EDEXCEL NATIONAL CERTIFICATE/DIPLOMA

SELECTION AND APPLICATIONS OF PROGRAMMABLE LOGIC CONTROLLERS

UNIT 25 - NQF LEVEL 3

OUTCOME 4 - COMMUNICATION MEDIUM

CONTENT

Understand data communications media and networks used with modern programmable controllers

***Communication media*:** selection criteria, description of features, frequency ranges, technology e.g. analogue, digital, wireless; media types (cable e.g. twisted pairs, coaxial, fibre-optic, shielded/unshielded, categories, operational lengths; connector e.g. Bayone-Neill-Concelman (BNC), registered jack (RJ-45), straight tip (ST), universal serial bus (USB) type A and type B; opto-isolator e.g. photodiode, phototransistor, thyristors, triacs)

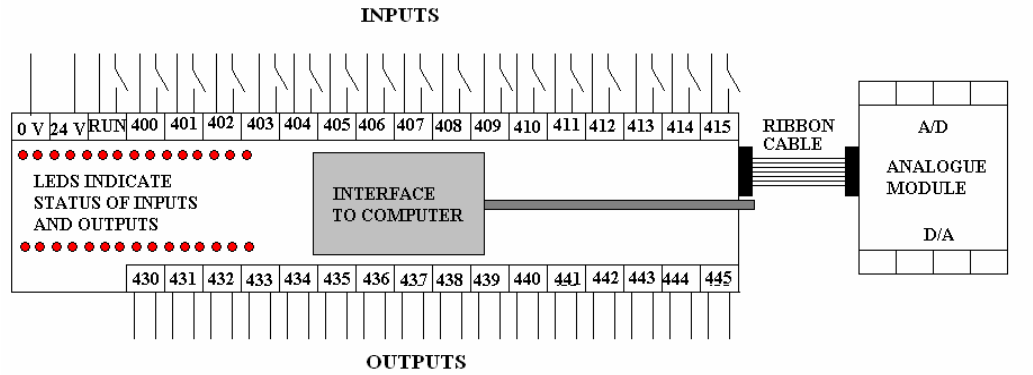
***Network*:** network architecture (fieldbus, distributed intelligence, 'open' communications networks); network standards/protocols e.g. International Organisation for Standardisation (ISO), Institute of Electrical and Electronic Engineers (IEEE), Manufacturing Automation Protocol (MAP), Electronics Industry Association (EIA - 485), Factory Instrumentation Protocol (FIP)

All the component parts within a PLC and the entire external network connecting everything together have to communicate with each other. It is vital that the signal being transmitted is compatible with equipment receiving it so international standards have to be adopted about the precise nature of the signals. This tutorial is about the type of signals used and the medium by which they are transmitted.

There are no self assessments included in this tutorial but you will find assignments on it at the web site www.freestudy.co.uk.

1. ANALOGUE DIGITAL SIGNALS

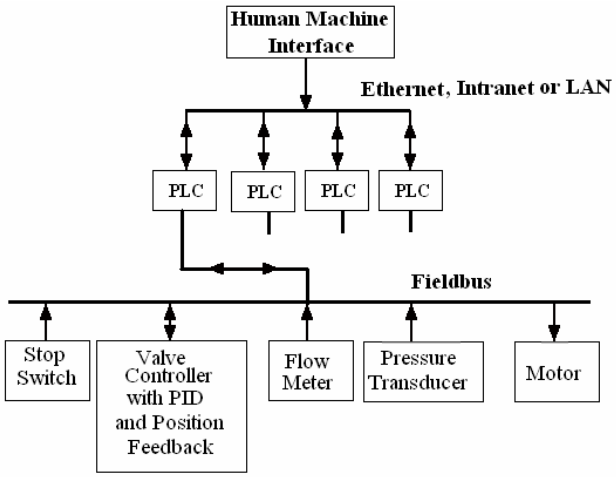
Analogue signals are still widely used by many items of equipment. The modern standard for electrical analogue signals is a current within the range 4 - 20 mA. Equipment may be made to accommodate older standards such as a voltage within the range 0 - 10 Volts. In order for a PLC to communicate with analogue equipment, it must convert incoming signals into a digital form and outgoing signals into analogue form. This is done with Analogue Digital Converters (ADC) and Digital Analogue Converters (DAC). These may be add-on modules plugged into the main PLC units as shown below.



All the communication with the PLC is digital whether we are talking about the A/D module above using the ribbon cable or the communication with computers and networks using various types of mediums. The digital information has to be in a standard form.

2. NETWORKS

A typical network for an industrial process might be like that shown. At the top is the Human Machine Interface which is most likely a computer but could be the monitoring and control station or mimic panel. This is linked to the PLCs controlling the industrial system by a network such as LAN, EHERNET or INTRANET.



