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NEW SOUTH WALES

STAGE 6

ENGINEERING STUDIES

RESOURCES IN CONTROL TECHNOLOGY AND TELECOMMUNICATIONS

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INTRODUCTION

The Engineering Studies Stage 6 syllabus has resulted from an extensive review of the Engineering Science syllabus. Whilst retaining some of the content from the earlier syllabus the new syllabus has been designed to foster approaches to independent learning as well as cooperative learning and with a view toward preparing students for future paths in training and employment. The syllabus has been developed as an application based study of engineering concepts and the profession and content has been updated to reflect changes in engineering practice.

To achieve this, two differently focused types of modules make up the structure of the syllabus – application modules and focus modules. The engineering application modules develop knowledge and understanding of engineering concepts and impacts through the study of engineered products. The engineering focus module develops knowledge and appreciation of the roles of engineers by emphasising a study of the nature of the engineering profession and the scope of engineering activities in a given field.

Modules, such as telecommunications engineering, bring new topics for teachers to present to the student of engineering studies, whilst revised areas of study from engineering science, such as lifting devices, now include new areas of content such as engineering electricity and electronics.

The material included in this teacher centred resource aims to provide some background information relating to the areas of **Control Technology** for inclusion within the modules Personal and Public Transport and Lifting Devices. It also contains some information relating to **Historical Development** and **Engineering Electronics** for the Telecommunication module.

Whilst some of the information presented provides examples not directly related to the syllabus content, it is included to assist teachers in understanding the topic and the range of application of the topic within our technological society.

CONTROL TECHNOLOGY

Basic Principles of Control Technology

One of the most important concepts in the study of technology is that of a **system**. In its most general form a system is a collection of related components which work together to carry out some purpose (eg the railway system).

A **control system** can be defined as a system which can monitor or regulate an operation or process.

Control systems have been of interest to people since ancient times. Humans devised traps with a release mechanism to kill wild animals from 6000 BC.

The connected levers in a pair of tongs can be seen as a simulation of the human grip – hence the term 'simulacra'. The extension of human actions was the system behind early tool construction. A development of this principle is to make the system automatic – hence the term 'automata' from which we get automation. The continuing refinement of systems is the impetus that has led to modern technology.

Historically, huge irrigation systems for riverside cultures are examples of control systems. The river rises, the water is led off in canals starting far up river from the area to be irrigated. The water is gathered in large basins and fed to the crops in times of drought.

Systems such as this were built in Mesopotamia as early as the 4^{th} millennium. The Sumerian engineers eventually developed accurate control for life-giving water. But in the 11^{th} century BC when the Euphrates changed course the system failed, thus contributing to their decline. The Egyptians' mastery of the Nile gave them a strong economy and their advanced culture.

The water clock (clepsydra) became common in Greece between the 4^{th} and 5^{th} century BC. This comprised a basin in a spillway. As water was added to the basin it ran continuously with a reasonably constant flow out of a lower opening and into another graded vessel – thus measuring the passing of time. This device can be regarded as a simulacrum – imitating the constant movement of the heavens which is the basis of our measurement of time.

Plato (427 – 347 BC) designed an 'alarm clock' to waken his pupils, based on the clepsydra. The graded vessel had a bowl in it mounted on a hinge. It contained a number of lead balls which, as the bowl filled, finally rolled onto a copper plate.

Hero of Alexandria, was one of the first people to design a means of controlling the level of water using a floating body which affected the discharge valve. This design is still used today in our cisterns and car carburettor float chambers.

Hero, around 2000 years ago, also invented the screw press, a device for squeezing the juice from grapes to make wine and from olives to make oil. His press had a threaded shaft attached to a wooden block that squeezed the fruit and so allowed great pressure to be applied. In this way, a lot more liquid could be squeezed from the fruit than in the earlier presses. Since those times people have invented innumerable devices that can be classified as 'automatic'.

From the middle ages on, much work was concentrated on clock-making. The famous ornamental clock in Ghaza was a fine example of their advancement. The text of a book by Archimedes still exists today that provides detail to enable the clock to be reconstructed.

Technological progress in the Renaissance led to the construction of life-sized automata where the Alexandrian devices had mainly been model-sized. Popular for the time were scenes with moving figures operated by waterwheels. The movements were triggered by 'programs' consisting of drums and cams. A construction in 1613 in the Hellbrunn Palace at Salzburg was enlarged to 256 figures in decorated caves. A hydraulic organ provided background music to mask the noise of the mechanism.

Jacques de Vaucanson (1709-1782) spent most of his life constructing mechanical devices – some involving 'moving anatomy'. Much of his work found direct application within the growing manufacturing industry. It is significant that, as a director of a silk mill, he improved semi-mechanical looms which laid a foundation for Jacquard's punch-card-programmed fully automatic weaving loom. These were still in use in Australia at least into the immediate post-war period.

