Unit 7: Controller Selection for Mechatronic Systems
Dr. Lutfi Al-Sharif (Revision 1.0 28/10/2012)

1. Controllers

When designing a mechatronic system, one of the most important and critical decisions the designer has to make is the type of controller (physical controller) to use in order to control the system. There are a number of possible options as follows:

1. Microcontroller/microprocessor (e.g. PIC microcontroller): A microprocessor or a microcontroller is an integrated circuit that can be programmed to carry out a set of instructions in response to hardwired inputs and that can send out outputs. It can carry out a large number of instructions per seconds.

   A microcontroller is usually used in applications that have a large number of products to be manufactured (e.g. washing machines, air-conditioners, and automotive applications). The cost of the device is low. It can do some signal processing but is very limited. It also has the disadvantage in that it requires interfacing the inputs and the outputs to the real world. It is very compact and small in size; thus, it does not take up much space.

2. Programmable logic controller (PLC): A programmable logic controller (PLC for short) is an electronic device that can be programmed using ladder logic and that has a set of inputs and outputs (both analogue and digital). It continuously runs a program that has been stored within it and scans for the status of inputs. It then sends outputs to control external devices.

   As opposed to microprocessors and microcontrollers, PLCs have ready designed input and output interfaces. PLCs are also more robust that microcontrollers and microprocessors and much easier to program.

   The PLC has a large size and thus requires more space. Its cost is higher than microcontrollers and microprocessors and could range from $300 to thousands of US dollars. It already has good interfacing for inputs and outputs. It has a high level of reliability. The PLC is not suitable for any signal processing; thus, the PLC is usually only used for simple logic processing that replaces old relay systems. The PLC is widely used in many industrial controllers, such as those in the water industries and factories. It is easy to program using ladder diagrams. The PLC is generally considered too slow to be used for high speed real time systems. The ladder language used in PLCs is easy to understand.

3. PC desktop/laptop: In certain situations, a desktop or a laptop is used as a controller. This is usually done in situations where extensive signal processing and analysis are required. Special interfacing is usually carried out by the use of interface I/O cards. The cost is usually higher than the PLC. The advantage of the use of a desktop or a laptop is that it offers an excellent user interface, but it is not suitable for industrial environments that have dust, grease, and liquids. It is also not suitable for applications that have a large number of units due to the high cost and hence this is only used for one off systems.

4. Digital Signal Processing (DSP) integrated circuits: These are powerful microprocessors that possess advanced signal processing capabilities. Texas instruments (TI) produces a large range of these devices some of which even include video processors.

5. Relay controllers: This method uses relays and their contacts (normally closed and normally open contacts that are denoted as NC and NO respectively) to implement ***'logic'*** functions. It is rarely used nowadays as it is bulky and consumes a lot of energy and takes up a lot of space.

6. Logic gates: Logic gates can be used to implement logic decisions. These can be implemented in an electronic format, such as gates (CMOS, TTL), programmable logic devices (PLD), or field programmable gate arrays (FPGA). They can also be implemented in pneumatic format although this is now obsolete.

The most widely used options of these are the first three. The table below shows a general comparison of the three options:

	Number of products to be manufactured	**Signal processing**	**Speed**	**Cost**
Microcontroller	High	Medium	High	Low
PLC	Medium	Low	Low	Medium
PC/laptop	Low	High	Medium	High

2. Examples

The following examples illustrate the selection of the type of controller used.

a) A one off control system that controls a domestic water heater to a temperature of 60 °C ±5 °C: In such a case a very simple controller such as a PLC controller can be used as there is no need for any complex signal processing.

b) A large number of accurate water pumping system that has to pump exact amounts of water: In this case, the system will need to measure the flow of the fluid and thus would need to interface to a flow meter. As the number of unit is large, a microcontroller can be used and interfaced to the flow meter.

c) A one off control system that accurately controls the speed of a conveyor belt and is subject to disturbances of load on the belt: With such an application, a PLC can be used as the number of units is small. Speed feedback will be provided, using a shaft encoder, and the signal is fed to the PLC.

d) A controller inside a modern air conditioning system: A large number of such controllers will be needed, and as the space is restricted, this will be an ideal application for a microcontroller.

e) A face recognition control system that has a camera feeding it and that will raise an alarm when detecting a criminal: Such a system requires extensive signal processing and image processing, and for this reason, a laptop or desktop will be used. This assumes that a small number of units will be produced.