UNIT 22: PROGRAMMABLE LOGIC CONTROLLERS

Unit code: A/601/1625 QCF level: 4 Credit value: 15

OUTCOME 4

4 Understand alternative Implementations of programmable control

PICs and other programmable devices: specification and use of PICs and other programmable devices; embedded controllers

PLC simulators: compare operation and functionality advantages and limitations

Learning outcomes **On successful completion** **of this unit a learner will:**	**Assessment criteria for pass** **The learner can:**
L04 Understand alternative implementations of programmable control	4.1 evaluate PICs and other programmable devices as programmable devices and embedded controllers 4.2 compare the operation, functionality, advantages and limitations of PLC simulators.

MICROCONTROLLERS

You can find microcontrollers in all kinds of electronic devices these days. Any device that measures, stores, controls, calculates, or displays information must have a microcontroller chip inside.

A microcontroller is basically a PLC on a single chip. It contains on one chip a processor and all the supporting circuits to enable it to communicate and interface with external equipment. Unlike a microprocessor a microcontroller does not require any external interfacing of support devices. Intel 8051 is the most popular microcontroller ever produced in the world market.

PERIPHERAL INTERFACE CONTROLLERS (PICs)

These are advanced microcontrollers developed by microchip technologies. They are sometimes called a computer on a single chip but might be best thought of as a PLC on a single chip. The programme to produce the required control function is developed and loaded into the chip. The chip is then embedded in a machine or device to control it.

Examples of machines that use them are:

Cameras/Camcorders
TV controllers
DVD Players
Microwave Ovens
Printers/Scanners
Keyboards and Mouse
Modems
Motor cars
Medical devices
Toys
Robots
Mobile Radios/communication devices
Vending Machines
….. and many more

The largest single use for microcontrollers is the automobile industry where they are widely used for controlling engines and power controls in automobiles. In industry they are usually set up to carry out a dedicated control function in a variety of processing/manufacturing systems. They are expected to be durable and to work for a long time. They are used widely to control individual items like conveyor belts largely independent of the main system but linked into the overall control system. They are embedded in some instruments to perform on the spot control and are interrogated by the main controller.

PICs are cheap and widely available with lots of free material including computer software to programme them so they are popular with hobbyist. They use flash memory so they can be reprogrammed.

MICROCONTROLLERS STRUCTURE/ARCHITECTURE

A Microcontroller is a single chip micro computer made through VLSI fabrication. A microcontroller also called an embedded controller because the microcontroller and its support circuits are often built into, or embedded in, the devices they control. A microcontroller is available in different word lengths like microprocessors (4bit, 8bit, 16bit, 32bit, 64bit and 128 bit microcontrollers are available today).

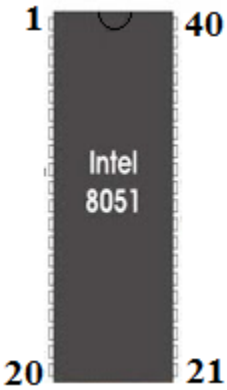
CHIP STRUCTURE

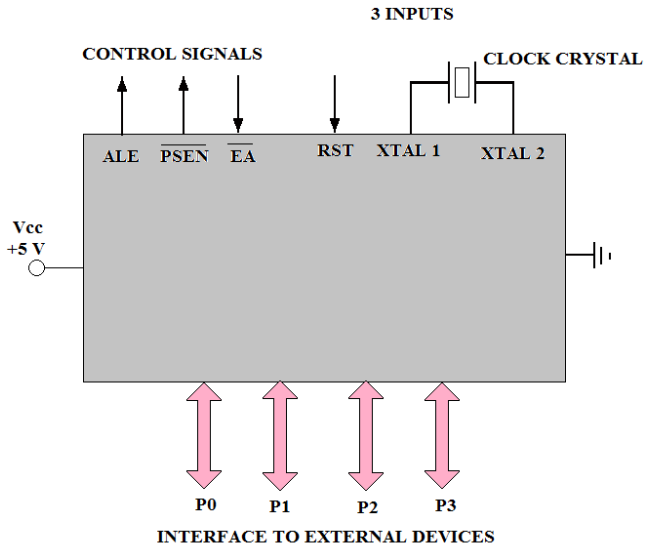
You will find more a detailed description and explanation at the following link.
http://www.circuitstoday.com/8051-microcontroller

The first diagram shows simplified details of a chip such as the 40 pin 8051. The main connections are shown. There are 3 input lines, 3 control lines and 4 ports for external interfacing. The power connections are Vcc and ground (0V).

