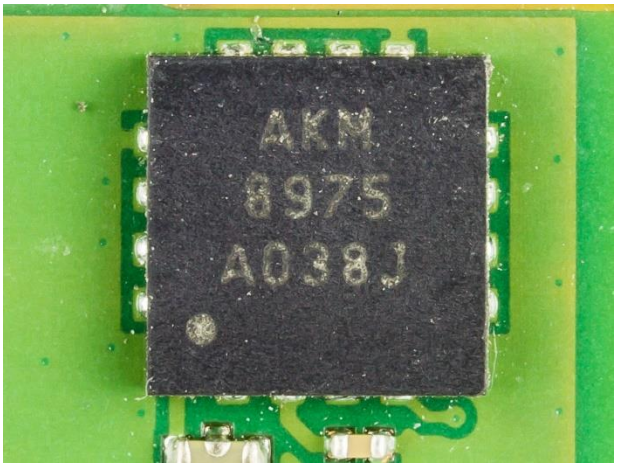
## 1. Compare the magneto-resistive sensor, potentiometer, and encoder. In addition, search for the differences between relative encoder and absolute encoder (list 3 pros and cons for each).

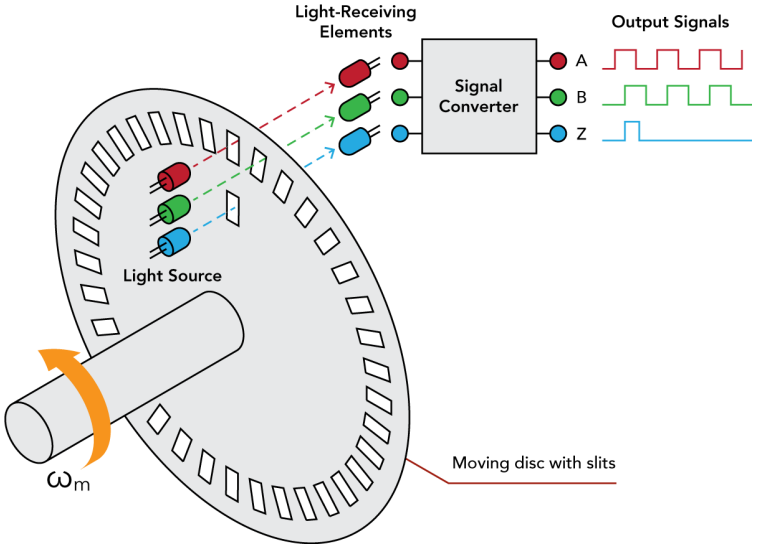
Magneto-resistive sensors are components used to detect the presence of a magnetic field. These sensors do not require electrical contact and can operate across a large air gap. Because no electrical contact is required, the sensor can operate across a relatively large air gap. To make embedding possible, Magneto-resistive sensors are designed to be small and operate on very little power. The sensor operates as follows: an object with its own magnetic field approaches the sensor. This leads to a change in electrical resistance. This change makes it possible to detect the angle at which the external magnetic field and the object is placed with respect to the sensor, allowing one to measure the distance to it.




A potentiometer is a measurement instrument for measuring electric potential (voltage). Essentially, a potentiometer is a resistor with three terminals. It forms an adjustable voltage divider with a sliding or rotating contact.

An encoder is a sensor to detect the rotation angle or linear displacement of another component. Encoders are used to detect the rotation and speed of a shaft in a motor. The method of controlling the motor rotation by detecting the rotation speed and angle using an encoder is called feedback control.

There are two main types of encoders: absolute encoder and incremental encoders. Absolute encoders can tell you the exact position of the shaft in its rotation in a given timestamp, whereas, incremental encoders can only inform you about a change in position.

