Assignment 3:

Comparison of Motors in Embedded System

Embedded Systems Design

MCTE 4342

SECTION 1

SEM 2 SESSION 2023/2024

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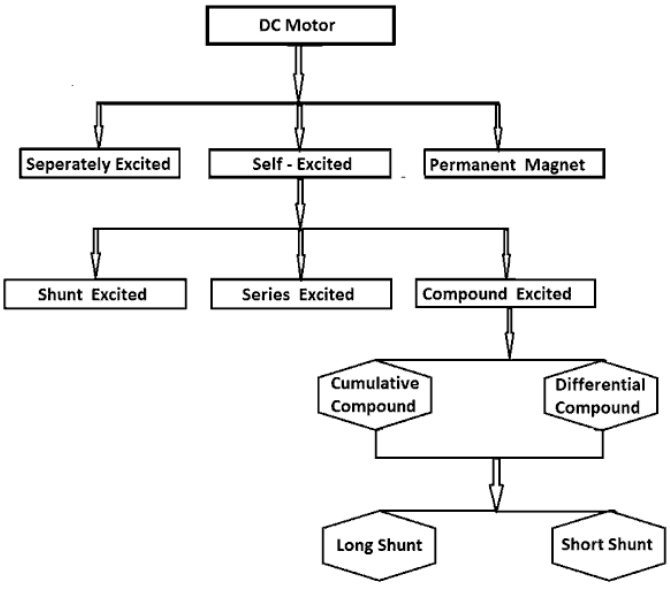
DC Motors

1) Description:
   The DC motors is one of the motors that are commonly found in the market with different types of variation and specification. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances.

2) Types of DC Motors:
   - Permanent Magnet DC Motor (PMDC Motor)
   - Separately Excited DC Motor
   - Self-Excited DC Motor
   - Shunt Wound DC Motor
   - Series Wound DC Motor
   - Compound Wound DC Motor
   - Short shunt DC Motor
   - Long shunt DC Motor
   - Differential Compound DC Motor
   - Brushless DC Motor
   - Switch Reluctance Motor



However, in small applications mainly the geared DC motors and brushless DC motor

- Example Geared DC Motor:

Worm Gear Motor, Planetary Gear DC Motor, Micro-metal gear motor, gear reduction dc motor, cycloidal drive motor,

Figure 0-2: Common DC motor

Figure 0-1: Worm Gear Motor

Figure 0-4: Micro Metal Gear Motor

Figure 0-3: Harmonic and Cycloidal Drive

Figure 0-5: Planetary gear dc motor

3) Advantages and Disadvantages

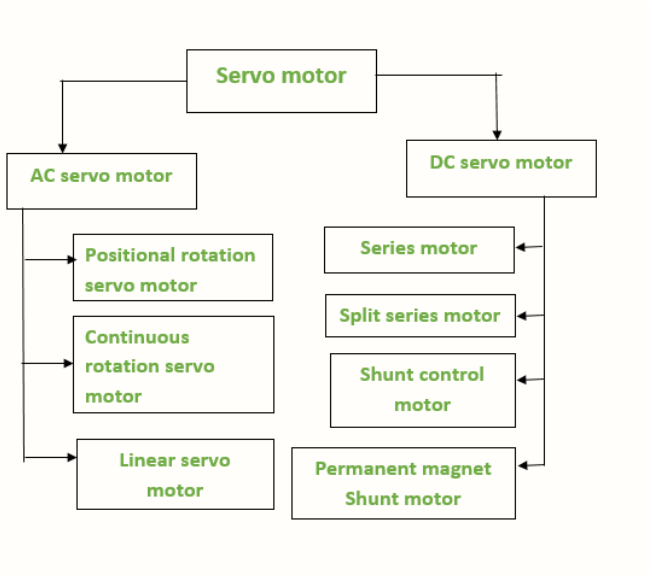
Advantages	**Disadvantages**
Simple control of speed	Require frequent maintenance
High starting torque	Higher initial cost compared to AC motors
Smooth and wide range of speed control	Brushes and commutator wear out over

	time
Excellent response to control signals	Lower efficiency due to friction and heat
Better for applications requiring precise speed control	Limited speed due to commutator limitations
Can operate in low-voltage applications	Bulky and heavier than equivalent AC motors

Servo Motors

1) Description:
   DC motor that are built to position mechanical elements at a given position within a given time and with precision. A servo motor is an electromechanical device that produces torque and velocity based on the supplied current and voltage. A servo motor works as part of a closed loop system providing torque and velocity as commanded from a servo controller utilizing a feedback device to close the loop. The feedback device supplies information such as current, velocity, or position to the servo controller, which adjusts the motor action depending on the commanded parameters.