Each PLC is linked to a sub system and must process data from the sensors and put out data to the actuators. Whilst smaller systems might have each component hard wired to the PLC, the modern way is to use a FIELDBUS so that a lot of individual channels may be connected through one path (Cable, wireless or optic fibre). The items connected to the fieldbus must have a suitable electronic interface to enable digital signals to be added or removed from the fieldbus. Modern instruments or actuators may have this integrated into them otherwise separate digital interfaces can be added.

The HMI at the top is the **MASTER** and the plcs are the **SLAVES**. Communication between them is master to slave or slave to master. Communication between the PLCs is peer to peer. There are various protocols and standards laying down the way they communicate such as:

ISO	**International Standards Organisation**
IEEE	**Institute of Electrical and Electronic Engineers (British)**
DIN	**German Standards**
ANSI	**American National Standards Institution**
EIA	**Electronic Industries Alliance**

Here are some other definitions you should know:-

SCADA - Supervisor Control and Data Acquisition

LAN - Local Area Network

ETHERNET - is a very common method of networking computers in a LAN using copper cabling. Ethernet will handle about 10,000,000 bits-per-second and can be used with almost any kind of computer.

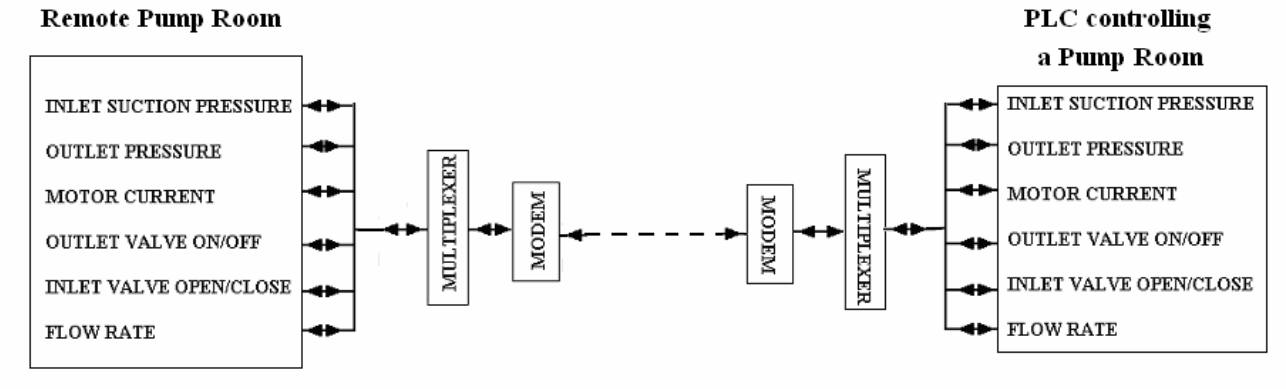
INTRANET - is a general name for networks linking computers within a private organisation such as colleges, businesses and government departments. They use standard network technologies like Ethernet and web servers. Users connected to the intranet often have access to the internet but a firewall prevents external users accessing it. Sometimes it may allow access to an extranet to provide controlled access to some outsiders (e.g. other government departments).

EXTRANET - is a private network that allows limited access to specified users. It uses the Internet for these links. A typical example is a bank with internet access for customers using secure protocols.

DISTRIBUTED INTELLIGENCE - When a process such as a manufacturing cell has robots and many smart sensors and actuators all linked into the network, there will be microprocessors that enable each to perform their jobs with a degree of intelligence. Distributed intelligence is when these are integrated so that new situations are analysed and combined action taken to self correct the situation.

MULTIPLEXERS

In PLC systems not using a field bus, the PLC may be connected remotely to all the sensors and actuators through a serial link (cable or wireless) using a multiplexer and modem. The signals have to be stacked in a queue in a special memory bank called a BUFFER and sent one at a time through the link by a modem (Modulator/Demodulator). When receiving the data it must be sorted correctly and put into a queue in the buffer and then be distributed to the separate channels. To do this a multiplexer is required. The diagram shows how a PLC may be located in a control room and connected to all the sensors and actuators in a remote location.



The multiplexer and modems must be able to tell when to send and when to receive, what channel is being used and be able to handle the type of digital signal in use. To do this we must have standards of **PROTOCOL**. Protocol is essential for any digital system to communicate with another.

3. PROTOCOL

When you come to a set of traffic lights, you observe the colour and interpret red as meaning stop and green as go. In Britain we also have orange which gives a warning of change but it does not take priority over stop or go. This is **PROTOCOL** and other countries have a different protocol so we must be very careful to use the correct protocol. The protocol for digital systems is covered in many standards. It is a digital pattern that is recognised as a command by all the systems (e.g. to start or stop sending or receiving information. Here are some of the names and abbreviations that you might come across.

MAP Manufacturing Automation Protocols is a token-passing local area network configuration adopted by General Motors for factory automation.