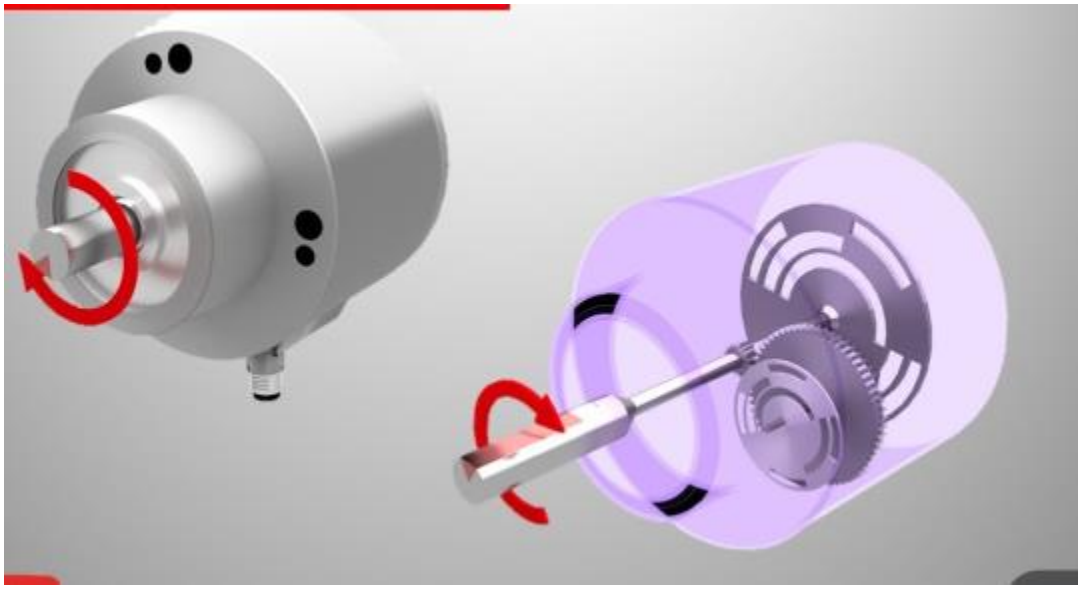



Pros of incremental encoders

- Low cost when compared to absolute encoders
- Provides simple signal processing that includes rotation direction discrimination and counter
- Offer great compatibility with incremental encoders from other manufacturers

Drawbacks of incremental encoders:

- Only measure the relative movements- provide signal only if there is a movement.
- In a scenario where there is a power loss to the incremental encoder, the current position of the shaft is lost and becomes unknown.
- Incremental encoders require constant monitoring because of the possibility of noise in the system, which may require the operator to have to reset the encoder reading.



Pros of absolute encoders:

- Can be combined in conjunction with other absolute encoders easily.
- Can overcome measurement errors that occur due to factors such as outside noise, and angle reading error, because the absolute position and the angle position can be reliably detected.
- Offer continuous position monitoring and can remember position after power outage.

Drawbacks of absolute encoders:

- Price of the absolute encoder is higher than the price of incremental encoders.
- Sensitive to noise due to the analogical nature of the feedback signal.
- Absolute encoders are not fit for use in outdoor and harsh environment.

## 2. Search, find and discuss the pros and cons of cable driven power transmission versus gear-based power transmission.

Power transmission is the movement of energy from its place of generation to a location where it is applied to perform useful work.

There are several types of power transmissions two of which discussed will be: gear-based power transmission and belt-driven power transmission.

**Gear-based power transmission**


A gear is a component within a transmission device that transmits rotational force to another gear or device.

In a gear drive power transmission setup, gears are used to transmit power from one shaft to another. A driving gear on the input shaft affects a driven gear on the output shaft. The meshing of the gear teeth results in power transmission from the source to the load.