2) Type of Servo Motor:



The main focus of this report servo dc motor. The dc servo motors are built with DC source that are separated in the field of armature winding. It can be controlled by managing the field current or the armature current.

Mostly Common used in small applications: 180 degrees & 270 degrees servo, continuous servo

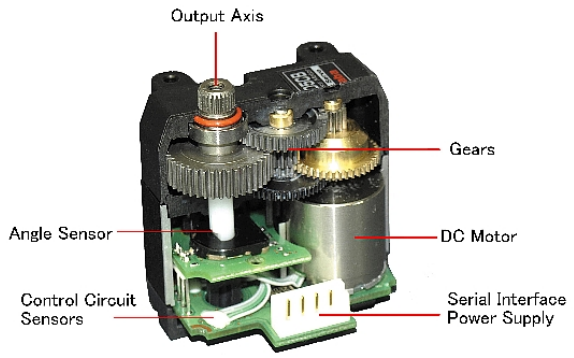


Figure 0-2Internal of Positional Servo

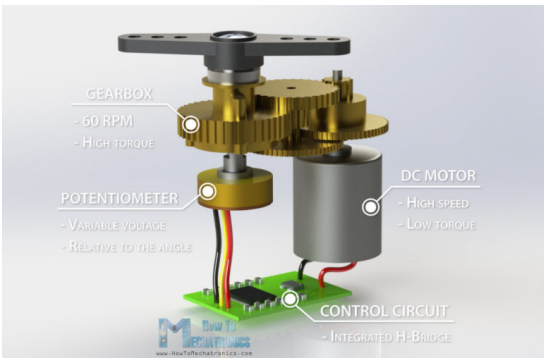


Figure 0-1: Continous Servo

3) Advantage and disadvantage of servo motor.

Advantages	**Disadvantages**
High precision and accuracy	Higher cost compared to stepper motors
Excellent torque at low speeds	Complex control systems required
High efficiency and performance	More sensitive to changes in load conditions
Fast response and quick acceleration	Can be affected by electromagnetic interference
Suitable for high-speed operations	Require regular tuning and maintenance
Smooth rotation over a wide range of speeds	Limited by maximum speed constraints
Can hold position without oscillation	Require feedback systems (encoders)

Dynamixel Motor

1) Description:

- The DYNAMIXEL is a smart actuator system developed to be the exclusive connecting joints on a robot or mechanical structure.
- DYNAMIXELs are designed to be modular, and daisy chained on any robot or mechanical design for powerful and flexible robotic movements.

