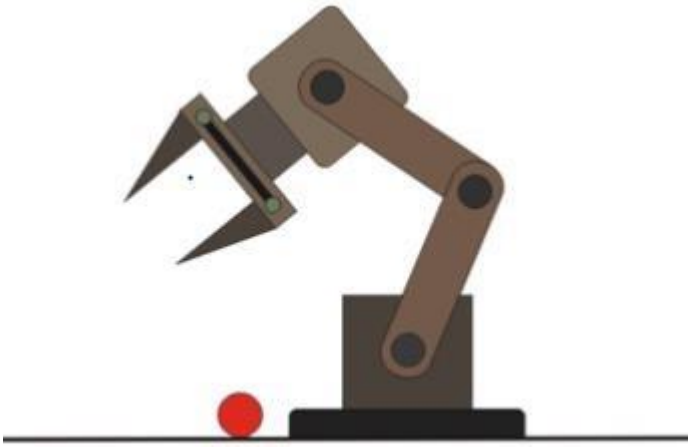
9. **Textiles:** Servo motors control industrial spinning and weaving machines, looms, and knitting machines that produce textiles such as carpeting and fabrics as well as wearable items such as socks, caps, gloves, and mittens.

10. **Printing Presses/Printers:** Servo motors stop and start the print heads precisely on the page as well as move paper along to print multiple rows of text or graphics in exact lines, whether it's a newspaper, a magazine, or an annual report.

11. **Automatic Door Openers:** Supermarkets and hospital entrances are prime examples of automated door openers controlled by servo motors, whether the signal to open is via push plate beside the door for handicapped access or by radio transmitter positioned overhead.

The world would be a much different place without servo motors. Whether they're used in industrial manufacturing or in commercial applications, they make our lives better, easier, and in many cases provide us with more affordable products.

1. Servo Motor in Robotics

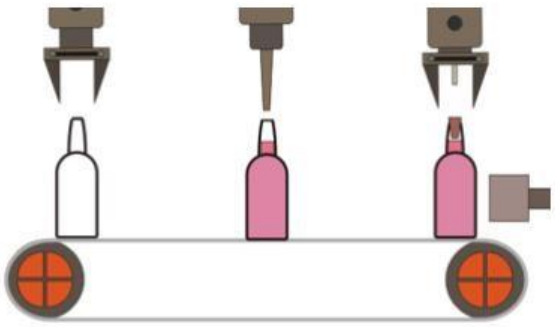


One of the most popular servo motor applications is in robotics. Consider a simple pick and place robot. A pick and place robot is such a robotic machine which is used to pick an object from one position and place the object at different position (as the name suggests).

Now, in order to pick an object from position A and place it in position B the motors which are used to actuate the joints are servo motors. This is because; we have to plan the angular movement of each and every joint to complete this task of pick and place.

Once this data is fed to the robot controller, the robot will continuously do its job. The controller will send PWM data to the individual motors of the robot. This gives precise angular control of the arm which is not possible with a regular DC motor. The application of servomotors in robotics can be experienced on a small scale in electronics projects. The best Arduino starter kits will include a small servo motor for experimentation.

