Pearson BTEC Levels 4 Higher Nationals in Engineering (RQF)

Unit 6: Mechatronics

Unit Workbook 1

in a series of 4 for this unit

Learning Outcome 1

Mechatronic Systems

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INTRODUCTION

In this Unit we will examine the design and operational characteristics of a mechatronic system.

Origins and Evolution:

History and early development, evolution.

Practical examples and extent of use.

Current operational abilities and anticipated improvements.

System Characteristics:

Design of systems in an integrated way.

Sensor and transducer types used.

Consideration of component compatibility.

Constraints on size and cost.

Control device requirements and examples of application.

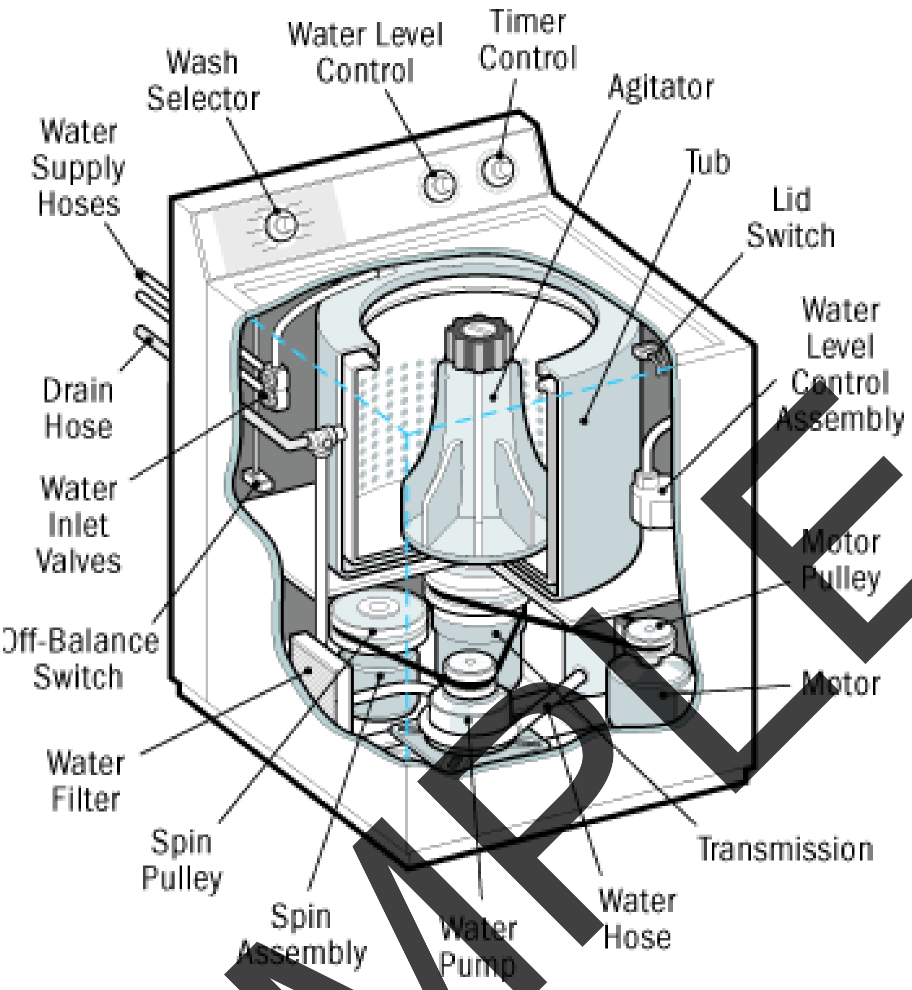

***Figure 3 –** Components of a washing machine*

Other examples of mechatronic systems are:

- Auto-focus camera
- Vehicle smart suspension
- Engine control unit
- Anti-locking braking system
- Industrial production line
- Microwave oven
- Elevator
- Escalator
- Robotic arm
- CNC machine
- Aircraft
- Shipping
- Temperature control system
- Heat-seeking missiles