FIELDBUS - is an industrial network system for real-time distributed control. In older systems, every instrument and sensor had to be connected by their own cable to the controller (PLC) by using serial communication (RS232). Fieldbus allows all the instruments and sensor to connect to a common point using LAN type connectors thus reducing the number and length of the cables. The sensor and actuators used in this system require a microprocessor and so become SMART instruments and may support more advanced control features such as PID control at the actuator instead of at the controller.

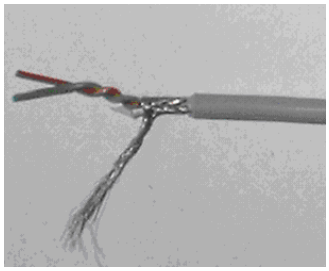
FIP - Factory Instrumentation or Interoperable Protocol now updated to WorldFIP. It is for automated systems in which Level 0 represents the sensors and actuators and level 1 represents the controllers (in this case the PLCs). This particular fieldbus protocol was not dedicated only for the real-time requirements but also for transferring the monitoring information from the plant and along the network to the supervisory equipments. This must be done without interfering with the basic real-time tasks of the protocol.

4. TRANSMISSION MEDIUM

SERIAL

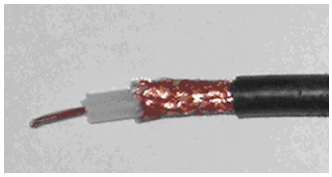
Digital data sent in SERIAL form such as **RS232** on the shorter links and **RS422** on the longer links. All these methods involve recognition of a voltage level to decide if a bit is on or off and it is prone to interference. Whereas voltage might be degraded over a long wire, current is not so another protocol uses **20 mA** to indicate a high bit. The transmission media for serial data could be wire free (radio link), optic fibre or a wire.

TWISTED PAIR



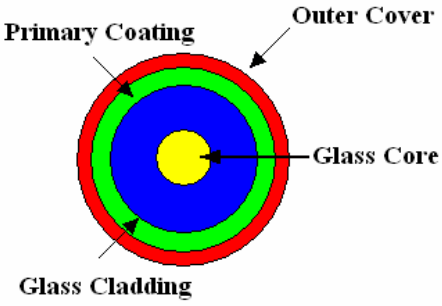
When information is sent along two wires, often a twisted pair is used. An example of this is the ordinary copper wire that connects your landline telephone to the network. To reduce the chances of picking up stray electro-magnetic signals from other lines running along side it, the two insulated copper wires are twisted around each other. More than one twisted pair may be placed inside an outer insulated layer and sometimes the cable is screened or shielded by a grounded outer layer. Twisted pairs come with each pair uniquely colour coded when it is packaged in multiple pairs.

COAXIAL CABLES



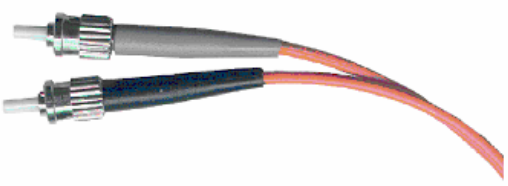
Coaxial cable is widely used to connect computers and PLC's with systems such as Ethernet and LAN. The cable has an inner conductor surrounded by a concentric conductor (coaxial with it) made from copper mesh and separated by a layer of insulation. The outer layer is usually grounded. They can carry information for a great distance.

FIRE OPTICS



Fibre optic cables are basically thin glass strands. When light is shone into one end of a strand (e.g. by a laser) it is carried inside the fibre over enormous distances without losing its strength. The light can be pulsed to carry digital information at enormous speeds and rates. Optical fibre carries much more information than conventional copper wire and is in general not subject to electromagnetic interference and the need to retransmit signals. Many strands can be bundled together to give many more channels. Computers needing high speed data transmission usually have fibre optic links to the server.

You can find out more about the cables and connectors at this web site http://www.arcelect.com/fibercable.htm



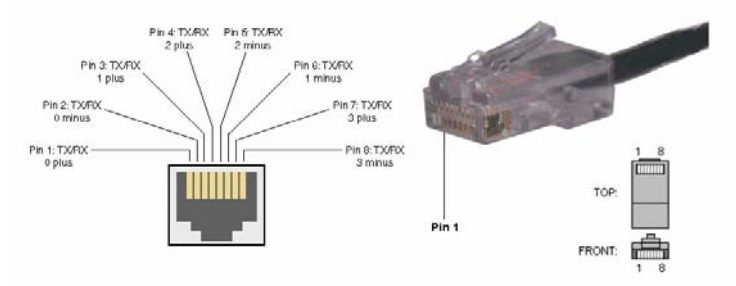
OPTIC FIBRE CABLES WITH TERMINATIONS

SERIAL PLUGS AND SOCKETS

BNC (Bayone-Neill-Concelman)
There are a wide range of plugs and sockets in electronics. The BNC is quite commonly used for coaxial and screened cables.