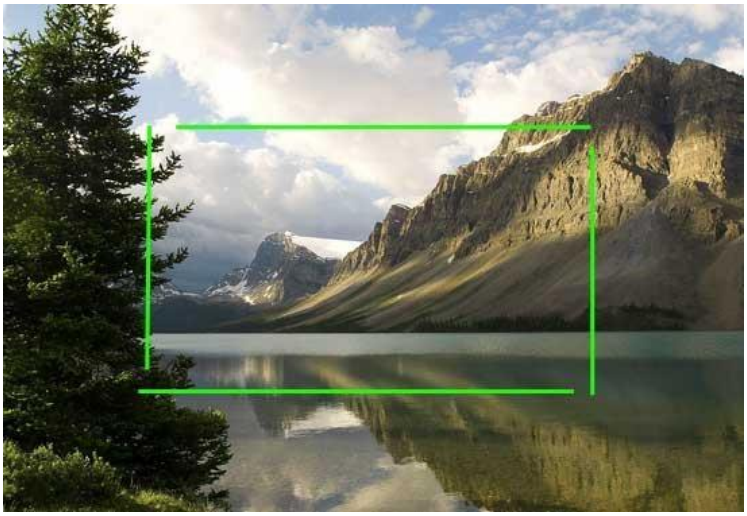
2. Servo Motor in Conveyors



Conveyors are used in Industrial manufacturing and assembling units to pass an object from one assembly station to another. Let's consider an example of bottle filling process, in the process the bottle needs to be filled with the liquid and moved to the next stage which is mainly the packaging stage.

So in order to achieve this conveyor belts are used with servo motors so that the bottle moves precisely to the desired location and stops so that the liquid can be poured into it and then it is guided to the next stage. This process continues until stopped. Hence the precise position control ability of the servo shaft comes in handy.

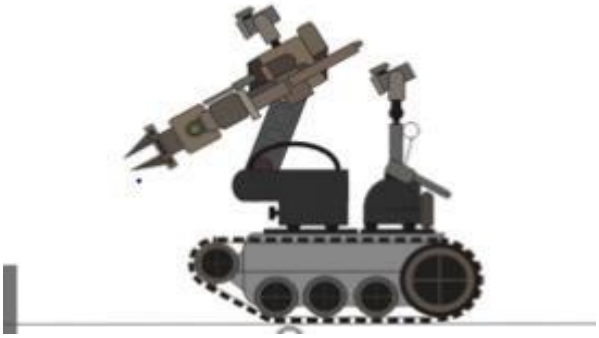
3.Servo Motor Applications in Camera Auto Focus



Today's modern digital cameras are very advanced. One of the advanced features is its ability to auto focus on the object to be captured. When the image of the object is created within the digital signal processor of the camera, it is checked for sharpness.

Basically, if the focal length (measured from camera lens) is not proper, the image appears to be blurred. The corrective action to position the lens precisely so that the sharpest image is captured is done using a highly precise servo motor fitted within the camera. This is another important example of servo motor applications.

4. Servo Motor in Robotic Vehicles



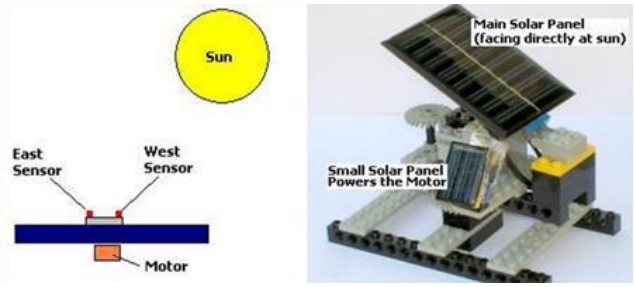
The robotic vehicles today which are used for highly complex military as well as industrial applications use servo motors for wheels. Here, the angular movement is not of importance since the servo used is a continuous rotation servo. The ability of the servo to generate enough

torque so as to quickly move the vehicle from halt and then to quickly stop it as well is what is important. Also the velocity with which the vehicle should move can be controlled.

5. Servo Motor in Solar Tracking Systems

Solar power generation and usage is gaining importance as people move towards clean and renewable energy regime. Earlier, Solar panels that were installed were static and remained in one position for the entire duration of the day. General Science dictates that the Sun is not always facing in one direction and that its position relative to the Solar panel will change. This implies that we are not fully utilizing the power of the sun to extract maximum energy out of it.

But, if we attach servo motors to the solar panel s in such a way that we are able to precisely control its angle of movement so that it closely follows the Sun, then the overall efficiency of the system vastly increases.