XTAL 1 and XTAL 2 are the system clock inputs from a crystal clock circuit. These time and synchronise things. RST is the RESET input and it initialises the microcontroller to the default/desired values to make a new start.

There are 3 control signals. EA is External Access, PSEN is Program Store Enable and ALE is Address Latch Enable (ALE). These control the access to the external memory. The interface to the external devices is 4 ports each with 8 bits so on the chip there are 8 pins for each port. More advanced chips have 16, 32 and 64 bits.



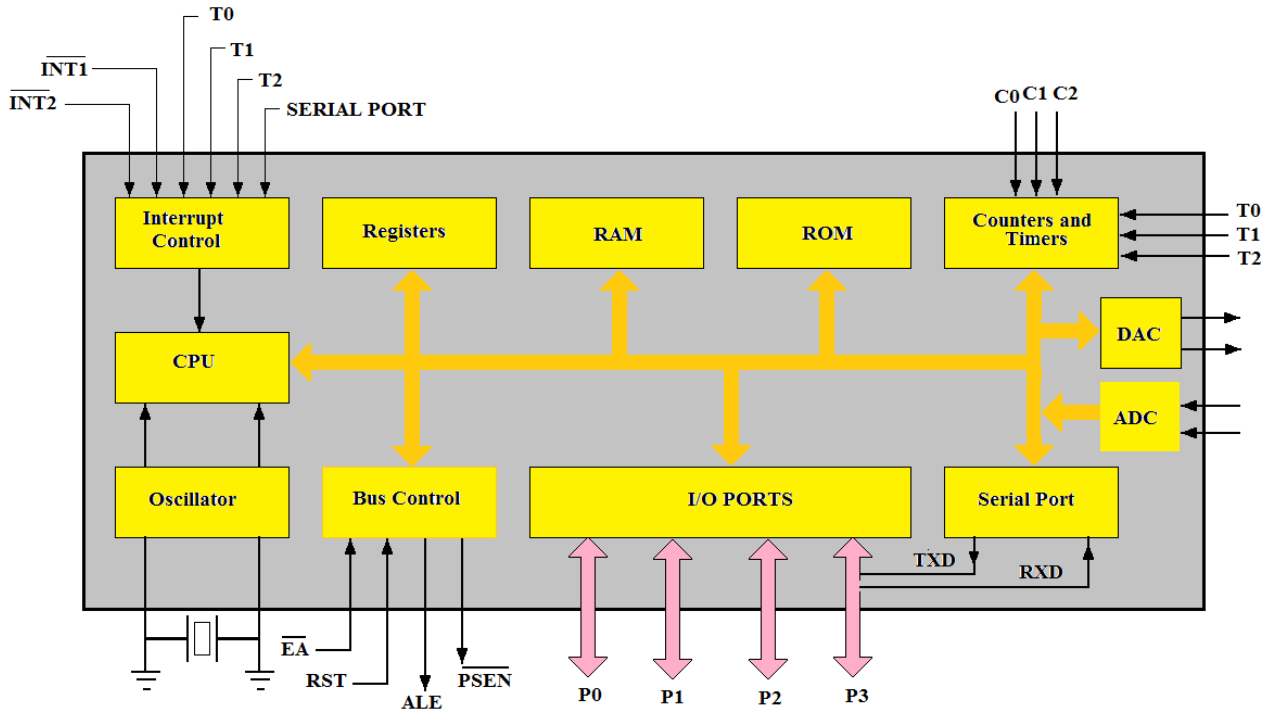


Pins 1 to 8 is Port 1
Pin 9: RST require a positive pulse.
Pin 10 to 17 is Port 3
Pin 10 is Serial Asynchronous Communication Input or Output.
Pin 11: Serial Asynchronous or Synchronous Communication Output
Pin 12: Interrupt 0 input.
Pin 13: Interrupt 1 input.
Pin 14: Counter 0 clock input.
Pin 15: Counter 1 clock input.
Pin 16: Writing Signal for Writing content on external RAM.
Pin 17: Reading Signal to read contents of external RAM.

Pin 18 and 19 are the clock. An internal oscillator is connected to Micro controller through these PINS.
Pin 20is grounded.
Pin 21 to 28 is Port 2
Pin 29: If we uses an external ROM then it should has a logic 0 which indicates Micro controller to read data from memory.
Pin 30: This Pin is used for ALE that is Address Latch Enable.
Pin 31: If we have to use multiple memories then by applying logic 1 to this pin instructs Micro controller to read data from both memories first internal and afterwards external.
Pin 32 to 39 is Port 0.

