UNIVERSIDAD NACIONAL DE COLOMBIA

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SERVOMECHANISMS

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T2 - Servo Basic Concepts (Industrial Perspective)

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1.

Perform an analysis of the video ”Servo Basic Concepts.ºf the company Yaskawa (16:43), accessible at https://www.youtube.com/watch?v=Gzo9m0tMD0A, answering the following questions:

Chapter 1

What are the main characteristics of a servo amplifier and a servomotor?

The main characteristics of a servo amplifier are:

- Input of low voltage commands for torque, speed or position.
- Output of these amplified signals into a high powered format for the servomotor.

The main characteristics of a servomotor are:

- Very accurate.
- Works at high speeds.
- Has a feedback device (encoder) that sends signals towards the servo amplifier.

Chapter 2

What are the main components of a motion control system?

The main components are:

- Operator interface
- Controller
- Servo amplifier
- Servomotor
- Servomechanism

It's possible to have only one component for the controller and the servo amplifier, also called as the driver.

Chapter 3

What is the meaning of axis of motion in the context of motion control systems?

For this context, the meaning of axis refers to each servo and the mechanism it moves, taking into account that the axis will provide no motion unless the servo is on.

Chapter 4

What are the three stages to enable a servo from a power-up perspective?

1. Control power: Turn on the amplifier.

2. Main power: Apply the high voltage and current power source that the amplifier will use to drive the motor.
3. Servo enable: Energize the servomotor so that it's ready to move when commanded.

What is the essence of the so-called directional movement and what is its importance in industrial applications?

The essence is to match the servo direction with the machine direction so that it's clear witch direction is forward and which is reverse. It's important because it gives the possibility of having a protective torque limit in only one direction, which allows someone to overpower the motor in one direction but almost impossible to do it in the other direction.

Chapter 5

What is over travel and what is its practical applicability?

Over travel, also called as the limit switch function, is an amplifier input that stops the motor from moving in one direction. One input for forward movement, and another one for reverse movement. They can prevent costly damages, as without them, it would be possible to have a collision of moving parts.

What is the difference between over travel stop and emergency stop?

An emergency stop prevents all motion in every direction of the servomechanism, meanwhile, over travel only stops motion in one direction and it would be possible to continue movement in the opposite direction.

Chapter 6

What are relative moving and absolute moving? Relative moving is to move the servomechanism a certain distance relative to its current location. Used for movements that need to repeat itself several times and it's related to distance commands. Absolute moving is to move the servomechanism to a preset position no matter the current location, it's related to position commands.

Chapter 7

What does Zero Point Return mean and how does a Homing Routine work?

Zero Point Return is to return the position of the machine to a defined point of the work space called the zero point, also called as homing.

A homing routine consists of moving an axis slowly in reverse and it stops when the home sensor is detected. Then, there could be a programmed offset from this detection point where the axis will travel and stop at the desired home position, which is called the position zero.

Chapter 8

What are the two main categories of motion actuators and their corresponding engineering units?

The categories are define by the type of motion the actuator produces. It could be linear or rotary motion, and their corresponding engineering units are:

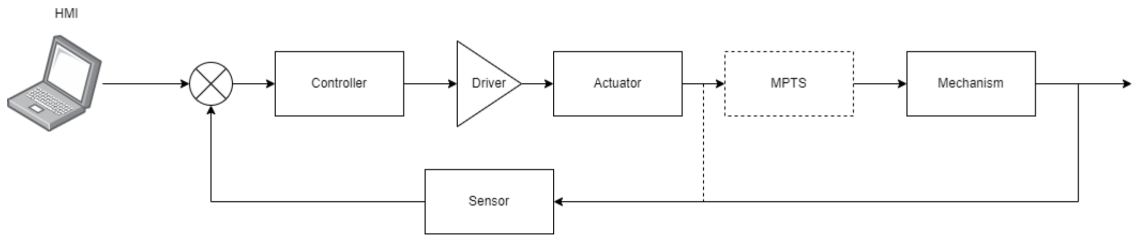
- Linear motion: in or mm
- Rotary motion: $^{\circ}$

Conclusion

How do you interpret the final expression of the Yaskawa's presenter: It's personal? The presenter is trying to convince the viewers that Yaskawa is the best in the industry by mentioning different qualities and advantages they have, stating that they have a high priority of making the experience of their customers, partners and employees with Yaskawa a great one, by treating them not as a job or as a number, but as human beings.

2.

Present a general block diagram for a Servomechanism (as a system) naming and indicating the function or purpose for each of its main parts. Consult manufacturers' manuals and indicate verifiable commercial references and associated costs for each of the component blocks.



- HMI: The Human Machine interface (HMI) is often used as the bridge between the user, and the process that's been controlled. With it, the user is capable of programming the reference the servomechanism has to follow in order to complete the task in hand.