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2) Type of Dynamixel Motor

- DYNAMIXEL DRIVE (DYD)
- DYNAMIXEL-Y
- DYNAMIXEL-P
- DYNAMIXEL-X

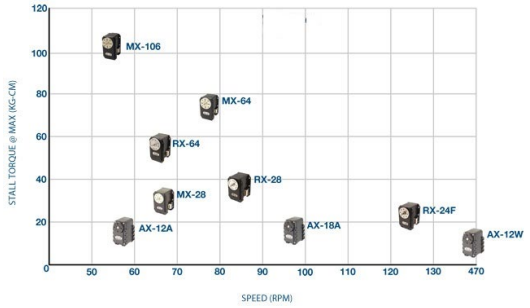

Figure 0-1: Stall torque versus speed of Dynamixel Lineup

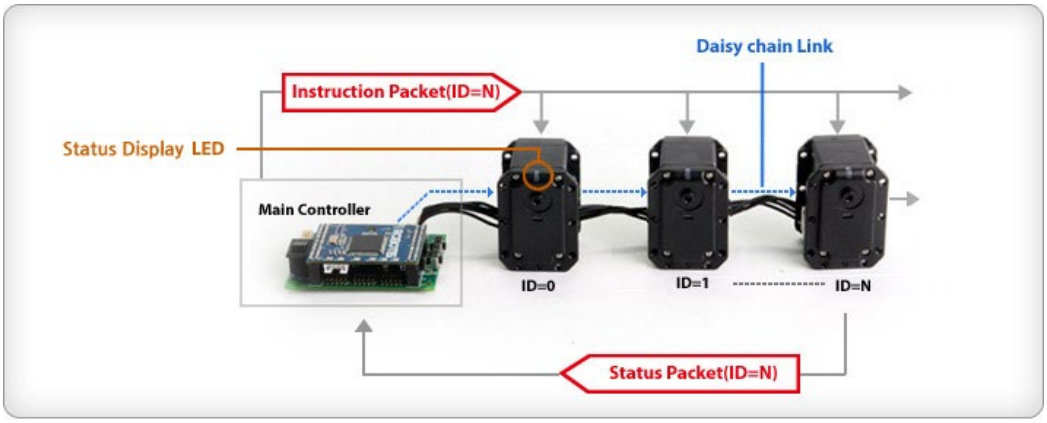

Figure 0-2: Daisy Chain Link of Dynamixel

Figure 0-3: Dynamixel Linup

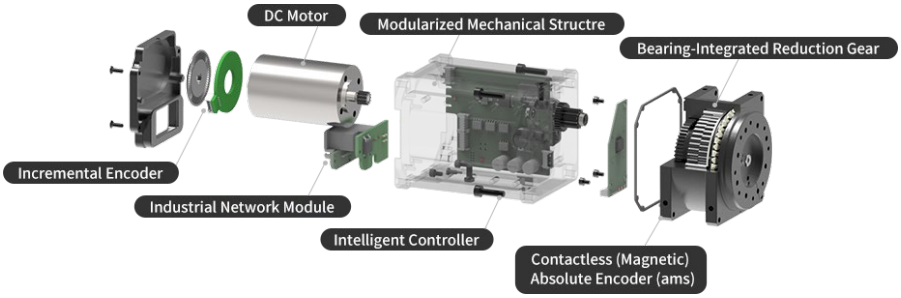

Figure 0-4: Example of Internal Structure of Dynamixel

3) Advantage and Disadvantage

Advantages	Disadvantages
High precision and reliability	Higher cost compared to standard servo motors
Integrated feedback and control systems	Can be complex to program and configure
Daisy-chain capability for simpler wiring and control	Requires proprietary communication protocols
Wide range of models for different torque and speed needs	Higher power consumption
Robust and durable, suitable for heavy-duty applications	May require specialized power supplies
Easy integration with various robotic platforms	Limited compatibility with non-Robotic controllers
Support for advanced features like velocity, position, and torque control	Possible overkill for simple applications

Stepper Motor

1) Description:
   A stepper motor is an electric motor whose main feature is that its shaft rotates by performing steps, that is, by moving by a fixed number of degrees. This feature is obtained thanks to the internal structure of the motor and allows to know the exact angular position of the shaft by simply counting how may steps have been performed, with no need for a sensor.

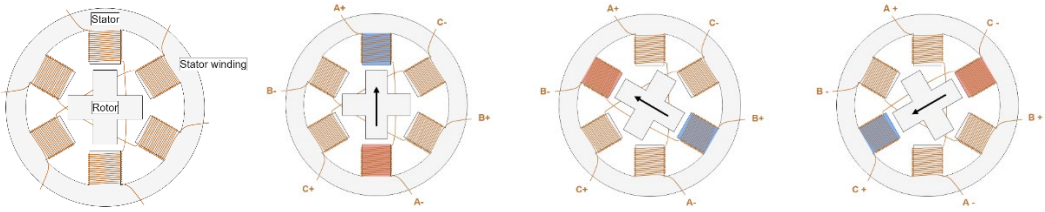

Figure 0-1: Cross Section and step of Stepper Motor

2) Type of Stepper Motor
   - Rotor
     - Permanent magnet rotor
     - Variable reluctance rotor
     - Hybrid rotor
   - Stator
     - Two Phase
     - Three Phase
     - Five Phase
   - Polar
     - Uni-polar
     - Bi-polar (most common used)