The next diagram shows more details of the internal architecture. A microcontroller basically contains one or more following components:

- Central processing unit (CPU)
- Random Access Memory (RAM)
- Read Only Memory (ROM)
- Input/output ports
- Timers and Counters
- Interrupt Controls
- Analogue to Digital Converters (ADC)
- Digital Analogue Converters (DAC)
- Serial interfacing ports
- Oscillatory circuits for clock/timers



The basic structure and block diagram of a microcontroller is shown in the above diagram. The system bus connects all the support devices with the central processing unit. 8051 system bus composes of an 8 bit data bus and a 16 bit address bus and bus control signals. From the figure you can understand that all other devices like program memory, ports, data memory, serial interface, interrupt control, timers, and the central processing unit are all interfaced together through the system bus. RxD and TxD (serial port input and output) are interfaced with port 3.

- **CPU** is the brain of a microcontroller and is responsible for fetching the instructions from memory, decoding them and then executing them. The CPU connects every part of a microcontroller into a single system.

- **Memory** function in a microcontroller is same as microprocessor. It is used to store data and program. A microcontroller usually has a certain amount of RAM and ROM (EEPROM, EPROM, etc) or flash memories for storing program source codes.

- **Parallel input/output ports** are mainly used to drive/interface various devices such as LCD'S, LED'S, printers, memories, etc to a microcontroller.

- **Serial ports** provide various serial interfaces between microcontroller and other peripherals like parallel ports.

- **Timers/counters** are a useful function of a microcontroller. A microcontroller may have more than one timer and counters. The timers and counters provide all timing and counting functions inside the microcontroller. The major operations of this section are to perform clock functions, modulations, pulse generations, frequency measuring, making oscillations, etc. This also can be used for counting external pulses.

- **Analogue to Digital Converter (ADC)** is used for converting the analogue signal to digital form. The input signal in this converter should be in analogue form (e.g. sensor output) and the output from this unit is in digital form. The digital output can be use for various digital applications (e.g. measurement devices).

- **Digital to Analogue Converter (DAC)** converts the digital signal into analogue format. It usually used for controlling analogue devices like DC motors, various drives, etc.

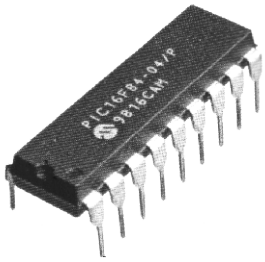
- **Interrupt control** is used for providing interrupt (delay) for a working programme. The interrupt may be external (activated by using interrupt pin) or internal (by using interrupt instruction during programming).

- **Special functioning block**
  Some microcontrollers used only for some special applications (e.g. space systems and robotics) these controllers contain additional ports to perform such special operations. This is considered as special functioning block.

  Microcontroller chips are made with 12 through to 32 bit instructions sets which are regarded as more basic and easier for beginners in programming. The number of instructions varies from about 35 to over 80 depending on the number of bits. These include instructions to perform a variety of operations on registers and program branching and so on.

PROGRAMMING AND SIMULATING

Just as for PLC systems, there are various simulators available for programming and developing PICs. A simple one takes the form of a development board. The chip plugs into the socket and on board connections are set to suit the chip. The board interfaces it with all the external devices such as a computer running programming software and the input/output devices.



The development module needs a computer to run programming software, such as Circuit Wizard. The computer will connect through a serial port or a USB port. When the program has been simulated and works as required, it is downloaded to the PIC microcontroller. The controller does not need the computer afterwards as it works independently. For mass produced machines the chips are all programmed and then embedded in the system.

There are many manufacturers of these development kits and most provide the software for designing, simulating and debugging the programmes on a computer. Some are more advanced than others and allow the system to be emulated on the screen. For example the developer shown from **Futurlec** has a touch screen. With this you can easily control your application with the user simply pressing on the required icon on the screen, to display some value or switch on and off a remote device. This board is ideal for incorporation in large control systems as a full stand alone controller, with all the necessary interface requirements to suit a wide range of applications. This controller can easily replace more expensive embedded computer boards at a fraction of the price of a full computer control system.

PROGRAMING WITH A COMPUTER

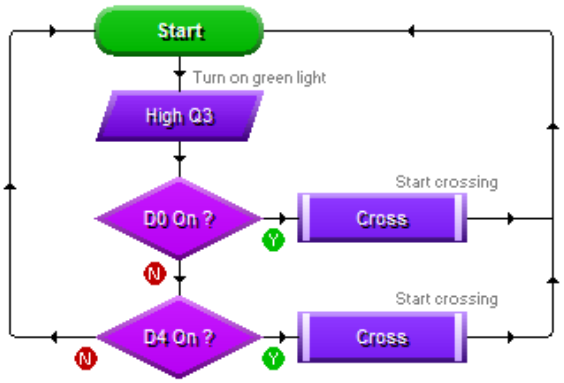
Programs are usually developed with the aid of kits and appropriate software. Here is a description of some of the software.

