TVET CURRICULUM DEVELOPMENT, ASSESSMENT AND CERTIFICATION COUNCIL (TVET CDACC)

Qualification Code   :   071606T4MCT

Qualification   :   Mechatronic Technician Level 6

Unit Code   :   ENG/OS/MC/CC/05/6/A

Unit of Competency :   Operate Mechatronic Systems

WRITTEN ASSESMENT

INSTRUCTIONS TO ASSESSOR:

1. Marks for each section are indicated in the brackets
2. The paper consists of **TWO** sections: **A** and **B.**
3. The candidate is required to attempt **ALL** questions from section **A** and **ANY THREE** questions from section **B.**

NB: *These only serve as a guide to expected responses.*

SECTION A: SHORT ANSWER QUESTIONS (40 MARKS)

1. What is a sensor?   (2 *Marks*)
   - ✓ **It senses the condition, state or value of the process variable and produces an output which reflects this condition, state or value.**

2. How does an actuator work?   (3 *Marks*)
   - ✓ **An actuator is a device that produces a motion by converting energy and signals going into the system. The motion it produces can be either rotary or linear. An actuator is a device that produces a motion by converting energy and signals going into the system.**
   - ✓ **The actuator could be electrical, pneumatic or hydraulic**

3. Explain the working principle of of a photoelectric sensor   (4 Marks)
   - ✓ **A Photoelectric Sensor consists primarily of an Emitter for emitting light and a   Receiver for receiving light. When emitted light is interrupted or reflected by the sensing object, it changes the amount of light that arrives at the Receiver. The Receiver detects this change and converts it to an electrical output.**

4. List four qualities of a good machine operator?   (4 Marks)
   - ✓ **Needs to think on their feet.**
   - ✓ **Need to technically literate.**
   - ✓ **Should be team players.**
   - ✓ **Must know how to handle heavy equipment.**
   - ✓ **Must be detail oriented.**

5. Describe two levels of troubleshooting and give an application of each   (5 Marks)
   - ✓ **System Level Troubleshooting: is a process where the trouble-shooter identifies,   through observation and measurement, the failed component of a system (i.e. power   supply, processor, input or output module, or field device). Since machine downtime   is costly for a manufacturer, most maintenance personnel in manufacturing plants   usually only perform systems level troubleshooting.**
   - ✓ **Component Level Troubleshooting: is the process where the trouble-shooter repairs the faulty component identified through systems level troubleshooting. This means finding the parts (i.e. IC, resistor and diode)**

within the component that must be replaced to repair it. Component level troubleshooting is generally performed off- line, away from the machine.

6. What is   (4 Marks)

   a) Transducer

      ✓ **It is a device that converts the energy from one form to another**

   b) Actuators.

      ✓ **An actuator is a device that produces a motion by converting energy and signals going into the system. The motion it produces can be either rotary or linear. An actuator is a device that produces a motion by converting energy and signals going into the system.**

      ✓ **The actuator could be electrical, pneumatic or hydraulic.**

7. Explain the operating principle of a Strain Gauge   (5 Marks)

   ✓ **The strains resulting from the diaphragm deflection are sensed by four strain elements that are bonded directly to the underside of the diaphragm. The changes are resistance of the elements that are measured as an indication of process pressure. The working element of the strain gauge transducer is a tube closed on one end, with the other end open to the process pressure. Four strain gauges are bonded to the outside of this tube. Two of the elements are strained under pressure and two are not because they are mounted longitudinally and circumferentially. When the tube is pressurized, its minute expansion changes the resistance of the gauges, which are connected to a Wheatstone bridge.**
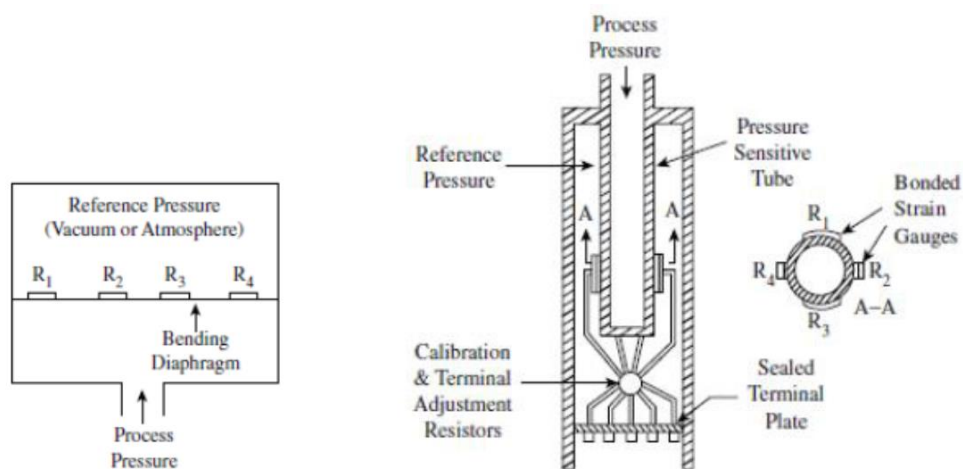
8. Briefly explain the working principle of the sensor below.   (5 marks)