Over centuries many attempts were made to produce 'mechanical' humans – androids – but these were very limited in their functions. Other early sensing devices included a temperature regulator by Drebbel in 1610. Another simplified thermostat was patented in 1783. Denis Papin developed a pressure regulator which we know of as the safety valve. It was fitted to Newcomen's atmospheric steam engine. In 1803 Boulton and Watt patented a pressure regulator used with low and high pressure steam engines.

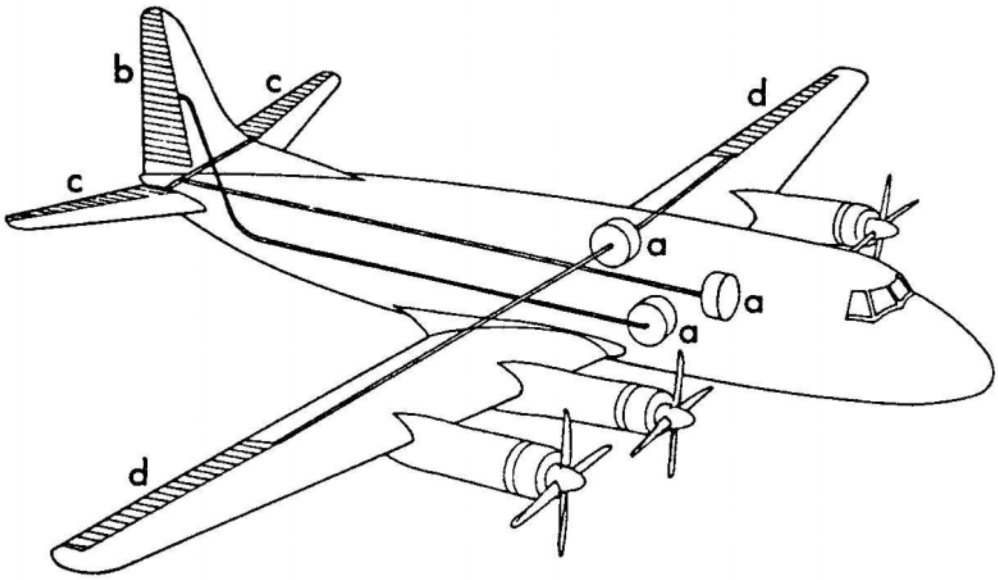
In the 1780s in the USA Oliver Evans produced a flour mill with a minimum operating manpower. This could be considered as the precursor to the fully automated factory. The mill was driven by 3 water wheels, with 6 automatically controlled millstones. Grain and flour were transported by 'Archimedian Screw' conveyors. Mills (wind or water powered) were a source of many 'control' devices.

The centrifugal governor was probably invented by Mead in 1767. Andrew Meikle installed a governor in a mill that was later visited by Mathew Boulton who told James Watt about its operation. James Watt invented an improved and more efficient steam engine which became the main source of power for industry and transportation throughout the Industrial Revolution. In 1769 he also designed a control system for steam engines that controlled the rate of steam entering the piston and thus the speed of the engine, even though the power demands on the engine varied. This became known as the Watt governor.

His governor is considered to be the first feedback controller used in Industrial Processing.

The mechanical amplifier (today the servomotor) was invented in the 1860s to make a very sensitive governor effective in controlling a steam engine. The amplifier comprised a twin piston in a small cylinder that directed steam onto one side of a larger piston, the amplifying factor being the ratio of the two piston areas.

The first flight by the Wright Brothers was in 1903. The first automatic flight control system (autopilot) was tried out in a Curtis flying boat in 1912 – just nine years later! An American engineer, Elmer Sperry, designed the first autopilot. The principle of the autopilot is based on the use of three gyroscopes to sense changes in the aircraft's attitude (roll, pitch and yaw) in each of three planes. The output from each gyroscope was fed to servomotors connected to the control surfaces (elevators, rudder and ailerons) of the aircraft in such a way as to maintain a preset course.



a) gyroscopes b) rudder c) elevators d) ailerons

The Autopilot

The development of electronics in the early 20th century transformed control systems from solely mechanical control to systems with the opportunity of limited feedback. The invention of the transistor in 1948 and the integrated circuit in 1959 advanced the development of control systems and introduced affordable computer technology. Over a relatively short space of time control systems technology has progressed from mechanical and electrical, through electronic systems to computer-based systems.

Computer-Based Systems

A **computer-based system** consists of the hardware, software, data, procedures and personnel which operate as a whole to carry out some function.

Thus a computer-controlled system can be defined as a control system in which the data is captured and processed by a computer in order to transmit signals to actuators which carry out some task within the system.

Control systems may be classified by the method of operation of the system. They may be **continuous** such as security/surveillance systems, steel rolling mills or those controlling a chemical process, **batch** systems such as those controlling bottling or packing processes, or **discrete** systems such as those which control the operation of traction motors in transport or lifting systems.