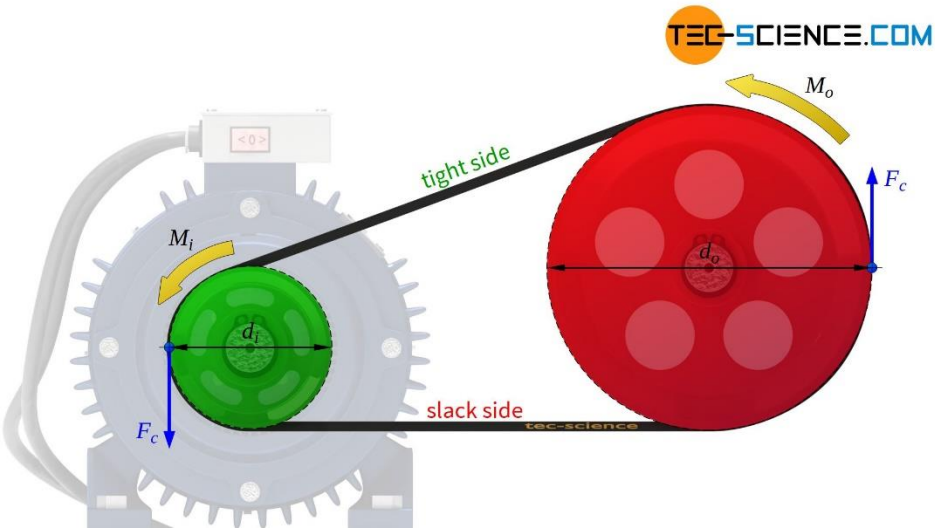
Advantages

- Effective for high mechanical power transmission applications.
- Gears are sturdy components and have long service lives.
- Setup is compact.
- Highly efficient system.

Disadvantages

- Direct connection is needed between input and output shaft so can't use when distance is high.
- Tend to vibrate and create noise.
- Metal gears are heavy and increase the weight of the machine.
- Additional costs related to lubrication of the gears.
- Expensive when compared to other drives (chain, belt, etc.).

**Belt-driven power transmission**




In a belt-driven power transmission system, power is transmitted between two or more shafts using pulleys and an elastic belt. It is mainly powered by friction and can operate at a wide range of speeds and power requirements.

Pros of belt driven power transmission:

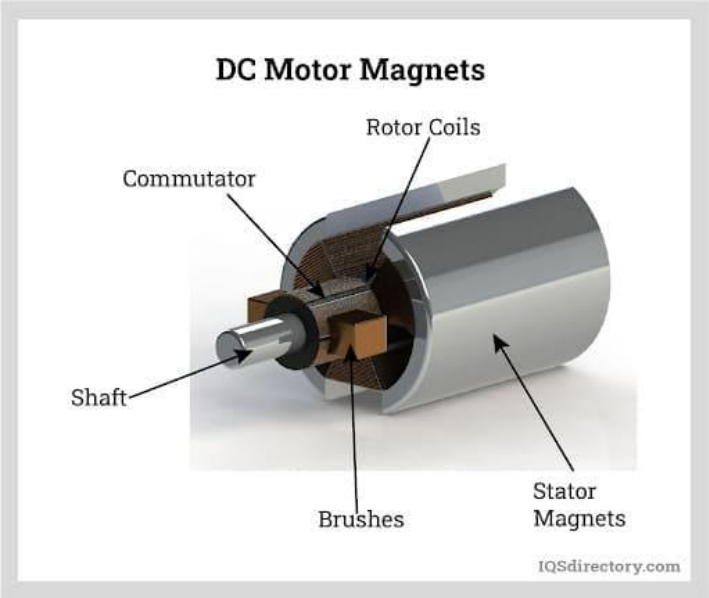
- Useful for power transmission over large distances between two shafts due to the flexibility of the belt, which can absorb vibration.
- Has a simple structure and relatively low cost.
- Can slip during overload to prevent other parts from being damaged.

Cons:

- The belt has a short lifespan and needs to be replaced.
- Power transmission efficiency is low.
- A tensioning device is required to measure the tension in the belt at all times.

## 3. Compare and contrast the main differences between stepper motors and DC motors. Discuss their functionality and list at least 3 applications in which they are used.

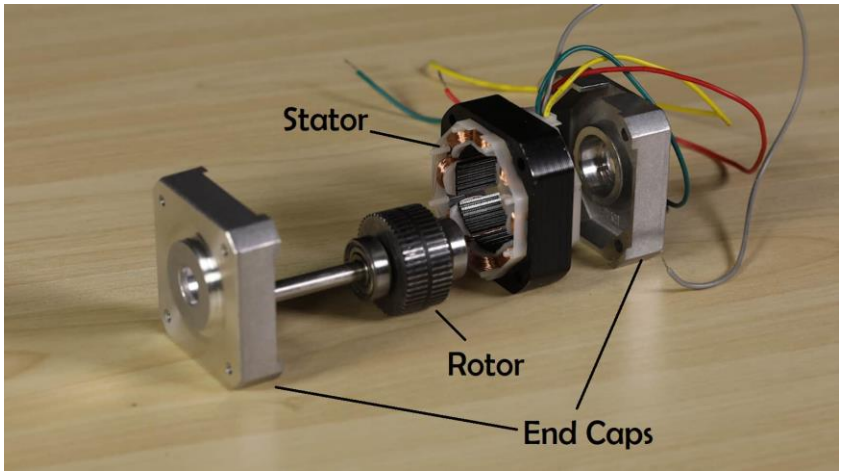
**DC motors**




DC motors use direct current to generate output rotation. It converts electrical energy to mechanical energy. There are 2 types of DC motors: brushed DC motors and brushless DC motors. DC motors are commonly used in in power tools, kitchen appliances, smartphones, and computers.

