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EXCELLENCE IN BROADBAND®

An Introduction to Broadband

Working for the Benefit of the Broadband Industry

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Welcome to the SCTE Manual

This handbook is designed as a stand-alone reference manual for those working in the broadband telecommunications industry. It is an adjunct to the SCTE "An Introduction to Broadband" course and intended to act as a reminder document for those who have attended the course.

We hope you and your career benefit greatly from this handbook and the associated training course. Please consider joining the SCTE and taking advantage of the benefits that come from being part of the industry's foremost technical institution.

About the SCTE

Founded in 1945, the SCTE is a non-profit making organisation, managed by an Executive Committee of elected volunteers, whose aim is to raise the standard of broadband engineering in the telecommunications industry. The Society particularly concerns itself with the training and career advancement of technical professionals in this field.

First introduced in 1994, the SCTE training courses have achieved wide acceptance as the standard for young technicians wishing to enter the field of cable telecommunications and for those wishing to advance their knowledge and career prospects. They are used in-house by a number of operating companies and SCTE engineers can be found working in a variety of international organisations.

As a Learned Society, SCTE is able to provide accreditation and certification for its members, giving them professional standing within the industry. Full Members and Fellows are allowed to use the designations MSCTE and FSCTE after their names whilst Technician Members may use TMSCTE. There are also categories for Student and Associate Members which carry the designations SMSCTE and AMSCTE respectively.

Copyright & Acknowledgements

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Section One

This course is intended as a primer for non-technical staff.

Engineers love to use technical terms to baffle or show off. These course notes will help you to refresh yourself with the course you have just attended and to offer you some useful information to use in the everyday interactions with the engineers in your company.

1.2 A brief history of communications - what is it all about?

Communication takes many forms. It may be as a point to point exchange of information (such as two people talking to each other), a broadcast communication (such as a football match on free to air television) or in variants of both where privacy or restricted access for commercial reasons is necessary.

Nearly all communication devices and networks will need to have a means of taking input or providing output that will be in a form that we as humans can recognise. This, in the first instance, is sound and vision.

Sound is a series of pressure waves at varying frequencies in the air that the human ear can respond to producing a smooth continuous stream of impulses for the brain to understand. Equally, vision receptors in the eye turn a wide range of different light frequencies into perceived colour and form. In both cases, the information received is in a continuously varying form and is thus described as an analogue representation of the original. It is as close to an exact reproduction as possible.

The transmission of analogue signals across communication networks is very well understood but, unfortunately as there are no 'perfect' networks, the signals will progressively degrade the further they travel. For speech on the telephone networks this limitation may be many thousands of kilometres, whereas for analogue television signals the limitation is much less, being a few hundred kilometres at best.

Before the discovery of the means of using electrical circuits to carry communications, various techniques were developed to transmit messages over long distances that mostly relied on turning the message into a simple code that could be easily identified at a distance. The semaphore flag signalling system is an alphabet signalling system based on the waving of a pair of hand-held flags in a particular pattern and was widely used in the navies of the world well into the beginning of the 20th Century.

With the development of the voltaic battery, long range electrical telegraph networks were developed using various methods of interrupting or varying the current to convey messages. The most well-known is the Morse Code whereby each letter in the alphabet is represented by a series of 'short' or 'long' electrical impulses, which in today's terminology would be described as '0's and '1's. In Morse Code, the letter 'A' consists of a short impulse followed by a long impulse which in today's digital world would be 01 for example. In these types of transmission networks, it is very easy to recognise and reproduce the original signal exactly leading to, effectively, lossless transmission regardless of the circuit length.

In the 1980s, the development of high speed electronic circuitry made it possible to measure (or sample) the value of an analogue signal very accurately and very quickly and to present the result as a digital number, ie a series of '0's and '1's. This process is called digitisation. Because the sampling consists of

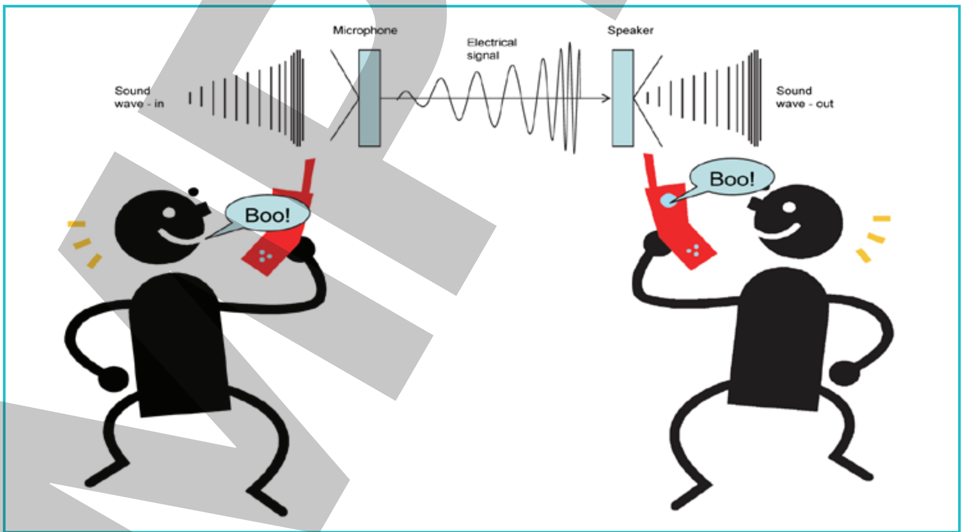
measurements spaced a short time interval apart, the actual representation of the original analogue signal is only an approximation, but if the sampling rate is fast enough, then the difference is imperceptible.