- ✓ **A tilt sensor has a metallic ball that is designed to move the two pins of the instrument from the 'on' to the 'off' position, and vice versa, if the sensor reaches a pre-determined angle. Tilt sensors are the environment-friendly version of a mercury-switch.**

9. What is troubleshooting a system?   (3 Marks)

- ✓ **Troubleshooting is a systematic approach to problem solving that is often used to find and correct issues with complex machines, electronics, computers and software systems.**
- ✓ **The first step in troubleshooting is gathering information on the issue, such as an undesired behaviour or a lack of expected functionality. Other important information includes related symptoms and special circumstances that may be required to reproduce the issue.**

10. List the five steps followed when troubleshooting a system or software   (5 marks).
   - ✓ **Identify the problem.**
   - ✓ **Establish a theory of probable cause.**
   - ✓ **Test the theory to determine the cause.**
   - ✓ **Establish a plan of action to resolve the problem and implement the solution.**
   - ✓ **Verify full system functionality and, if applicable, implement preventive measures.**

11. The mechatronic approach to design involves four general approaches in design of mechanisms. Giving an example for each, explain the four approaches.   (5 marks).

   - ✓ **Simplification of Mechanisms: The functionality of tasks such as profiling and speed and position control can be provided**

by the microprocessor and actuators, e.g. typewriters, large telescopes.

✓ **Enhancement of Mechanisms: By combining sound mechanical design with closed loop control, enhanced speed, accuracy and flexibility of movement are achieved, e.g. advancements in motors used in robots**

✓ **Synthesis of Mechanisms: The use of embedded microprocessor systems enables the synthesis of different mechanisms, as well as functions, e.g. bi-directional wash action in automatic washing machine.**

✓ **Replacement of Mechanisms: The mechanism may be completely discarded, the functionality being replaced entirely by the microprocessor and actuators, e.g. electronic watches, digital cameras**

SECTION B: EXTENDED ANSWER QUESTIONS (60 MARKS)

12. With aid of the diagrams explain the importance and working principle of a variable frequency drive. **(20 Marks)**

 ✓ **It is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor. Other names for a VFD are variable speed drive, adjustable speed drive, adjustable frequency drive, AC drive, micro drive, and inverter.**

 ✓ **Frequency (or hertz) is directly related to the motor's speed (RPMs). In other words, the faster the frequency, the faster the RPMs go. If an application does not require and electric motor to run at full speed, the VFD can be used to ramp down the frequency and voltage to meet the requirements of the electric motor's load. As the application's motor speed requirements change, the <u>VFD</u> can simply turn up or down the motor speed to meet the speed requirement.**
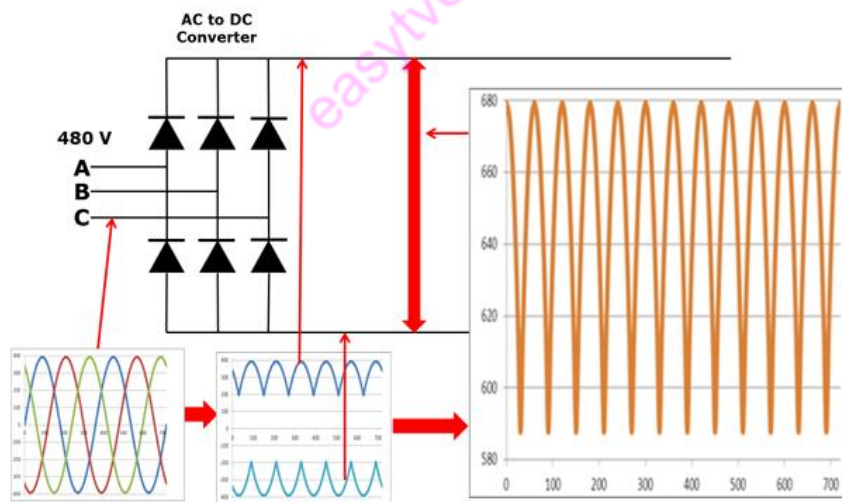
 ✓ **The first stage of a Variable Frequency AC Drive, or VFD, is the Converter. The converter is comprised of six diodes, which are similar to check valves used in plumbing systems. They allow current to flow in only one direction; the direction shown by the arrow in the diode symbol. For**