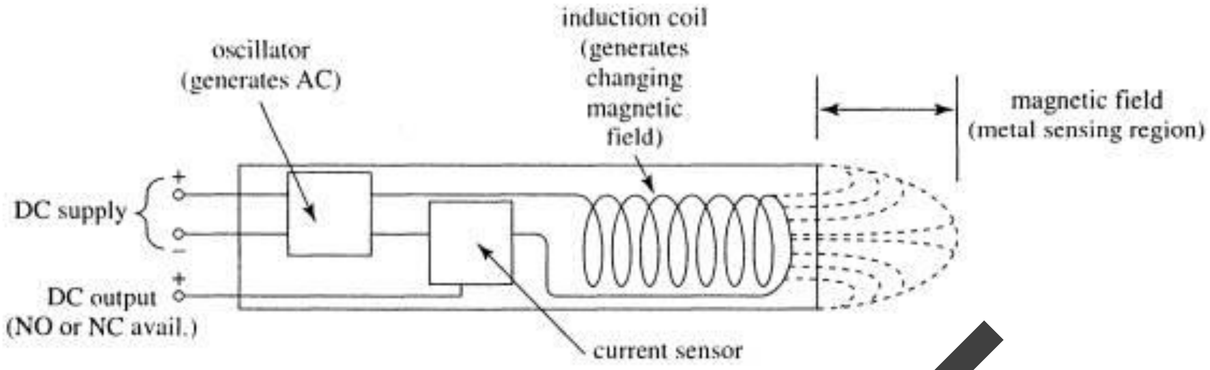

Figure 4 *Principle of an inductive proximity detector*

In figure 4 we see that a DC supply powers an AC oscillator. This oscillator provides a varying sinusoidal current to a coil. The coil can be wound on a ferrite or iron core. The electromagnetic field produced by the coil in this state emanates magnetic flux (shown dotted) from the side of the coil.

When a metallic object locates itself inside the flux emanating from the coil here will be a change in the overall inductance of the coil, changing the level of current flow. This change in current is detected by the current sensor, which then outputs a signal which can be in the form of a DC level, or either activating normally-open or normally-closed contacts. A typical inductive proximity detector is shown in figure 5.

Figure 5 *A tubular inductive proximity detector*

Hall Effect Sensor

In this type of sensor, a current is applied to a thin strip of metal. If a magnet is brought near to the metal strip the electrons which form the current are drawn to one side of the strip's long edge. This causes a voltage difference across the metal strip, which is used to indicate the presence of the magnet. This effect is depicted in figure 6.

Figure 8 *A clamp meter used for measuring current in a cable*

Microphone

A moving-coil microphone has a coil glued to a membrane (diaphragm). A strong magnetic field produced by a permanent magnet is formed to surround the coil. When a pressure wave (sound) hits the microphone, the membrane moves in sympathy with the varying level of the sound wave. Since the membrane moves, so does the coil, and, as we know, relative movement between a coil and a magnetic field produces a current in the coil. This current is then amplified and sent to a further stage, perhaps a loudspeaker. The principle of operation of a moving coil microphone is depicted in figure 9.