The main entities involved in a computer control system are sensors, processors and actuators.

Sensors provide input data to a system. They may detect motion, change in pressure, temperature etc, and use some physical property or change in physical property to generate an electrical signal which is transmitted to the computer for processing.

Processors (controllers) receive data from the sensors and feedback from actuators. They process this data according to suitable programs and produce an output. This output is fed to the actuators which create an appropriate response.

Actuators (or effectors) are activated by a signal from the computer. In many cases the actuator is some form of electrical switch which allows power to be turned on, or off, to a device which does a task, eg in a security surveillance system the effector may be a switch which turns on a light and sounds an alarm. In an crane it may be a switch which powers a motor to slew the jib.

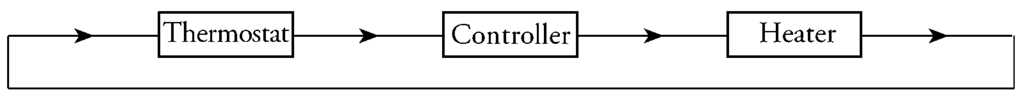
Computer-controlled systems are often represented by **block diagrams** to show the relationships between sensors, the controller and actuators, eg

A system such as that above is called an **open-loop** system. The information received by the sensor from its environment causes it to transmit data to the controller which in turn sends a signal to the actuator which is activated.

An ‘automatic’ washing machine fitted with a water heater which is controlled by a timer is an example of an open-loop system.

The starting of the timer turns on the heater and the stopping of the timer turns off the heater. Water is heated for a set number of minutes.

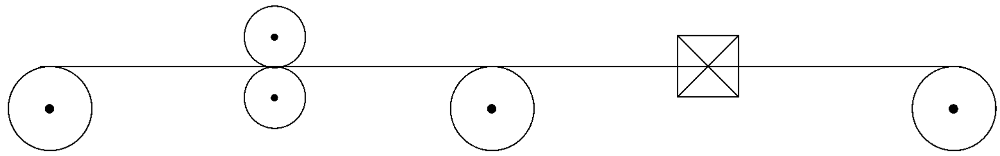
If, however, the action of the actuator produces a change in the information being received by the sensor which in turn causes a change in the operation of the actuator, the system is said to form a **closed-loop**. An example of a closed-loop system is an ‘automatic’ washing machine which is fitted with a water heater controlled by a thermostat.



The turning on of the heater causes information about the temperature of the water to be sent back to the thermostat which in turn sends data to the controller to turn off the heater when a pre-set temperature is reached. This loop is called the **feed-back** loop.

Many computer-controlled systems can be broken down into sub-systems. Each of the **sub-systems** may be open-loop or closed-loop.

Consider this diagram of a steel rolling mill.

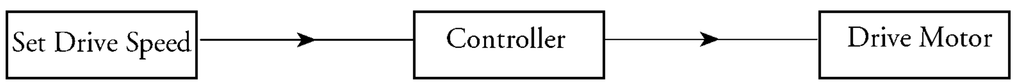


Steel feeds from the unwind reel, through the rollers which control the thickness of the steel and onto the rewind reel.

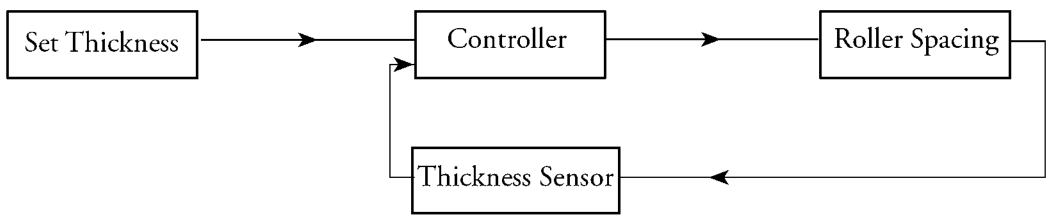
The three sub-systems which cooperate to produce steel sheeting of a set thickness are:

- Drive Speed
- Thickness Adjustment
- Tension Adjustment.

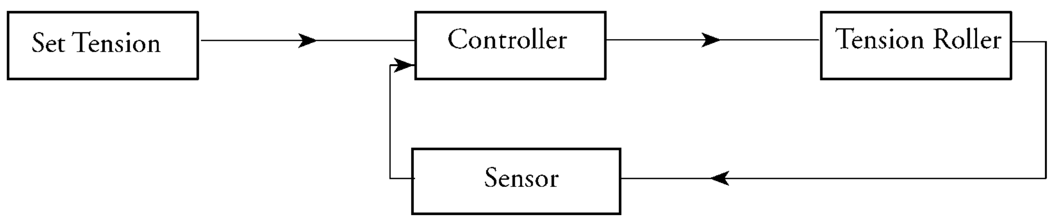
These three sub-systems are illustrated below:



Open-Loop

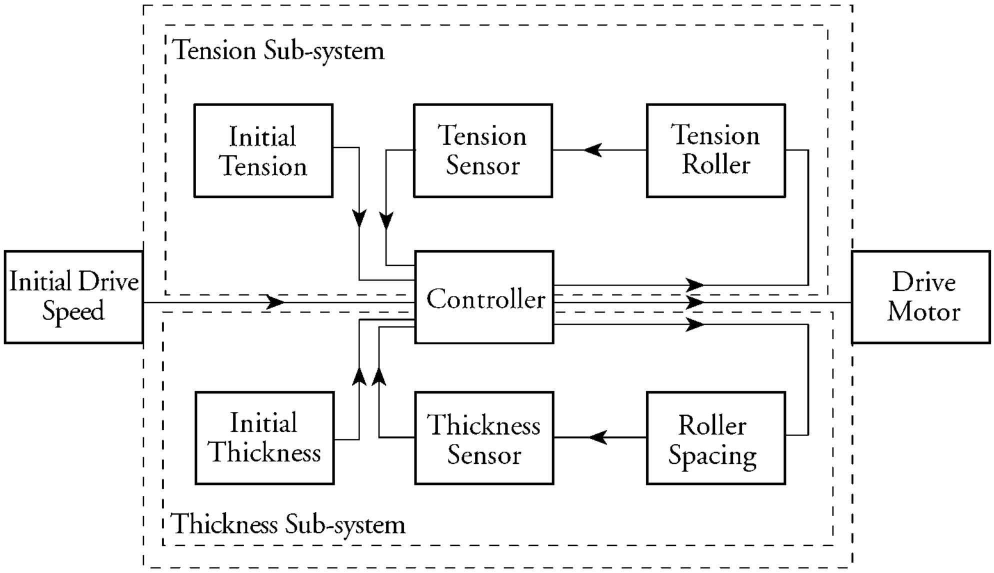


Closed-loop



Closed-loop

If, in fact, the thickness is determined by a combination of the roller spacing, drive speed and tension then the component sub-systems can be represented as:



At one level the rolling mill is an open-loop system in which the drive speed is set and the drive motor operates at that fixed speed.

If the component sub-systems inside the 'controller' are examined there are three separate sub-systems, two of which are **closed-loop** systems even though the total system may be viewed as an **open-loop** system.

These are just some examples of applications of computer-controlled systems.

Applications of Computer-Based Systems:

Computer-based systems have become an integral part of everyday life. In personal transport systems such as the family car computer control systems are used to monitor and control engine performance, they measure and display speed, and they control pollution levels. In devices such as lifts they control the acceleration and deceleration of the lift, and monitor its position within a building to ensure that the lift stops accurately at a given floor.

It is becoming increasingly difficult to distinguish between a computer-based system and a computer-controlled system. If the decision-making process is carried out by a computer, based on data provided by some form of sensor, and the computer provides a signal to some form of actuator to cause an action to take place, then the system can be classified as a computer-controlled system.

It may be useful to consider applications of computer-controlled systems within a number of areas such as:

1. Commercial/Consumer Applications

The EFTPOS (Electronic Funds Transfer at the Point of Sale) has become a major component of society over recent years and is involved in a continually widening network. EFTPOS must be considered to be the largest computer-controlled system in Australia, operating nationally with a multitude of outlets and available cards. When automatic tellers and point of sale are included in the same network, it increases in size dramatically.

EFTPOS was first established in Australia in 1982 on a trial basis and existed as a trial up to 1986. Since that time it has been widely accepted and is in common use by utilities from service stations and supermarkets to the local nursery.

2. Industrial Applications

(a) Robots in Manufacturing

'A Robot is a machine that can easily be directed to do a variety of tasks without human supervision'. (Health, 1985).

Industrial Robots were first designed to perform tasks that were 'dirty, dangerous or difficult'. These three features become known as the 3D justification for Robots. Repetitive functions that require high degrees of accuracy have become the major design features of modern robots.

Industrial Robots are generally classified into three functional groups. These are:

(i) Servo robots, which are motors or mechanisms which adjust or move robots at any given time.

(ii) Non-servo point-to-point robots, which perform single processes at given points without 'feedback' from the unit or input from the controller. An example of these could be found in spot-welding functions.

(iii) Servo-continuous part-robots which operate with the controller (computer) continually sending and receiving information about the position and function of all sections of the robot, eg Mechanical Assembly Robots.

Servo-continuous part-robots perform continuous movements through a variety of points. They can maintain a constant velocity but change direction as required, eg spray painting.

(b) Manufacturing and Product Control

The application of computer-controlled systems in manufacturing and product control has increased in significance due to technological advances and increased speed of information processing. The analysis of material in production lines in the process from raw materials to the finished product enables variations in compositions, compensation for wear of tools, automatic maintenance, and many other processes to be carried out without significant time loss or product wastage.