  An example of an industrial HMI can be the HMIST6400 by Schneider Electrics, part of their Harmony ST6 Series. The international cost of this HMI can be around $\$1,200$, or bought locally, around $\$4{,}100,000$ COP. In general, the range for these HMI can be around $\$1000$ and $\$2000$

- Controller: The controller is used as the designed control system capable of using the retro-alimentation signal and the reference from the HMI to calculate the error of the system, and correct it using control theory, which in the industry normally is a PID controller.

  The cost of a PID controller may vary a lot depending of the manufacturer, an example of a low cost PID controller available locally is the PID P10-1011-001A (Conch brand), or sale for approximately $\$300{,}000$ COP. But, a more robust controller, like a Siemens PLC reference 6AG1052-1CC08-7BA1, can be bought for approximately $\$1{,}300{,}000$ COP, or around $\$300$.

- Driver: The driver is used to amplify the signal generated by the controller to feed the actuators of the system, giving enough voltage and current for their correct operation point. It's usually sold corresponding to the actuator, but as an example, there's the servopack SGDH-A5AE Yaskawa, for 1PHASE, 52AMP, 50W 200V and costs $\$2{,}518{,}323$ COP, or around $\$570$. A standard price range for servo drivers can be around 00 and $\$1000$.

- Actuator: The actuator, in this case a servomotor, which can generate rotary or linear motion, is used for generating the required motion of the mechanism.

  As costs go, it depends on the specifications needed, as an example, there's the MPL-A320P-MK72AA Allen-Bradley, which is a BLDC servomotor of 230V of 5000RPM, it costs $4{,}237{,}730$ COP, equivalent to $\$960$. Normally, the cost range for these type of specifications for a servomotor can be around $\$500$ to $\$1000$.

- MPTS: The mechanical power transmission system is optional, depending on the application and the specifications needed for completing the task in hand. The main purpose of the MPTS is to reduce the speed and augment the torque generated by the actuator, therefore, there's a coefficient N given by the speed relationship of the MPTS. Also, this speed reduction gives a better controllability of the system as it reduces the inertia ratio of the actuator.

  As for the costs for these type of transmissions, it mainly depends on the technology used, and it could easily be more expensive than the actuator. a possible range ol costs for these components is between $\$500$ and $\$1500$. An example of a MPTS, there's a generic "CAJA REDUCTORA NEMA 34 10:1" which costs around $\$2,000,000$ COP, or approximately $\$500$, which can be considered a low cost MPTS.

- Mechanism: The mechanism, composed of joints and links (at least one static link), is the mechanical part of the servomechanism, which moves to complete the task of the servomechanism with the help of the motion generated by the actuator involved. As the mechanism depends on the design or the application of the servomechanism, it is really difficult to give an estimate cost for it, but it is clear that for big applications, it could be the most expensive component of them all.

- Sensor: For motion control systems, the sensor is used to acquire kinematic of dynamic variables of the mechanism or by the actuator, it could be position, velocity, force, torque, or others. These values are then used by the controller to calculate the error of the mechanism given a reference. Usually, the servomotor have an integrated encoder as the sensor of the closed loop, but it's also possible to use an external one. These external encoders, depending of their resolution, can be around the range of $\$100$ to $\$500$ or even more.

  As an example of an external encoder, there's the AS37-H39B-B12S by Mouser Electronics. Its and absolute rotary encoder of 2 channels, with a resolution of 39 bits. It has a cost of $\$250$. Although there are a lot of cheaper encoders which works with an acceptable resolution for most applications.

3.

Make a list of five (5) non-trivial terms in English that, in your opinion, are key or of great interest to engineers working with motion control systems. For each term, provide a formal definition or description supported by the technical literature citing the references consulted.

1. Optimization: When a process is defined, many reasons develop to a necessity of an interest

over select a design that not only works, it also fits as the best possible design under the considerations given. The process of determining the best design is called optimization [1].

2. Target: In engineering, target stands for one or several mutually agreed ample attributes that are specific and applicable to the project on develop, and also permits to evaluate the performance of itself through an analysis of the deviation from them [2].

3. Winding: The motor winding is an arrangement which develops a magnetic field by electrical induction (Faraday's Law), and provides energy for turn the rotor on a motor. Those are made from electrical conductor materials, and their properties define in the biggest part the behavior and characteristics of the motor [3].

4. Quadrature: In Mathematics, Quadrature refers to a process in which gets determined an area under different possible methods, essentially leading to solve an integral associated to a specific variable [4]. In motion control, this definition is specifically used on encoders, a device capable of act as sensor of movement and speed measuring in a system. When an encoder is able to perform motion direction analysis, based on a two-channel (A and B) discrepancy of phases which indicates the direction of the motion [5].

5. Slewing: Refers to a rotation of an object, around to a defined axis. When putted onto a component name, Slewing let the designer know that the element can experiment or permit rotation during a specific movement for which were designed [6].

References for Section 3: [1] A. R. Parkinson, R. J. Balling and J. D. Hedengren, *Optimization Methods for Engineering Design: Applications and Theory*. Brigham Young University, 2013.

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