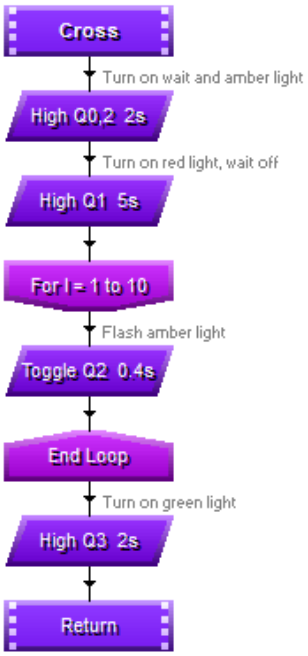
CIRCUIT WIZARD http://www.new-wave-concepts.com/ed/circuit.html

You need a computer to run this software. It allows you to program a PIC microcontroller circuit. The computer will need a serial port or a USB port. This is used to connect the computer to the microcontroller circuit. For educational use Genie Design Studio is a version of the same software.

GENIE DESIGN STUDIO http://www.genieonline.com/

This is software for programming **GENIE** microcontrollers. Its powerful language and highly graphical interface make the whole process of developing electronics-based projects quick and easy. You construct a flow chart by dragging and dropping commands from the library.
By double clicking on the box you can set labels, timers and input/output designations available on the selected chip. This replaces numerous lines of text programming code and means that a program can be written quite quickly, with fewer mistakes. It is then simulated on the screen to check that it works. The program is finally downloaded to a **GENIE** microcontroller. The circuit board design is also shown and if a suitable socket is added to connect it to the computer, the chip can be programmed on the board. The following shows a flow chart and circuit from the screen. The circuit can be tested by simulating on the computer.

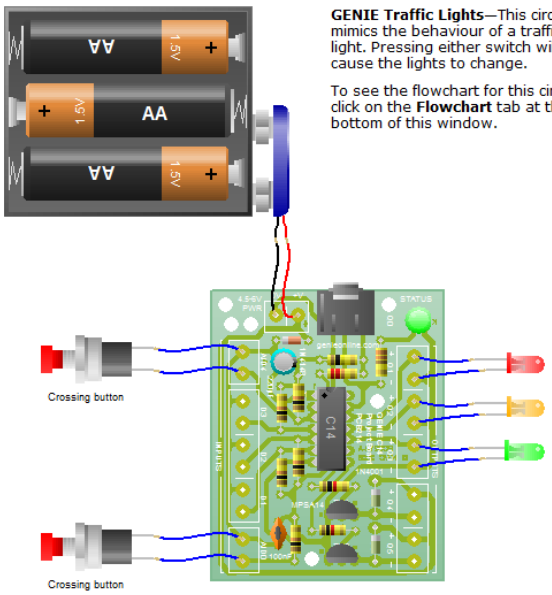




GENIE Traffic Lights—This flowchart determines the behaviour of the microcontroller.

The traffic light LED sequence (containted in the Cross subroutine) is started whenever either of the two connected switches (on inputs D0 and D4) are pressed.

To see the circuit for this program click on the **Design** tab at the bottom of this window.