Digitisation has another advantage. Using modern fast processing techniques, it is possible to inspect the digital data flows and to compress the information stream by removing repetitive sequences of '0's and '1's so that more than one set of signals may occupy a common transmission path at the same time, thus providing a degree of transmission efficiency that creates modern multi-channel digital networks.

To enhance security, the signals may be encrypted in some manner so as to make them understandable only to the parties involved in the communication.

1.3 Phone, TV and other signals

To allow such information to be carried beyond human range, we use devices called transducers. This might be a microphone for sound or a camera for vision, to create analogue electrical signals that can be transmitted to a distant device, a loudspeaker or a TV screen, for example, to recreate the original.

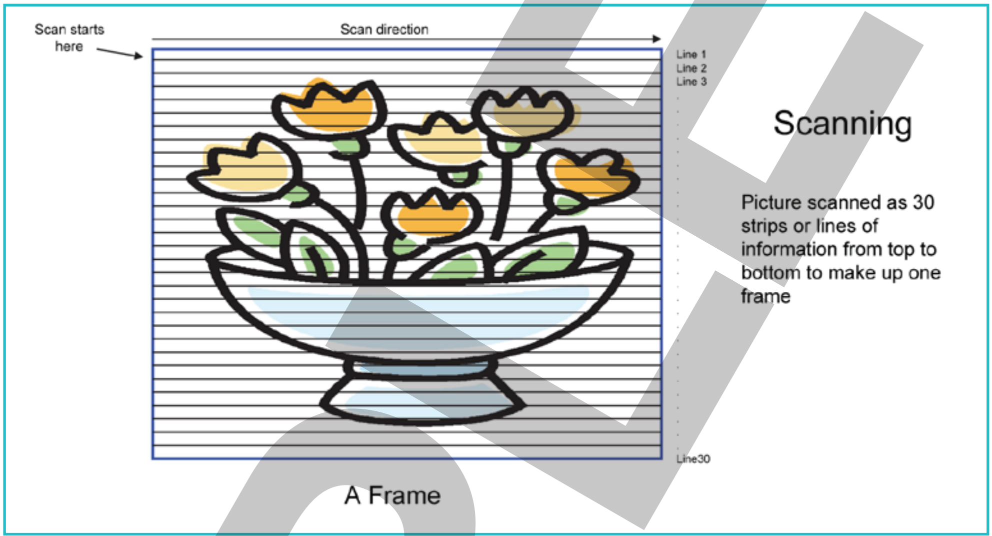


When you speak into the telephone several things happen at once. As air passes over the human vocal chords, the airflow is pinched or modulated into a series of repetitive bursts which we call sound waves as in the diagram above.

The microphone converts these sound waves into electrical voltage signals which travel along a cable to the loudspeaker at the far end, where the reverse process happens.

For television signals the issue is more complex for the TV image, as it is generally two dimensional. Converting the image into a transmittable electrical signal is done by a process called scanning, whereby the picture is broken up into a series of strips of information that can be sent one after the other and then reassembled at the display screen to rebuild the original image.

If this is done sufficiently quickly, the human brain will perceive the original image. There are two processes at work here. The image is initially scanned from side to side starting at the top and in a series of strips better known as lines. Original analogue TV had 405 lines from top to bottom and modern HD pictures may have over 1,000. Once the whole picture or frame has been scanned, the process then repeats again starting from the top. Provided the rate at which the frames repeat is greater than about 25 frames per second,



the displayed image will apparently move to the human eye without any flickering.

This overall effect is called persistence of vision. The picture here shows the principle.

In this simple example the picture is broken into 30 lines, with each line being scanned from left to right starting at the top left hand corner, scanning the image across to the right and then dropping down a line and repeating until the whole frame is scanned. With so few lines, the reproduced image would be very low resolution but the principle remains the same in a modern TV picture.

Plainly if there are 1,000 plus lines to be scanned for each frame and 25 or more frames must be sent each second, the quantity of information being sent is very much more than that for a simple voice conversation. This introduces the concepts of bandwidth and frequency.

A single note on a guitar, say, the top ‘E’ string vibrates back and forth when plucked about 330 times a second, technically described as a frequency of 330 Hertz. The Hertz unit is named after the notable 19th century German physicist, Heinrich Hertz.

The human ear can hear frequencies up to about 12,000Hz, although this reduces with age. This range of frequencies could be described as the bandwidth of the human ear. For convenience the mathematical expression is reduced to 12kHz where the letter k (kilo) is used as shorthand for 1,000. Similarly the letter M (Mega) is used for 1000,000 and G (Giga) for 1,000,000,000. A TV picture as produced in the studio camera will have a bandwidth in hundreds of MegaHertz.