Advantages Of Servo Motors Over Stepper Motors

The basic difference between servo and stepper motors is the use of feedback. Servo motors have a position encoder attached to the drive motor that reports the actual position of the motor shaft back to the motor controller. Therefore, the servo controller may take the corrective action whenever any positioning error exists. However, stepper controllers can only issue a move command, and the user has no way to be sure that the motor has actually reached the desired position.

1. Servo motor systems always know exactly where the motor is at, so all step commands are executed and no lost of pulses.
2. Servo motors work with full torque at high speeds whereas the torque of stepper motors falls off as the motor speed increases. This problem of stepper motors is caused by the electrical time constant and poor current utilization.
3. Because of their high encoder resolutions, servo motors are inherently smooth, typically at least ten times finer than a stepper motor's number of positions per revolution.
4. Servo systems draw power only as required, and the power drain is proportional to the load torque applied to the motor. While stepper motors must have high currents applied at all times, even while they are stationary with little or no load.
5. Stepper motor resolution may be increased via a process, called microstepping, in which currents are applied to the motor windings in proportionto the desired position between normal steps.

Industrial Applications of Brushless Servomotor

Introduction

A synchronous machine with permanent magnets on the rotor is the heart of the modern brushless servomotor drive.
The motor stays in synchronism with the frequency of supply, though there is a limit to the maximum torque which can be developed before the rotor is forced out of synchronism, pullout torque being typically between 1.5 and 4 times the continuously rated torque. The torque–speed curve is therefore simply a vertical line.

The industrial application of brushless servomotors has grown significantly for the following reasons:

- Reduction of price of power conversion products
- Establishment of advanced control of PWM inverters
- Development of new, more powerful and easier to use permanent magnet materials
- The developing need for highly accurate position control
- The manufacture of all these components in a very compact form

They are, in principle, easy to control because the torque is generated in proportion to the current. In addition, they have high efficiency, and high dynamic responses can be achieved.

Brushless servomotors are often called brushless DC servomotors because their structure is different from that of DC servomotors. They rectify current by means of transistor switching within the associated drive or amplifier, instead of a commutator as used in dc servomotors.

Application Examples

1. Feed-to-length
Applications in which a continuous web, strip, or strand of material is being indexed to length, most often with pinch rolls or some sort of gripping arrangement.
The index stops and some process occurs (*cutting, stamping, punching, labeling, etc.*).

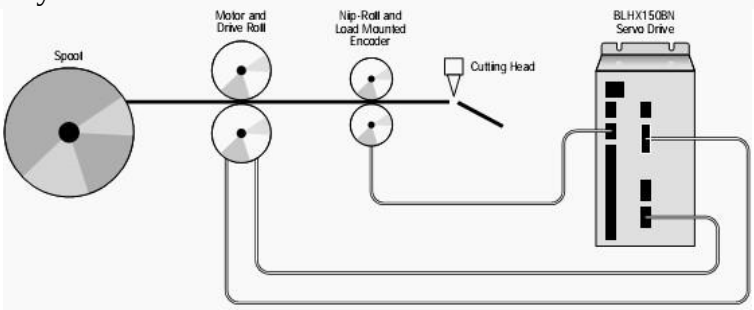
I. BBQ Grill-Making Machine

Application Type: Feed-to-Length
Motion: Linear

Application Description: A manufactuer was using a servo motor to feed material into a machine to create barbeque grills, shopping carts, etc. The process involves cutting steel rods and welding the rods in various configurations. However, feed-length was inconsistent because slippage between the drive roller and the material was too frequent. Knurled niprolls could not be used because they would damage the material.
The machine builder needed a more accurate method of cutting the material at uniform lengths. The customer used a load-mounted encoder to provide feedback of the actual amount of material fed into the cutting head.

Machine Objectives:

- Compnesate for material slippage
- Interface with customer's operator panel
- Smooth repeatable operation
- Variable length indexes
- High reliability



Application Solution:

By using the global position feedback capability of the servo drive, the machine builder was able to close the position loop with the load-mounted encoder, while the velocity feedback was provided by the motor-mounted encoder and signal processing. The twoencoder system provides improved stability and higher performance than a single loadmounted encoder providing both position and velocity feedback.