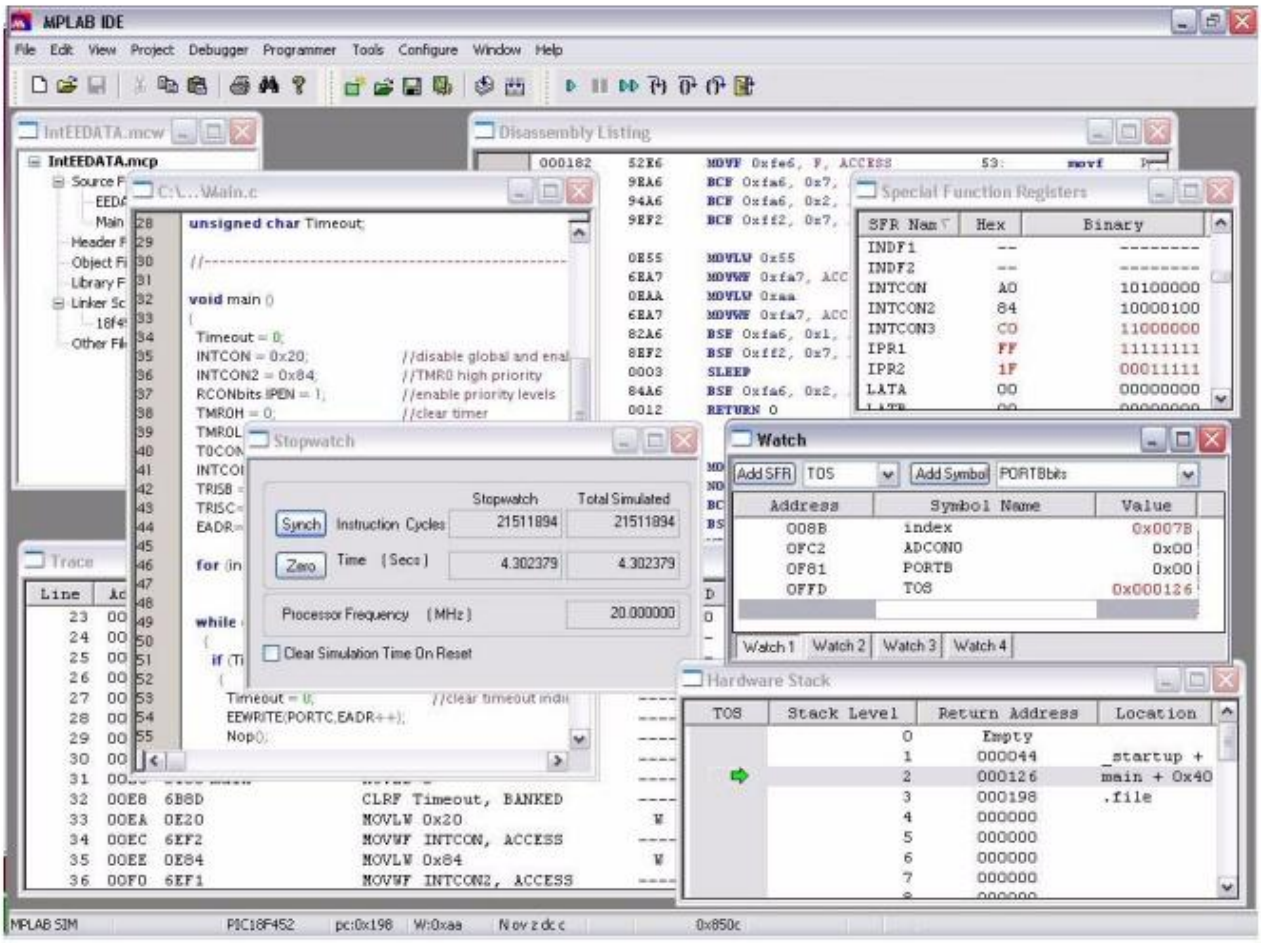


GENIE Traffic Lights—This circuit mimics the behaviour of a traffic light. Pressing either switch will cause the lights to change.

To see the flowchart for this circuit click on the **Flowchart** tab at the bottom of this window.

MPLABS

This is free very advanced programming/debugging software for a wide range of Microchip's more than 800 8-bit, 16-bit and 32-bit MCUs and digital signal controllers, and memory devices. The screen dump below shows that you need to be a serious programmer to use this.



See also PICkit™ 3 which is a kit to enable a chip content to be examines and debugged.