In computer-controlled manufacturing systems, sensors are major components and they are designed for specific uses and applications. New and varied systems have been refined to ensure greater operational speeds and production efficiency.

3. Entertainment/Education Applications

Multi-media and interactive videos are becoming more widely available in the entertainment field and in education. Multi-media systems include the use of music, narration and digital images, all controlled by a computer system and usually stored via CD-ROM.

In many areas of education and training, packages are now available which manage the total learning process (even if this is only in some limited area). These are usually described as Computer Managed Instruction packages.

In such systems the computer provides the student with a pre-test, processes the student's answers and on the basis of these results determines which resources would best suit the student. The system then selects appropriate lesson modules for the student to undertake and the order in which they should be completed. At all times the computer uses the data generated from the student's responses to monitor and modify the path which the student needs to take through the prescribed material.

Thus, without human intervention, the total teaching strategy is controlled by the computer. It must be noted that, no matter how well the delivery system is controlled by the computer, the efficiency and effectiveness of the learning process is determined by the competence of the human teachers who constructed the package and determined the decision-making criteria which the software follows.

4. Medical Applications

Microelectronic diagnostic equipment is common in most modern health care facilities. There are many computer-controlled systems which measure various aspects of a person's health and so aid in diagnosis. An example of this is the stress test for people who have had heart problems, where a person's vital signs are monitored as they walk a treadmill which gradually increases in speed and angle to the horizontal. There is continual monitoring of a person's blood pressure, pulse rate and rate of respiration as the stress levels increase, so that the efficiency of the heart can be measured and possible further problems diagnosed early.

The control aspect mainly affects the speed and inclination of the treadmill since input from the sensors attached to the human subject is processed by the computer to determine any changes to be made to the speed and/or inclination of the equipment.

The data provided from the sensors about the vital signs can also be processed by a separate program in order to give general diagnostic information to the medical practitioner. Thankfully, the treatment proposed is still under human control.

Computer-controlled techniques now make it possible to take three-dimensional pictures of conditions inside the body. The computer is used to enhance the images of x-rays. The pictures show the full depth, or outline of an object; in this way diagnosis can be more accurate.

Other computer-controlled systems which aid in diagnosis include:

- Computerised Axial Tomography (CAT scan), which produces images of the outlines of soft tissues, eg the brain. It is based on an injection of intravenous contrast medium and a moving x-ray tube, where each scan produces a slice approximately 1cm thick. The positioning of the x-rays is controlled by a computer which also processes and enhances the information into a picture. The computer-controlled system is that which accurately moves the scanner to provide the necessary multiple scans.
- Positron Emission Tomography (PET scan), which allows a similar type of body observation to the CAT scan, and is used to study the brain and coronary arteries.
- Echo Scanning (Ultra-sound), where computers are used to control and translate the minute sounds which are reflected off different organs of the body into a picture that can be analysed.

Discussion of medical applications should also include some of the systems which have been developed to enhance the lives of the disabled. Computer-controlled devices such as the autocue, bionic ear, artificial pancreas, electronic leg, reading machines etc, can be considered.

5. Motor Control Applications

Good examples of motor control in personal and public transport systems can be found through a study of the control systems for traction motors used in electric trains and light railways. Railway locomotives for the Channel Tunnel between France and England have microprocessor controlled induction motors. This system provides accurate control for speed, reliability, and regenerative braking on each train, thus ensuring efficiency of power usage and maximum safety against fire and electrical breakdown.

The overhead catenary wire provides a 25 kV alternating current potential difference with the rail. The locomotive pantograph collects this current and, using a transformer, capacitors and special semiconductor circuits known as thyristor bridges, converts it to 1500 V direct current (dc). The constant voltage supply is then inverted to a 3 phase alternating current supply using specially designed Gate Turn-Off (GTO) thyristors (another form of semiconductor) which is fed to the twelve 465 kW induction motors (total 5.6 MW). The driver controls the motors by providing signals to a microprocessor which varies the frequency of a signal sent to the gates of the GTO thyristors. Changing the gate frequency changes the frequency of the ac supply, and hence the speed of the motors themselves.

The ac induction motors used on these locomotives are of the asynchronous (squirrel cage) type of motor, which is not unlike (in operation) the motors used in some washing machines. Maximum tractive force for acceleration 0–20km/h is 400 kN, reducing to 126 kN at 160km/h. Maximum design speed is 176km/h.

Sensors monitor the wheel speed and compare it to the train's velocity. Any wheel slip during acceleration or braking is compensated for by the control system, thus reducing wheel wear and increasing safety.