example, whenever A-phase voltage (voltage is similar to pressure in plumbing systems) is more positive than B or C phase voltages, then that diode will open and allow current to flow. When B-phase becomes more positive than A-phase, then the B-phase diode will open and the A-phase diode will close. The same is true for the 3 diodes on the negative side of the bus. Thus, we get six current "pulses" as each diode opens and closes. This is called a "six-pulse VFD", which is the standard configuration for current Variable Frequency Drives.

13. Using examples give application of open-loop and closed-loop control systems.

(20 Marks)

idle – speed control system (OPEN LOOP)

- ✓ **main objectives of an idle-speed control system of an automobile**
- ✓ **To eliminate or minimize the speed drop when engine loading is applied**
- ✓ **To maintain the engine speed of a desired value.**
- ✓ **The throttle angle and the load torque (due to the application of conditioning power steering, transmission, power brake) are the inputs and the engine speed is the output**
- ✓ **The engine is the controlled process of the system**
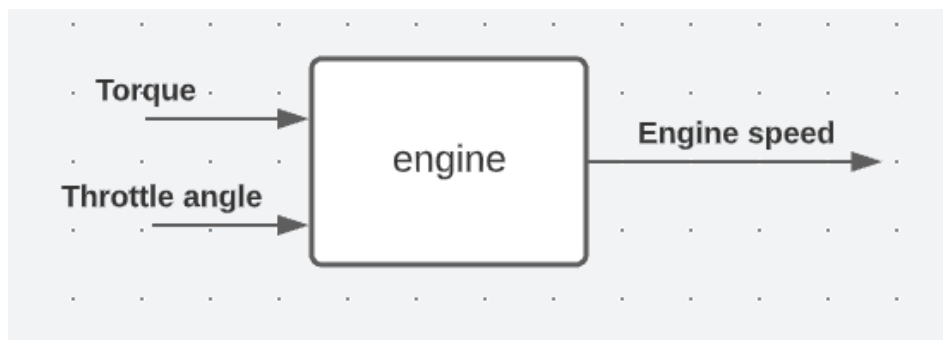
A closed-loop idle-speed control system (closed loop)

- ✓ **The reference speed sets the desired idling speed. The engine speed at idle should agree with reference speed and difference such as load torque is sensed by speed transducer and the error detector. The controller will operate on the difference and provide a signal to adjust the throttle angle to correct the error.**

14. Explain the basic architecture of a programmable logic controller.   (20 Marks)

✓ **Hardware**

The main components of a PLC consist of a central processing unit (CPU), power supply, programming device, and input and output (I/O) modules.

✓ **CPU**

The CPU is the brain of the PLC and carries out programmed operations. These operations or outputs are executed based on signals and data provided from connected inputs.

✓ **I/O Modules**

PLC input modules connect various external devices, such as sensors, switches, and push buttons to the PLC to read various digital and analog parameters, such as temperature, pressure, flow, speed, etc. Output modules convert signals from the CPU into digital or analog values to control output devices.

✓ **Power Supply**

The power supply provides power to the PLC by converting the available incoming AC power to the DC power required by the CPU and I/O modules to operate properly.

✓ **Software**

✓ **Ladder Logic**

Ladder Logic is a graphical PLC programming language and is the most common method of programming. Ladder Logic can be used to execute tasks such as sequencing, counting, timing, data manipulation, and more. Ladder

Logic is structured similarly to relay logic; however, the physical switches and coils used in relay logic are replaced by the PLC's memory locations and I/O.

15. Show the various components of a hydraulic system.   (20 Marks)

- ✓ **Pump – it delivers high pressure fluid**
- ✓ **pressure regulator – It limits the pressure in the system**
- ✓ **valves – These control flow rates and pressures**
- ✓ **Distribution system – It is composed of hoses or pipes**
- ✓ **Infrastructure – consists of the elements contained in the dashed box**