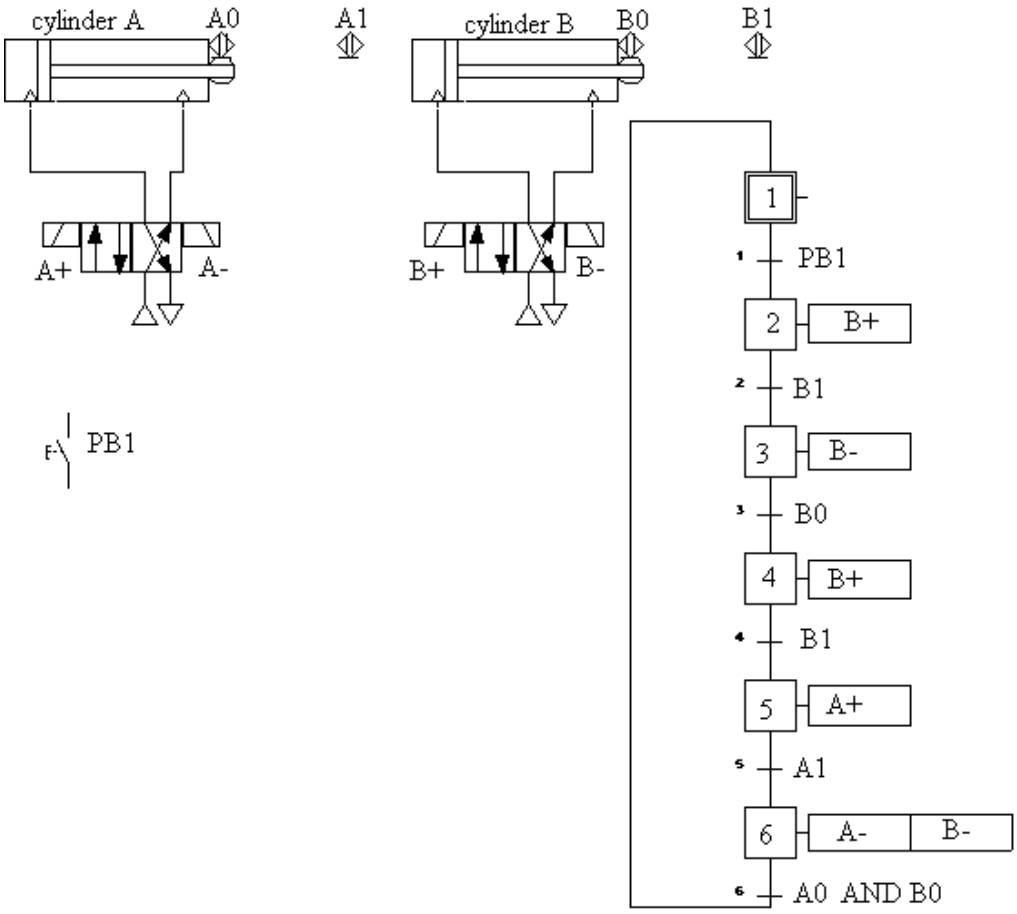
http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1406&dDocName=en538340&redirects=pickit3

PLC SIMULATORS

These have already been described in the previous outcomes. It is usually best to adopt any software and simulator hardware recommended by the manufacturer of the PLC chosen.

AUTOMATION STUDIO™

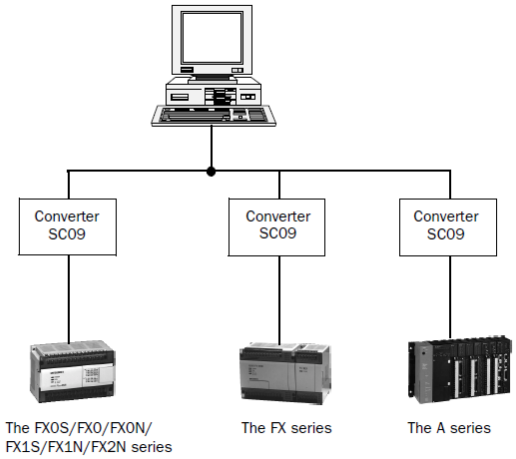
This is a professional suite of programmes allowing the construction of electric, electronic, pneumatic and hydraulic circuits (Mechatronics) and their associated PLC control circuit in Ladder programming or Grafcet/SFC programming. Automation Studio™ can import SFC/Grafcet codes either in XML or in Cadepa™ software format. It also allows you to export SFC/Grafcet into Siemens™ S7 PLC and XML format. The circuit is simulated on screen and transferred to the PLC through an interface. It can also be used to control hardware directly through a suitable interface making the computer into a PLC. The diagram shows a circuit and SFC programme.