A particular advantage of this locomotive drive system is that the instant the brakes are applied, the electronic control system reverses. Energy is produced by the motors (thus assisting the braking process) and fed directly into the overhead supply system. This power is fed back into the national grid for use by other trains and consumers. This is known as 'regenerative' braking. This system makes use of braking energy rather than dissipating it as heat from the brake pads. This reduces electrical power generation, and severely reduces wear on the train's mechanical braking system. Due to practical limits the regenerative braking system is limited to developing 190 kN braking force over the speed range 0–110 km/h. Full braking force is a combination of the electrical braking force and the mechanical braking force.

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Television Programs

Beyond 2000

Quantum

The Elegant Solution (SBS television). A series of 13 television programs in a magazine format, not unlike *Beyond 2000*, that examines numerous engineering marvels, their design and construction and their impact on society.

Journals

Journal, *Information Transfer*, NSW CEG

Journal, *Australian Educational Computing*, Australian Council for Computers in Education

Periodical, *What is New in Process Engineering*, Westmick-Farrow Pty Ltd, Sydney

System Simulations:

Intellecta MITE, Intellecta Technologies Ph: (08) 8351 8288

http://magnify.educ.monash.edu.au/measure/intlhome.html

Department of Education & Training Curriculum Resources

The following publications were produced by the Computer Education Unit and are available from the Curriculum Resources and Marketing Unit, Department of School Education, Small's Rd Ryde 2112:

CEU035	Using the Community as a Computer Awareness Resource
CEU065	An Annotated Bibliography for Computing Studies 7-10 and 11-12
CEU102	Ideas and Strategies for Computing Studies 11-12: Control Systems

Videos

CEU070	Excerpts from *Beyond 2000*
CEU071	Potential Unlimited
CEU072	Robots
CEU082	Bionic Ear-Computer Application Resource: From Pigment to Pixel

Relevant Websites

http://www.tsi.lv/en/getquestion.sql?IQ=61&IC=4

http://www.siemens.ie/Transport/trafficcontrol.htm

http://telerobot.mech.uwa.edu.au/

http://www.cs.uwa.edu.au/~mafm/robot/index.html

http://www.sestechno.com/techno/dcs01.htm

TELECOMMUNICATIONS SYSTEMS

Introduction

Communication is a basic human need through which people share their knowledge and experience. People need to be able to communicate, often beyond face-to-face contact, and there has been an unprecedented technological response to satisfy these needs of the modern world.

The need to communicate faster and more efficiently has become a central focus in our technological society. Closely associated to this is the need to record, disseminate and distribute a multitude of ideas. The vast distances that might separate sources of information and people, not only nationally but globally, have emphasised the significance of a highly technical communications base.

To inform and communicate, many present day systems are used, such as the telephone, television, radio, computer networks and the print media.

Background Information

The communication of visual signals such as fire and light from one post to another has been carried out since ancient times. Early peoples also used sound, produced by a variety of means, to communicate over quite long distances.

Electricity played a vital role in the rapid advance of communication systems. The electrical industry is exceptional in that its birth and development were the direct consequence of scientific research and, moreover, the date of transition from experimental science to useful industry can be fairly accurately established. The key event was the practical demonstration of electromagnetic induction by Michael Faraday, announced to the Royal Society on 26 November 1831. Within a very short time electromagnetic generators were being manufactured commercially. Various developments finally resulted in the production of electricity on a commercial scale and its distribution from power stations. The distribution of electricity facilitated the relaying of electronic signals over large distances. Without this development, communication systems connected with the telephone, television, radio or computer networks would not have been possible.

The rapid improvement in audio visual communication was hastened by the French Revolution. In the 1790s Claude Chappe, a French inventor, focused his energy in developing long-distance telegraphy. He finally introduced a series of relay stations equipped with semaphore arms and telescopes relaying coded messages across France. The development of an efficient long-distance telegraph waited for discoveries in electricity. Using electromagnets, Cooke and Wheatstone (in England, 1837) and Morse (in the US, 1840) developed successful telegraphs. By 1844 Washington was linked by telegraph to Baltimore in the United States. By 1851, there were over 50 telegraph companies in the United States. In Europe, the links also proliferated with the first transatlantic telegraph cable successfully laid in 1866.

Technologies associated with the development of the telegraph paved the way for long-distance audio communication tools, such as the telephone. It was in 1876 that Alexander Graham Bell finally succeeded in speaking and hearing words over a telephone. Later in that year, Bell and his assistant Watson held the first two-way long-distance telephone conversation. They spoke between Boston and Cambridge, a distance of 3 kilometres.

Most of the early pioneers focused on communicating by sending telegraph signals. It was not until 1906 that voice transmission by radio was demonstrated. On Christmas Eve, a station near New York City sent out two speeches, a song and a violin solo. Two years later Lee de Forest sent voice transmission from the Eiffel Tower in Paris and by 1920 the first commercial radio broadcast station, KDKA in Pittsburg, began regular transmission. Six years later television was first demonstrated but commercial broadcasting only started in the late 1940s.