After a DC motor is powered, a magnetic field is created in its stator. Magnets on the rotor are attracted and repelled by the magnetic field, which causes the rotor to rotate. In order to ensure continuous rotation of the rotor, the commutator attached to brushes connected to the power source supply current to the motors wire windings. Primary advantages of DC motors include the ability to precisely control their speed, and the ability to immediately start, stop, and reverse.

**Stepper motors**




Stepper motors are also powered by direct current. Rather than using brushes and mechanical commutators found in typical DC motors, stepper motors use a type of brushless DC motor where the stator contains many evenly spaced windings of wire that behave like magnetic poles after being powered. The rotor is also composed of permanent magnet pairs in a gear shape. An electric controller switches current to successive stator coil to lead the rotor magnetically from one pole to the next pole. The ability

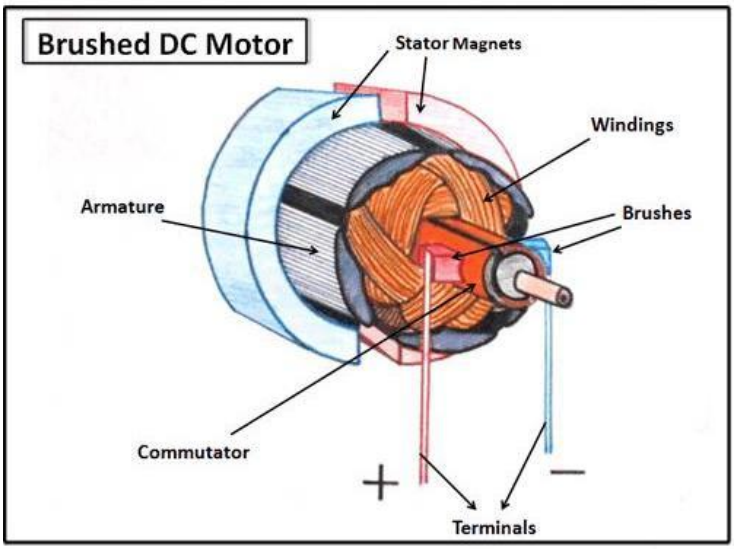
of operators to control the pole to which the rotor jumps is the reason why these motors are called stepper motors, as one can effectively allow precise, stepwise rotational movements.

Stepper motors are also known for providing holding torque (positive torque value at zero speed), which makes them a great fit for robotic applications. Although stepper motors are less efficient than common DC motors, the former's ability to provide repeatable movement that is both reversible and controllable makes it useful in appliances like hard drives, control systems, and printers.

## 4. Compare and contrast the difference between brushed and brushless DC motors. List 3 pros and cons of each.

A brushed DC electric motor is constructed with permanent magnets inside its outer body with a rotating armature inside. These stationary permanent magnets are called the "stator." The rotating armature, known as the 'rotor,' contains an electromagnet.

The rotor is allowed to spin 180-degrees when an electric current is applied to the armature, beyond which the poles of the electromagnet must flip. This flip in magnetic field is done by the carbon brushes that are in contact with the stator as the rotor spins.