Thus we have generated electrical signals ready for dispatch. In the first instance, this will be via a cable to connect our programme and other sources to our customers.

Section Two

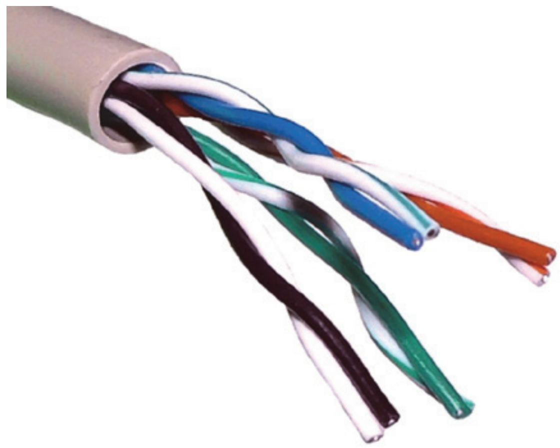
Metallic cables have been around since the beginning of the communications age in the early 1830s. Those used to connect equipment together for the carriage of sound, vision or data information will generally fall into two groups.

2.1 The two wire line

Early telegraph and phone lines consisted of a circuit 'pair' of two wires, generally copper, with some insulating medium between and around them to make sure the current flowing should reach its destination with as little loss as possible. The simplest form of this is the classic telegraph pole configuration with bare copper wires held up and apart in the air, air being a very good insulator. The picture here shows an example of this.

Circuits of this type can work well and are capable of carrying voice and telegraph messages for very considerable distances, however, this is a clumsy and expensive way to operate a lot of individual circuits and is difficult to manage within a building. Various materials became common to use as an insulating medium to form around the wire to permit the wire to be held much more closely and compactly together, as is the case in a modern multipair cables.

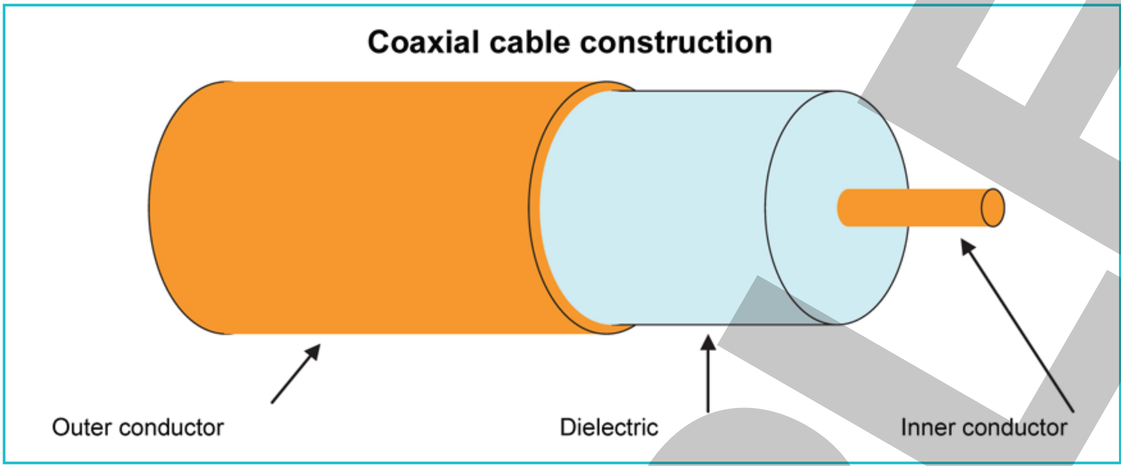
Here we see a common image of such a cable used for voice and data, the individual pairs being twisted around one another for ease of identity and to keep signal leakage between pairs under control.



The twisted pair does have one significant drawback, however, which is its relatively low bandwidth capability. This is because as frequency rises both the losses and resistance to interference deteriorate significantly. For low bandwidth voice this is not an issue but for data, such as common local area network ethernet or the relatively high bandwidth for TV signals, range is restricted to around 100 metres or less. It is possible to regenerate the signals at these limits, but it is not common to do so and rarely practical.

2.2 Coaxial cables

As the name infers, the two conductors in a coaxial cable share a common axis. Such a cable is shown overleaf in an idealised form.



Here the signal travels in the contained space between the inner and outer conductor and is effectively shielded from causing or suffering from interference by the outer conductor.

These cables are capable of carrying high bandwidth signals for many hundreds of metres and are suited to the use of amplification to recover them for further onwards transmission for several kilometres, that is, with the right choice of cable.

2.3 Hybrids

When voice (telephony) and television services are delivered together, it is sometimes done using the advantages of both of the above types, ie the long range of relatively robust and low cost twisted pairs, together with bandwidth efficiency of coaxial, in a hybrid design. Such a cable is shown below in end view. It is generally known as a Siamese Cable and is commonly used in the customer drop cable running into the home from street side distribution points or cabinets.