Our modern society has become very dependent on efficient means of communication for conducting our daily affairs. Microwaves, satellites and fiber-optic systems have been developed to respond to the need for greater variety and access to electronic communication channels and systems. The field has become widely known as Telecommunications.

As in many other cases, an increasing number of different technologies are being combined to provide telecommunication of all types. In electronic communication radios are being combined with computers, telephones and video systems. Satellites have added a vast new dimension to global telecommunication techniques and led to a totally new field of study.

All communication systems are founded on similar concepts. This unit covers the basic concepts of telecommunication, including the radio, telephone, and television.

The Radio

Radio is the name given to the system of transmission and reception of information by the propagation of electromagnetic radiation, in this case commonly called radio waves, through space. It is the most significant modern technique for the transmission of information over distances.

Some significant Historical developments

The following were some of the significant developments in radio communication:

- James Maxwell, a Scottish physicist, in 1864, predicted that electro-magnetic energy could travel through space
- Heinrich Hertz, in 1888, succeeded in producing a spark that jumped a predetermined gap and also proved that the spark radiated electrical energy in the form of radio waves
- Marconi developed the antenna, which by 1901 could be used to send coded messages
- the discovery and development of the microphone, the transmitter, the loudspeaker, land and sea cables and satellite transmissions.

Need for Development

In addition to its wide use as an entertainment medium, radio is used for communication where it is expensive or impossible to lay telephone cables between two points. These include communication between:

- aircraft and airports
- ship and ports
- police vehicles and headquarters
- explorers and their base
- spaceships and earth.

Scientific and Technological Principles Involved

Sending and receiving by radio involves three essential elements: the transmitter, the channel and the decoder. The transmitter changes the sound signals supplied by the microphone or tape recorder into electromagnetic waves which move with the speed of light. These waves are then radiated by the transmitting antenna through what is commonly called a channel. Before the sound can be heard by the human ear, the electromagnetic waves must be changed back to sound waves by the receiving radio.

The electromagnetic waves picked up by the radio are used to generate a signal that activates a loudspeaker which reproduces the sound originally produced by the microphone.

The Processes Involved in the System

The processes of using radio communication comprise:

1. Encoding data

Before a message can be communicated, it must be put into a form that can be easily transmitted. In radios, the microphone changes acoustical energy into electrical energy so that it can be transmitted through the air.

Sound in the microphone causes the background electrical current in the microphone to alter. The current from the microphone is mixed with the carrier signal from the transmitter (modulation) and the combined signal is beamed out by the transmitter.

2. Transmission of the data

The Radio Transmitter sends messages into the air at a specific frequency in the spectrum. All radio frequency electromagnetic signals change polarity on a regular basis and this polarity change defines the frequency.

An important component of the transmitter is the oscillator, which produces electrical signals which can be amplified and are then transmitted. One type of oscillator is the crystal oscillator, where the heart of the oscillator is a specially shaped quartz crystal that resonates or vibrates strongly at a particular frequency.

All radio waves have three basic characteristic properties:

- frequency
- wavelength
- amplitude.

In its simplest form the properties of a radio wave can be illustrated by visualising water waves. The following are important features of frequencies of radio waves:

- frequencies are measured in cycles per second
- one cycle per second is called one hertz
- radio signals with low frequencies are called long wavelengths (LW)
- radio waves with high frequencies are called short wavelengths (SW).

Radio waves are part of the electromagnetic spectrum. The 'peaks' and 'troughs' of different radio waves vary in height (amplitude) and length (wavelength), but are constant for a particular wave. Features of wavelength are:

- variations in length from 1,000 kilometres to only 1 millimetre
- transmitters send out radio signals of different wavelengths so that one program does not accidentally mix with another
- the different sets of radio waves used by broadcasting stations are designated SW, MW, LW depending on the radio wavelength.

AM stands for amplitude modulation, a broadcasting method where the **amplitude or strength** of the waves is changed to match changes in the audio-frequency waves. FM stands for frequency modulation, a method in which the frequency of the waves is changed to match changes in the audio-frequency waves.

3. The channel, route or medium which the message takes

In radio communication, information is sent through space from a transmitting antenna to a receiving antenna. The channel is that portion of the electromagnetic spectrum used, in space, between the transmitter and the receiver. Since transmitters use different frequencies, many signals are transmitted by different transmitters at the same time. The process of radio waves passing through the air is called propagation. The waves travel at a speed of about 300 million metres per second. Radio waves in the 540 to 1600 kHz frequency range may travel from the transmitter to a radio receiver by three ways:

- direct waves (waves that travel straight through the atmosphere to the receiver)
- sky waves (waves that are reflected from the ionosphere, a charged layer of the atmosphere)
- ground waves (waves that travel along the ground).