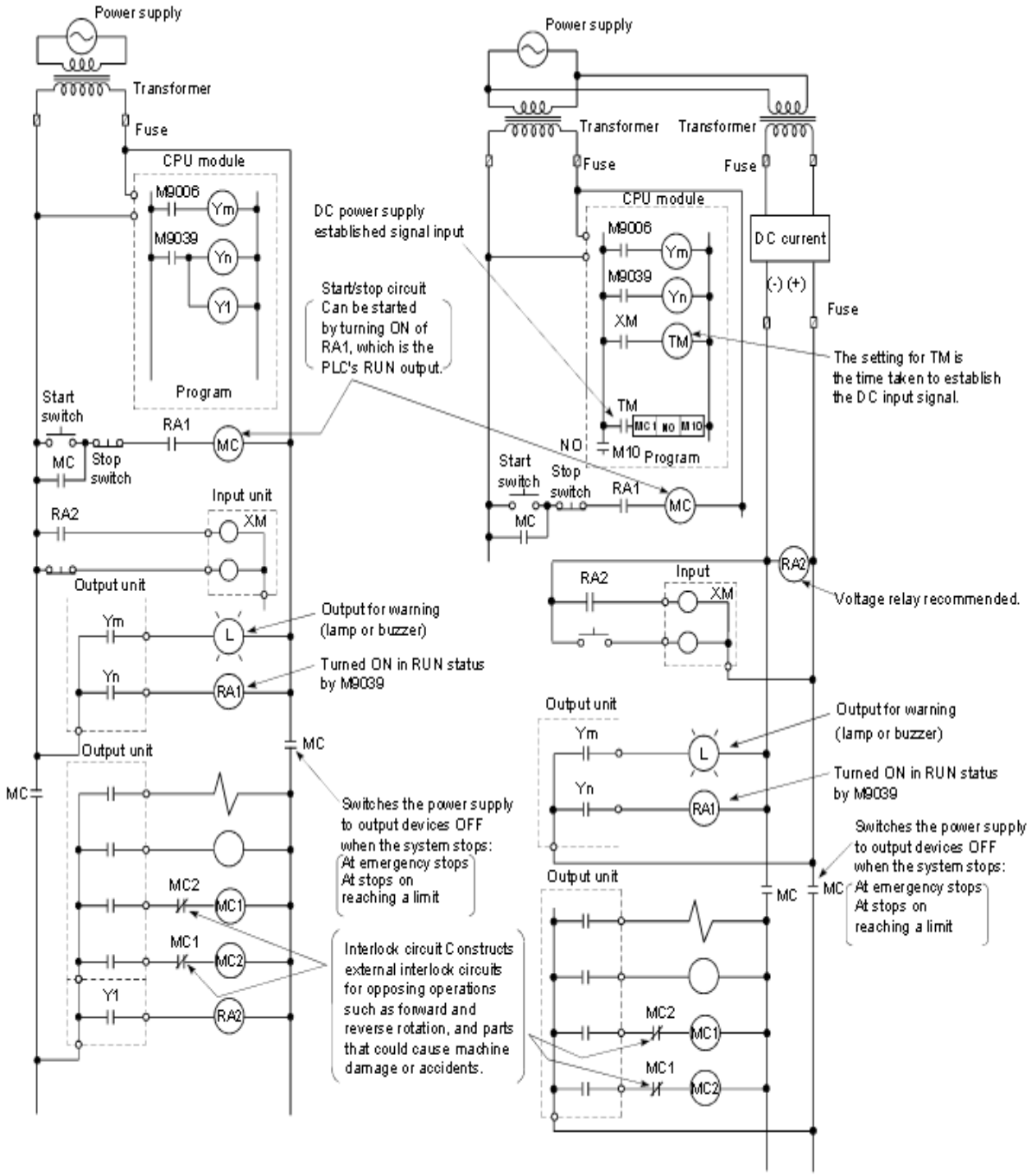
MITSUBISHI/MELSEC

With the appropriate hardware to connect the PLC to the computer, programmes can be created, tested, simulated, downloaded or uploaded from the PLC and the PLC can be monitored when running.

MEDOC's connection to the MELSEC PLC system

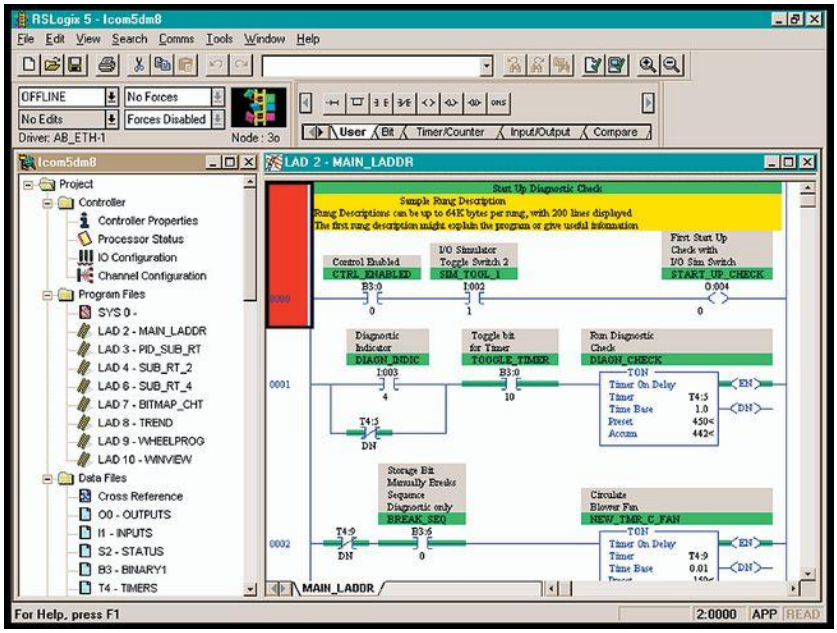


The diagram below shows a typical programme designed with the software.