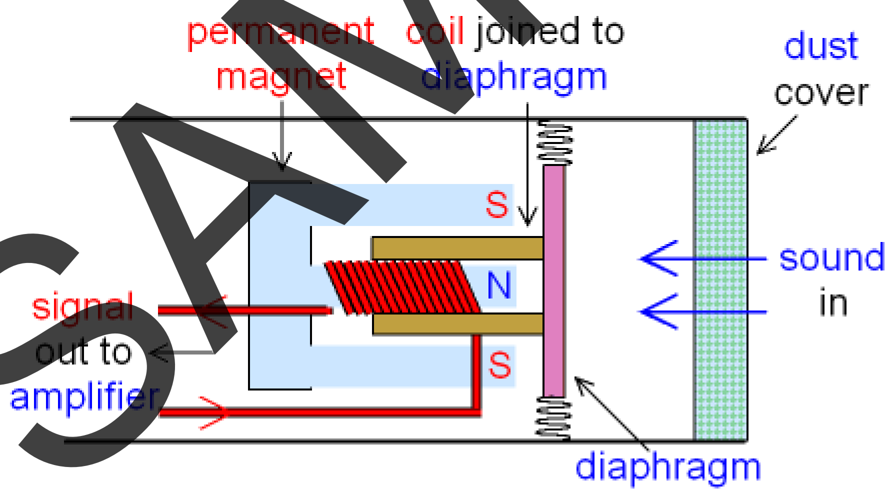

Figure 9 *Principle of operation of a moving coil microphone*

Antenna

An antenna can act as a sensor and operates on the principle of electromagnetic induction. As shown in figure 10, an incident electromagnetic wave (green) causes slight variations in the voltage induced in the antenna (red and blue). There are many variations of antenna, but the principle of operation is generally the same.

Actuator Types

Relay

A relay is used when there is a requirement to separate the control circuit and the output device. A relay consists of a coil which has an armature separated by a small air gap. When current flows through the coil, the coil sets up an electromagnetic field which then attracts the armature to the coil. The movement of the armature in this way causes contacts to be opened (normally-closed) or closed (normally-open), as depicted in figure 12. When the current to the coil is removed the armature springs back to its normal position, resetting the original state of the contacts.

When the relay is energised or de-energised, there is a back emf (electromotive force) generated, which can be several thousand volts. The back emf is an unwanted property of forming and collapsing magnetic fields around coils. To prevent the back emf from interfering with circuitry sharing the same power supply as the relay, a reverse-connected diode is normally connected across the relay coil contacts to suppress this high voltage (the diode sinks the current generated).

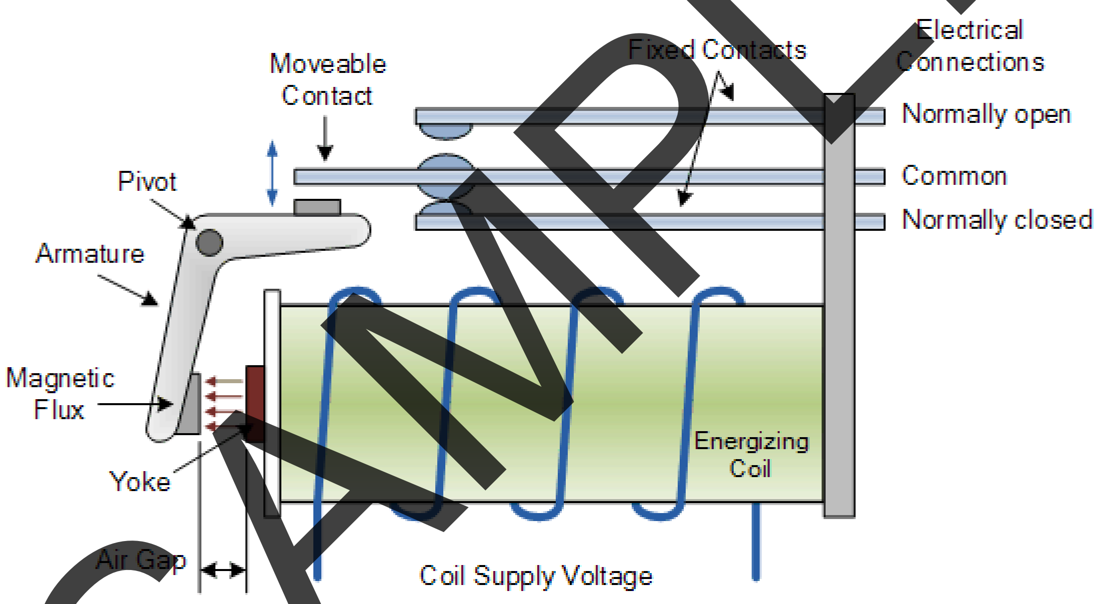

Figure 12 *Principle of operation of an electromagnetic relay*

A relay can be used to switch on a motor via a low voltage control circuit. Relays are common in high power switching applications, for example in railway signalling systems.