3) Techniques
   - Step/Direction – By sending a pulse on the Step pin, the driver changes its output such that the motor will perform a step, the direction of which is determined by the level on the Direction pin.
   - Phase/Enable – For each stator winding phase, Phase determines the current direction and triggers Enable if the phase is energized.
   - PWM – Directly controls the gate signals of the low-side and high-side FETs.

4) Advantage and Disadvantage

Advantages	Disadvantages
Do not require a sensor for position detection	Can miss a step if the load torque is too high
Simple control and lower control effort	No way to know the real position if steps are missed
High position accuracy with micro stepping (up to ~0.007°)	More likely to miss steps with micro stepping
Good torque at low speeds	Always drain maximum current, even when still
Great for holding position	Lower efficiency and potential for overheating
Long lifespan	Low torque at high speeds, becoming noisy
	Low power density and low torque-to-inertia ratio

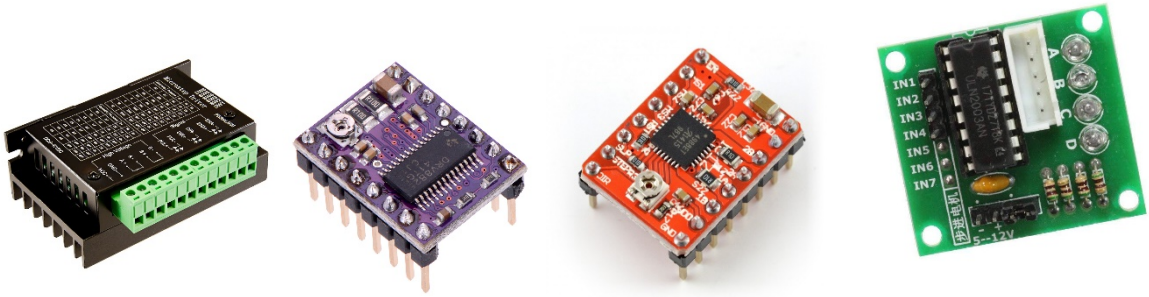

Figure 0-2: Stepper Motor Driver

Figure 0-5 Microstep Stepper Motor

Figure 0-4: Bipolar Stepper Motor

Figure 0-3: Unipolar Stepper Motor

Brushless Motor

1) Description:

- Brushless DC motors (BLDC) feature high efficiency and excellent controllability and are widely used in many applications.
- Fixed brushes supply electric energy to the rotating commutator. As the commutator rotates, it continually flips the direction of the current into the coils, reversing the coil polarities so that the coils maintain rightward rotation. The commutator rotates because it is attached to the rotor on which the coils are mounted.

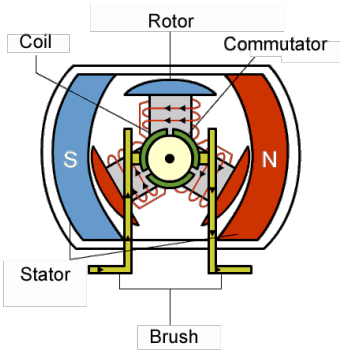

Figure 0-1: Working mechanism of BLDC.

2) Type of BLDC

-In runner: permanent magnets on the outer section that moves as it turns the output shaft.

-Outrunner: electromagnets inside a fixed outer housing, while permanent magnets are on the internal rotor.