4. Decoders

A radio can be tuned to a particular frequency (channel or station) to pick up specific signals. At the receiving end, the radio waves are demodulated into electrical signals which pass into loudspeakers where the varying electrical current is converted back into acoustic waves (decoded).

The conversion of radio waves to audible sound involves the following:

- the interception of the radio waves by the receiving antenna
- waves broadcast by radio stations within the receiver's range strike the antenna and induce currents, which flow to the receiver
- only the waves of the desired station are amplified and demodulated
- the blocking and selection of the signals on the appropriate frequency is done by a detector circuit
- the weak signals from the antenna need to be strengthened by power amplifiers
- power amplification also magnifies noise that is combined with the signal (Noise is unwanted electrical interference in the signal. This could be interference from an electric machine or closely packed broadcasting stations straying into the field of reception, or from electrical storms or electricity wires nearby.)
- the higher the signal-to-noise ratio, the clearer the resulting sound.

5. The Loudspeaker

- electrical currents pass into the loudspeaker where they are converted into sound waves
- the basic parts of a speaker are a magnet and a coil of wire called the voice coil
- the voice coil is attached to a cone, usually made of paper, which vibrates in time with the electrical signals flowing through the coil
- the cone's vibrations create sound waves like those that originally went into the microphone.

The Telephone

Technologies associated with the development of the telegraph paved the way for long-distance audio communication tools, such as the telephone. Alexander Graham Bell stated the principle of telephone transmission as follows:

'If I could make a current of electricity vary in intensity precisely as the air varies in density during the production of sound, I should be able to transmit speech telegraphically'.

With modern telecommunication systems it is possible to speak to someone in almost every country. The telephone systems spanning the world consist simply of a number of telephone systems connected to a switching centre or exchange. Local exchanges link up to regional and international networks. The growth of widespread telephone use was initially slow. The number of telephones grew to connect more and more people over wider areas. By 1900 there were about 13 million telephones in the United States. When Bell died in 1922 all telephones where shut down for one minute as a token of respect.

With the development of the silicon chip, information of many different types such as music, television programs and computer data, can be transmitted through the telephone network.

Transmission of telephone messages has undergone remarkable changes because of modern technological advances. Two of the most significant technological advances which have dramatically changed the role of the telephone network are the satellite and optical fibres.

Television

The first successful television transmissions were carried out by John Logie Baird between 1928 and 1935, using the BBC's medium wave transmitters. His work was based on the principles developed by Nipkow in 1884 who evolved the method of sequentially scanning an object. The world's first high definition service, using 405 lines, was launched in 1936 from Alexandra Palace in North London. Television programs using 625 and 405 lines later facilitated the international exchange of programs.

The technique of dividing a picture into very small elements is used in creating pictures in television. Information about the degree of grey (or brightness) of each element is sent to the receiver where it is used to build up a reproduction of the original scene. In television, visual information is converted into electronic signals. It is similar to radio communication except that the kind of information transmitted is different.

Since those first pioneer days of television, technology has moved strongly ahead to give the world colour television, and, through satellites, the transmission of live pictures over vast distances.

The system basically consists of:

- the camera which serves as the encoder and is also part of the transmitter. It converts a picture into electrical (video) signals. A microphone encodes the audio signal just as in radio transmission.
- a mechanism which either stores or transports the video signals and serves as the channel. This can occur via direct cabling (closed circuit TV), by television cable, over the air by using television transmitters, or manually by physically transporting the video on recorded videotape.
- a monitor which decodes the video into visual images on a screen.

Computer Networks

Computer technology is responsible for causing great leaps forward in telecommunication technology. Like other technological systems, computer systems have inputs, processes and outputs. The input devices provide command inputs and information inputs. The computer's processor acts on the information resources in response to the command input. The output of the system is the processed data. Feedback may be provided by a person, or automatically through hardware or software. Feedback is used to modify the process in order to get the desired result.

The output of computers can be sent to other computers, or terminals located at a distant location. This kind of information exchange is called data communication and a modem is often used in this exchange. This unit can be studied with special reference to:

- on-line computer networks
- electronic mail
- computer-aided design
- desktop publishing
- computer-aided manufacturing.

Resources/Excursions

Radio Broadcasting Stations

Television Stations

Optus Satellite Earth Station

Electricity Technology Advisory Centre

Computer Companies

Powerhouse Museum

Local Museums

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Television Programs

Beyond 2000

Quantum

The Elegant Solution (SBS television). A series of 13 television programs in a magazine format, not unlike *Beyond 2000*, that examines numerous engineering marvels, their design and construction and their impact on society.

Relevant Websites

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http://microstructure.copper.org/

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http://www.howstuffworks.com/satellite.htm

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ENGINEERING STUDIES – OTHER RELEVANT WEBSITES

Engineering Materials

http://www.mdacomposites.org/

http://www.matweb.com/

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