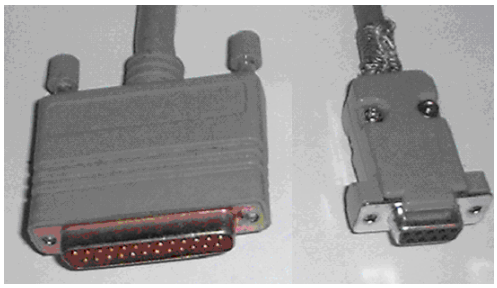
RJ45 (Registered Jack)

These are widely used in various forms networks using modem connections and increasingly other areas. They may be used with telephone type cables and may be connected to the wires with a simple crimping tool making assembly simple and solder less.



DB25 AND 9

For reasons not explained here, these have many wires but essentially they are still serial connectors widely used in digital systems and computer com ports. The 9 pin is a cut down version of the 25 pin. They are also used for other applications even parallel transmission.



USB (Universal Serial Bus)

The USB plugs and sockets are increasingly popular on PLC equipment. These were originally produced for connecting to peripheral equipment and come in various sizes. The 4 pin version is detailed below.

TYPE A

TYPE B

MINI

Pin	Name	Cable Colour	Description
1	VCC	Red	+5 VDC
2	D-	White	Data -
3	D+	Green	Data +
4	GND	Black	Ground

4 PIN USB AND WIRING CONNECTIONS

PARALLEL

These are widely used to link industrial equipment using digital technology. There are still examples of digital data channels being sent simultaneously in parallel and a typical medium is the ribbon cable and Centronics plug shown. These have smaller versions also. The DB plugs are also used for this and it use to be quite common to find a printer cable with a DB25 at the computer end and the Centronics type (36 pins) at the other end.

5 TRANSMISSION STANDARDS

References to various standards have already been made. Here is some more information on them.

RS 232 (This is an EIA standard)

RS-232 is a system originally developed for linking telly printers and is a relatively slow serial data transmission system. The standard is for the physical interface and protocol used in many links from computers to industrial electronic equipment. The system has undergone many updates and RS232C is the current one. Typical uses are in computer modems and linking any device using serial communication. Somewhere in the equipment is a Universal Asynchronous Receiver/Transmitter (UART) chip. The data is transmitted to a modem (or other serial device) from its Data Terminal Equipment (DTE) interface. Data inside equipment flows along busses (Data and Address busses) and these are parallel circuits. Serial devices can only handle one bit at a time. The UART chip converts the groups of bits in parallel to a serial stream of bits.

RS 422

The RS422 is similar to the RS232 but it more suited to transmissions over long cables. Converters are devices which allow different systems such as the RS232 and 422 to communicate even though the protocols are different.

IEEE 488

This is the main standard for parallel data transmission such as used on the printer ports (LPT) of computers. When the Centronics parallel interface was first developed, the main peripheral was the printer. Since then, portable disk drives, tape back up drives, and CD-ROM players are among devices that have adopted the parallel interface. These new uses caused manufacturers to look at new ways to make the Centronics parallel interface better. In 1991, Lexmark, IBM, Texas instruments, and others met to discuss a standard that would offer more speed and bi-directional communication. Their effort and the sponsorship of the IEEE resulted in the IEEE 1284 committee. The IEEE 1284 standard was approved for release in March, 1994.

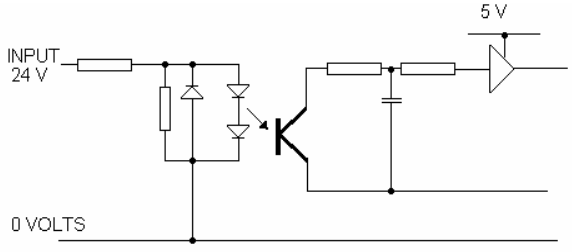
EIA-485 (formerly **RS-485** or **RS485**)

This is a standard for 2 wire serial communication in which data is conveyed by the voltage difference between the two wires. Logic 1 (or high) occurs when the polarity is positive and a logic 0 (or low) when it is negative.

6. OPTO ISOLATORS.

This is a safety feature built into a signal path to isolate the equipment from live electricity on the signal line. Typically you find them inside the PLC to isolate the input terminals and the internal systems. The input module connects the input terminals to the rest of the system. The input voltage from the switching device is typically 24 V but manufacturers make them work on a range of voltages included 110V a.c. in some cases.

Opto Isolators allow the status of the input (on or off) to be passed on by use of a light emitting diode and phototransistor. A typical opto isolator is shown.



They have the advantage of reducing the effects of spurious pulses generated from electro magnetic sources. It is also a safety feature to prevent live voltages appearing on the input lines in the event of a fault.