Figure 0-3: Inrunner BLDC

Figure 0-2: Outrunner BLDC

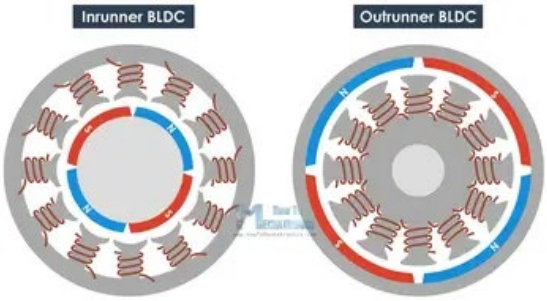

Figure 0-4: Comparison of Outerunner and Inrunner BLDC

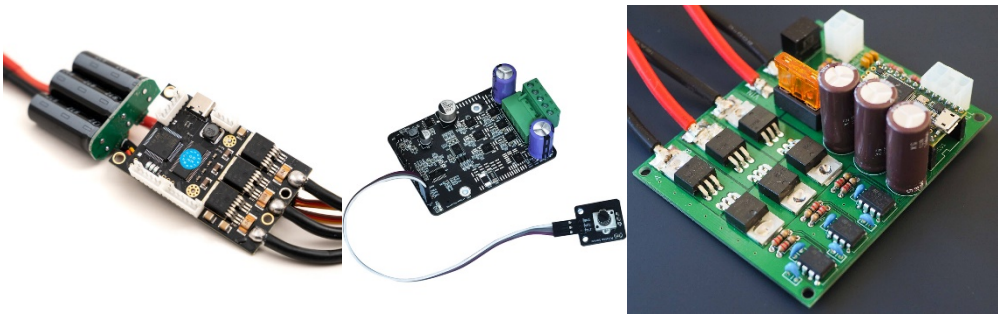

Figure 0-5: Motor driver for BLDC.

3) Advantage and Disadvantage

Advantages	Disadvantages
High efficiency and reliability	Higher initial cost compared to brushed motors
Low maintenance due to absence of brushes	Requires a complex controller for operation
Long lifespan	Can generate electromagnetic interference (EMI)
High power density and compact size	More challenging to repair due to complex electronics
Excellent speed-torque characteristics	Initial setup and tuning can be more complicated
Smooth operation and low noise	Requires precise control of current and voltage
Better heat dissipation, allowing for higher power output	Limited availability of standard parts for repair

Linear Actuators Motor

1. Description

- Electric Linear Actuators are a type of actuator that converts energy and signals into a linear motion, in other words a backward or forward motion.
- This linear motion is then used to tilt, lift, push or pull an object where force is required.

2. Types of Linear Actuators
    - Mechanical or electromechanical linear actuators
    - Hydraulic linear actuators
    - Pneumatic linear actuators
    - Piezoelectric actuators

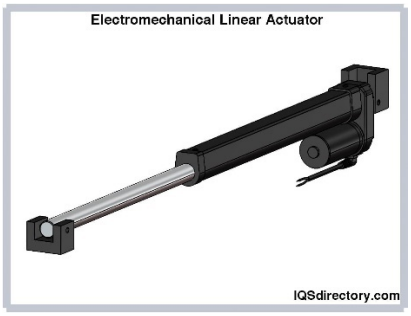

Figure 0-2: Electromechanical Linear Actuator

Figure 0-1: Piezoelectric Linear Actuator

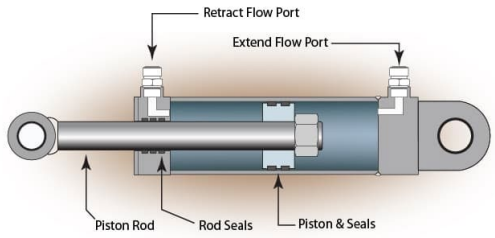

Figure 0-4: Hydraulic Linear Actuator

Figure 0-3: Pnuematic Linear Actuator

3. Advantage and Disadvantage

Advantages	Disadvantages
Precise and repeatable motion	Limited speed compared to rotary actuators
Can generate high force with compact size	Can be expensive, especially for high-precision models
Simple design and easy to install	Limited stroke length in some models
Quiet and smooth operation	Require regular maintenance in some types (e.g., screw actuators)
Versatile and can be used in a variety of applications	Potential for backlash in mechanical components
Good for applications requiring push/pull actions	Limited duty cycle in some models
Can be controlled with high precision using feedback systems	Power consumption can be high for high-force applications