2.On-the-Fly Welder

Application Type: Feed-to-Length

Motion: Linear

Description: In a sheet metal fabrication process, an unfastened part rides on a conveyor belt moving continuously at an unpredictable velocity. Two spot-welds are to be performed on each part, 4 inches apart, with the first weld 2 inches from the leading edge of the part. A weld takes one second.

Machine Objectives:

- Standalone operation
- Position welder according to position and velocity of each individual part
- Welding and positioning performed without stopping the conveyor
- Welding process must take 1 second to complete

Motion Control Requirements

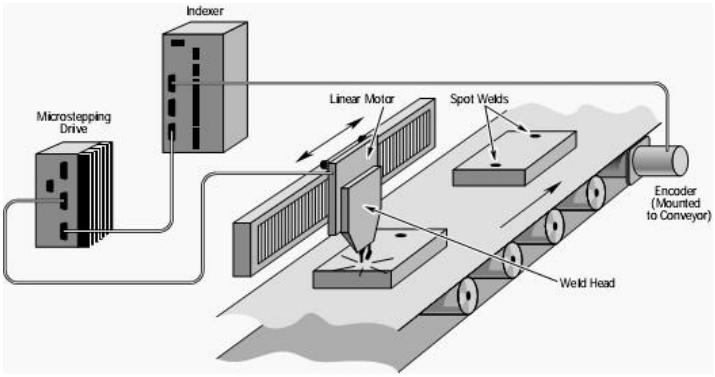
- Programmable I/O; sequence storage
- Following
- Motion profiling; complex following
- High linear acceleration and speed

Application Solution:

This application requires a controller that can perform following or motion profiling based on a primary encoder position. In this application, the controller will receive velocity and

position data from an incremental encoder mounted to a roller on the conveyor belt carrying the unfastened parts.

BBQ Grill-Making Machine



On-the-Fly Welder

The conveyor is considered the primary drive system. The secondary motor/drive system receives instructions from the controller, based on a ratio of the velocity and position information supplied by the primary system encoder.

The linear motor forcer carries the weld head and is mounted on an overhead platform in line with the conveyor. Linear motor technology was chosen to carry the weld head because of the length of travel. The linear step motor is not subject to the same linear velocity and acceleration limitations inherent in systems converting rotary to linear motion.

For example, in a leadscrew system, the inertia of the leadscrew frequently exceeds the inertia of the load and as the length of the screw increases, so does the inertia. With linear motors, all the force generated by the motor is efficiently applied directly to the load; thus, length has no effect on system inertia.

This application requires a 54-inch platen to enable following of conveyor speeds over 20 in/sec.

2. Indexing/Conveyor

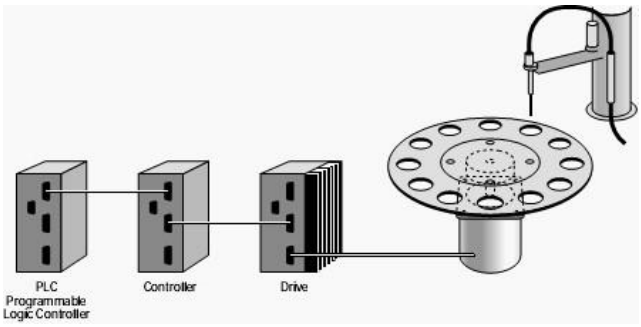
Applications where a conveyor is being driven in a repetitive fashion to index parts into or out of an auxiliary process.

Rotary Indexer-:

Application Type: Indexing Conveyor
Motion: Rotary
Application Description: An engineer for a pharmaceutical company is designing a machine to fill vials and wants to replace an old style Geneva mechanism. A microstepping motor will provide smooth motion and will prevent spillage. The indexing wheel is aluminum and is 0.250-inch thick and 7.5″ in diameter.