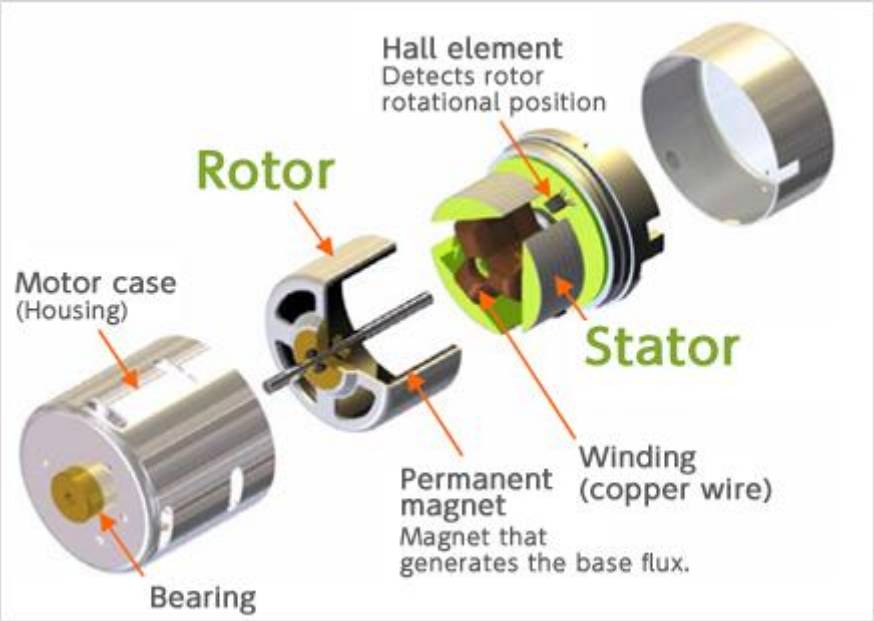

Pros

- High initial torque- in any application requiring motors to get up to speed really quickly, brushed electric motors perform the job.
- Brushed DC motors are relatively inexpensive.
- Well suited for industrial environments due to their high initial torque.

Cons

- Require high maintenance due to the friction that is built on the motor's carbon brushed, which make them wear over time. The maintenance comes in the form of brush cleaning or replacement.
- Low speed. Although they start with high torque, brushed motors are not capable of maintaining high-level speeds.
- Inadequate heat dissipation, which causes them to often become warm.

In a brushless DC motor permanent magnets are fitted to the rotor, with electromagnets on the stator. The brushless motor is an inside-out brushed motor and works by alternating the polarity of windings inside the motor. It also uses an electronic speed controller (ESC) to regulatr the charge to the electromagnets in the stator to allow 360 degrees' rotation.




Pros:

- Lower maintenance- brushless DC motors do not have to deal with the friction caused by the brushes so lesser maintenance is required when compared to brushed motors.
- The absence of brushes boosts the lifespan of the motors as they do not wear out that often.
- Brushless DC motors operate quietly and smoothly because there are no brushes making noise.

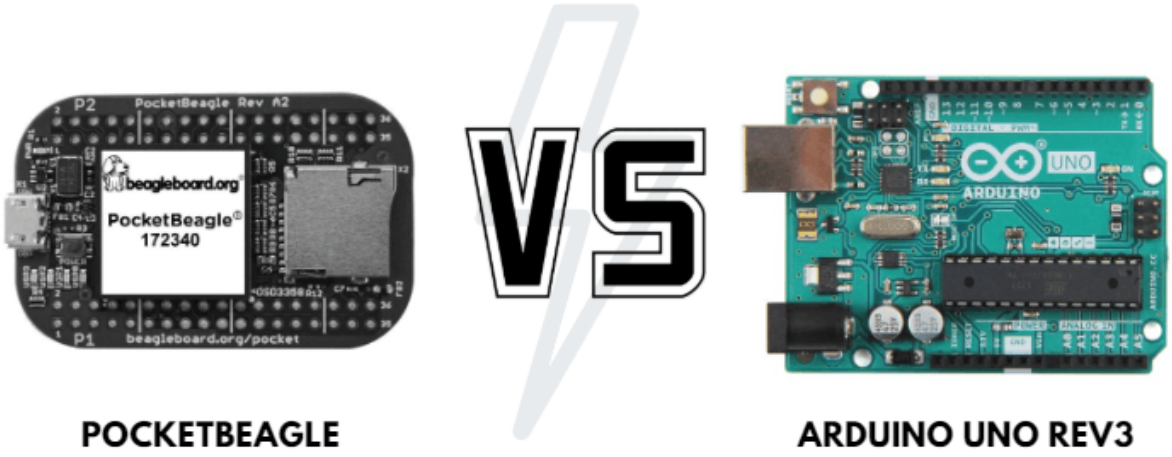
Cons:

- Require a controller- brushless DC motors have an extra component in the form of electronic speed control (ESC), to enable current to flow to the electromagnets.
- The presence of the controller makes brushless DC motors more expensive.
- At low speed rotations, brushless DC motors experience slight vibrationss

## 5. Search and discuss two other devices that can be used to replace Arduino Uno in the Hapkit device. How do they differ from Arduino Uno?