Rotary

A rotary actuator converts electrical energy into rotational/torque energy. The rotational energy may be continuous or, perhaps, movement to a fixed /pre-determined angular position, as in servo or stepper motors. Servo motors are commonplace in mechatronics, robotics and drone technology. Examples of rotary actuators are shown in figures 15, 16 and 17.

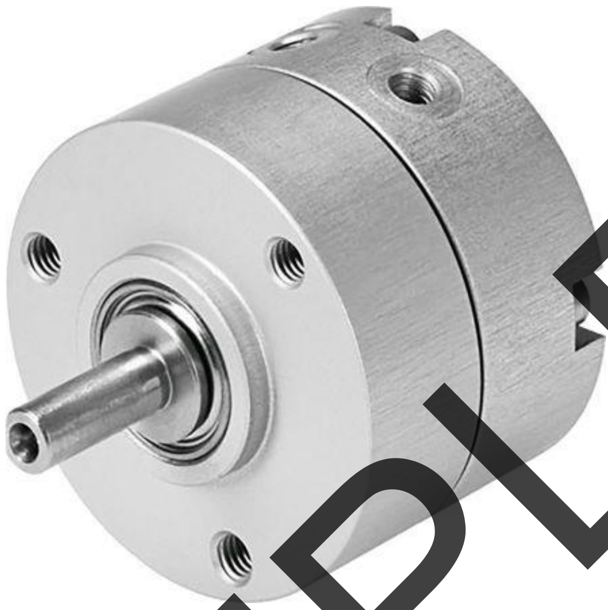

Figure 15 *A linear actuator*

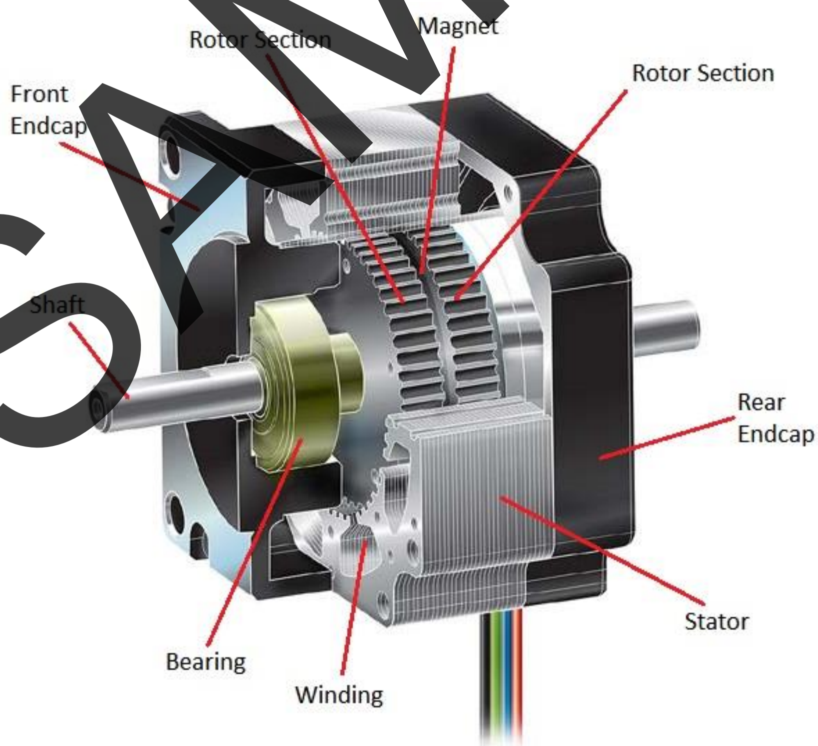

Figure 16 *A stepper motor (actuator)*

Size and cost constraints

The size limitations of a mechatronic system will have a strong influence on which sub-systems are chosen, and the type of those sub-systems. Furthermore, the type of components within the sub-systems will be constrained by the overall size limitations of the overall system.

Any mechatronic system will have an overall budget. The size of the budget will influence which sub-systems and components may be chosen. As technology advances in many disciplines there is always the likelihood that further integration, and therefore reduced cost, will increase the possibility of enhancing the system within the original budget.