RSLogix 500 Software

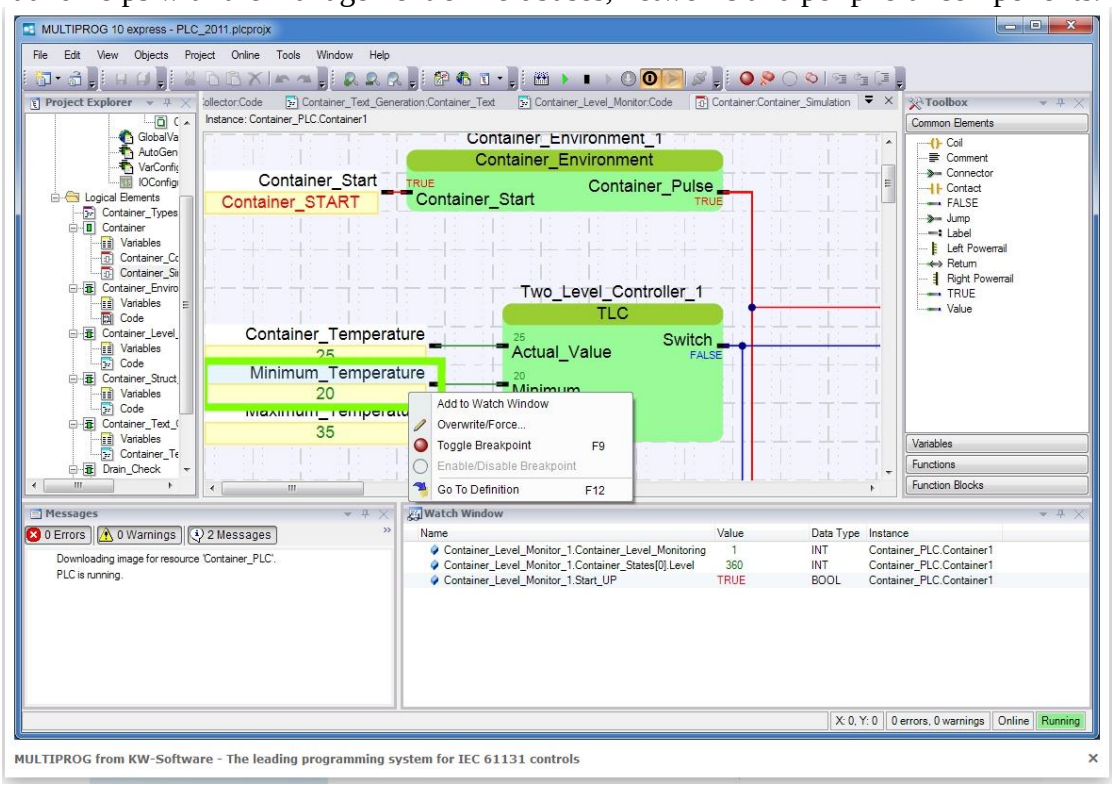
The RSLogix software is a design studio using ladder logic programme compliant to IEC-1131.
It is designed to be used the **Allen-Bradley SLC 500 and Rockwell MicroLogix family of processors**.



MULTIPPROG

This is a programming suite from KW Software. Details may be found at this link.
https://www.kw-software.com/en/iec-61131-control/programming-systems/multiprog-5

This software allows programmes to be produced using any of the five programming systems defined in the international standard IEC 61131 and explained in outcome 3. Apart from the actual programming function, a modern programming system provides a broad range of intelligent additional functions, which support programmers in developing, testing, and commissioning their application. It takes care of the project management and helps with the management of fieldbuses, networks and peripheral components.



SELF ASSESSMENT EXERCISE

1. A company is going to manufacture large numbers of digital flow meters with built in PID (3 Term) control. The meter will display the reading and be able to be interrogated remotely at a central control station.

   Would you choose to use a PLC or an imbedded microcontroller in the instrument? Explain your reasoning.

2. A sorting and packaging machine is to be designed by a company for use on its own premises to deal with its products. It has a series of actuators and sensors to perform its functions. There will be the usual On/Off and reset controls.

   Would you choose to control the machine with a PLC or an imbedded microcontroller? Explain your reasoning.