There are several microcontrollers in the market that are worthy contenders for replacing Arduino in the Hapkit device. The two that will be discussed are PocketBeagle – OSD3358ARM Cortex-A8 512MB and NodeMCU v2 – Lua-based ESP8266.

PocketBeagle – OSD3358ARM Cortex-A8 512MB RAM



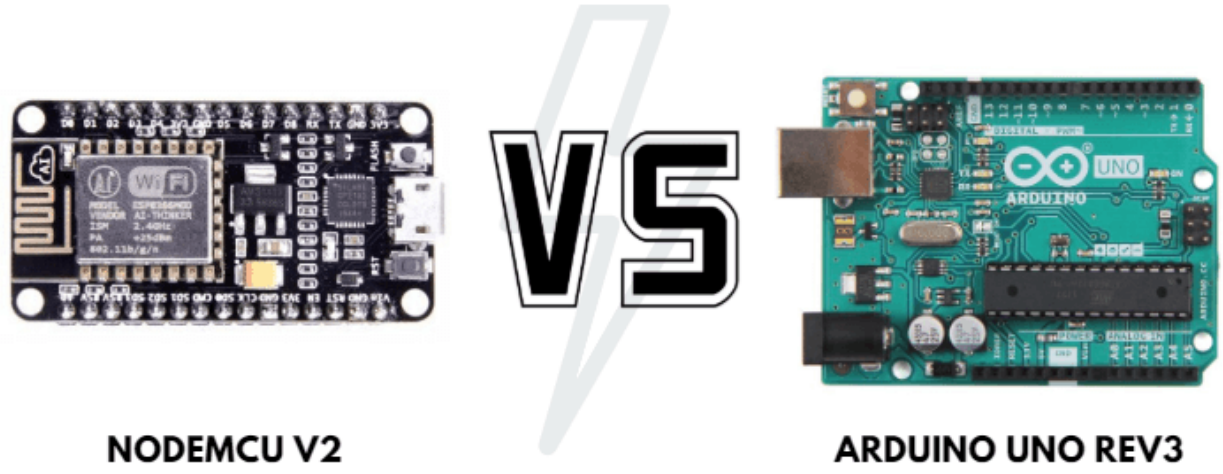

PocketBeagle distinguishes itself from Arduino Uno by having the ability to run Linux right out of the box. It is a single-board computer (SBC) that can be programmed right through the web browser.

PocketBeagle is designed to function like an Arduino Uno with 5 analog inputs with 44 GPIO pins and a MicroSD slot, but has the advantage of having a full onboard operating system.

Here are the major differences between Arduino Uno and Pocketbeagle:

- PocketBeagle has a better processor- Octavo Systems OSD3358 1GHz ARM® Cortex-A8 which has a 512MB RAM compared to 2KB of RAM on the Arduino Uno
- PocketBeagle has 8 analog inputs compared to 6 on the Arduino Uno
- PocketBeagle has 44 digital GPIO compared to 14 on the Arduino Uno
- Arduino Uno has a more robust community and is easier to use than PocketBeagle

NodeMCU v2 – Lua based ESP8266 development kit ($8.20)




The ESP8266, also popularly known as the NodeMCU, is an open-source Arduino-compatible dev board with built-in Wifi.

NodeMCU can be programmed using Lua script or by using the Arduino IDE software. NodeMCU has similar hardware IO like Arduino and one can also code on it using the Arduino IDE software using Lua script.

NodeMCU can function like an Arduino but also has the added advantage of built-in wifi and the ability to program Lua directly on the board.

Here are the major differences between Arduino Uno and NodeMCU:

- The NodeMCU uses the newer micro USB port compared to regular USB on Arduino Uno.
- The NodeMCU comes with a larger 128KB RAM compared to 2KB RAM on the Arduino Uno.
- The NodeMCU has wifi built on board, which makes it better than Arduino Uno where additional shields need to be attached to enable wifi.
- Arduino Uno has a more robust community and is easier to use than NodeMCU.
- The NodeMCU has 4mb of ROM compared to the Arduino Uno with 32kb which means that the NodeMCU can store and run more code than Arduino can.