Solving the equation for the inertia of a solid cylinder indicates that the wheel has 119.3 ozin^2. The holes in the indexing wheel reduce the inertia to 94 oz-in^2. The vials have negligible mass and may be ignored for the purposes of motor sizing. The table holds 12 vials (30°apart) that must index in 0.5 seconds and dwell for one second. Acceleration torque is calculated to be 8.2 oz-in at 1.33 rps^2.

A triangular move profile will result in a maximum velocity of 0.33 rps.
The actual torque requirement is less than 100 oz-in. However, a low load-to-rotor inertia ratio was necessary to gently move the vials and fill them.



Rotary Indexer

Machine Requirements:

- Smooth motion
- PLC control
- Variable index lengths

Application Solution:

The index distance may be changed by the engineer who is controlling the machine with a programmable controller. Move parameters will be changing and can therefore be set via BCD inputs. The indexer can be "buried" in the machine and activated with a remote START input.

3. Following

Labelling Machine

Applications that require the coordination of motion to be in conjunction with an external speed or position sensor.

Application Type: Following
Motion: Linear
Application Description: Bottles on a conveyor run through a labelling mechanism that applies a label to the bottle. The spacing of the bottles on the conveyor is not regulated and the conveyor can slow down, speed up, or stop at any time.

Machine Requirements:

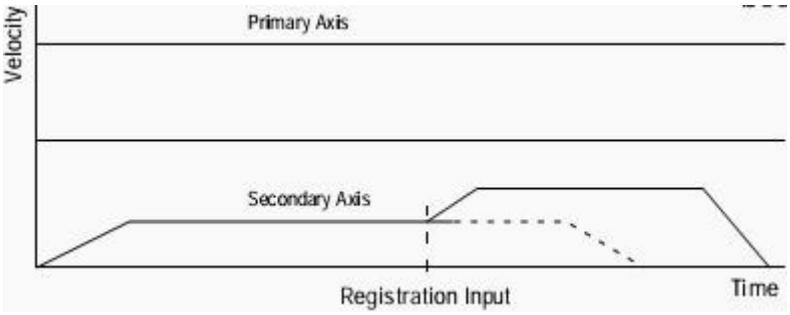
- Accurately apply labels to bottles in motion
- Allow for variable conveyor speed
- Allow for inconsistent distance between bottles
- Pull label web through dispenser
- Smooth, consistent labelling at all speeds
- Open-loop stepper if possible

Application Solution:

A motion controller that can accept input from an encoder mounted to the conveyor and reference all of the speeds and distances of the label roll to the encoder is required for this

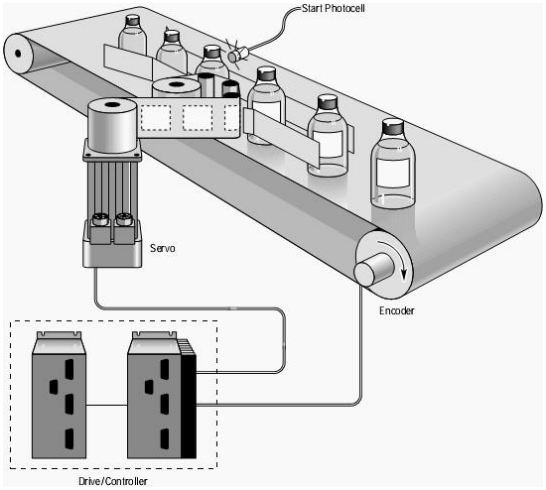
application. A servo system is also required to provide the torque and speed to overcome the friction of the dispensing head and the inertia of the large roll of labels.

A photosensor connected to a programmable input on the controller monitors the bottles' positions on the conveyor.



Labelling Machine Motion Control Diagram

The controller commands the label motor to accelerate to line speed by the time the first edge of the label contacts the bottle. The label motor moves at line speed until the complete label is applied, and then decelerates to a stop and waits for the next bottle.



Labelling Machine Principle