

Unit 11: Telecommunications Principles

Unit code: J/601/3295
QCF Level 2: BTEC Specialist
Credit value: 7
Guided learning hours: 60

Aim and purpose

This unit provides knowledge of the basic principles underpinning telecommunications including the electromagnetic spectrum, circuits and transmission lines, transmission of binary information, analogue and digital signals and multiplexing.

Unit introduction

Telecommunications have developed rapidly from a simple circuit switched network into the current 21st century broadband network capable of carrying a wide range of multimedia applications. Technological innovations in fibre optics have led to the construction of vast networks at a lower cost to the user. The use of cellular and wireless technologies (3G) along with the development Asymmetric Digital Subscriber Line (ADSL) techniques has resulted in the majority of people being able to access the new networks from their own homes. This unit introduces learners to some of the basic concepts, terminology and methodologies of telecommunications systems and telecommunications networks.

Most of the content is based on the use of digital techniques and signals that continue to supplement or replace analogue techniques. Practical work should be used to reinforce learners' understanding of concepts and theory.

The unit starts with learners gaining an understanding of the electromagnetic spectrum and how it is used for communications. It then looks at telecommunications circuits and the way in which binary information is transmitted. This leads into the problems of converting analogue signals into digital signals, and the problems of multiplexing the signals.

Learning outcomes and assessment criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria determine the standard required to achieve the unit.

On completion of this unit a learner should:

Learning outcomes	Assessment criteria
1 Understand the electromagnetic spectrum as applied to telecommunications	1.1 describe the physical properties of electromagnetic radiation and the relationship between frequency and wavelength 1.2 list the principal bands of the electromagnetic spectrum and their associated frequencies and wavelengths 1.3 identify the main telecommunications applications of electromagnetic radiation
2 Know the relationship between telecommunication circuits and transmission lines and their effect on a digital signal	2.1 identify the circuit properties (resistance, capacitance, inductance and leakage) of alternating current (AC) circuits and describe their effects on transmission lines 2.2 design an equivalent circuit model of a transmission line using the primary line constants 2.3 describe characteristic impedance in transmission lines including open circuit, short circuit and matched termination
3 Know how binary information is transmitted as a digital signal	3.1 describe the properties of digital signals including frequency, mark space ratio and triggered timing 3.2 describe the advantages of digital signals in terms of regeneration, accuracy and recovery 3.3 explain why digital signals need to be modulated onto an analogue carrier 3.4 use keying to demonstrate how a digital signal is modulated onto an analogue carrier
4 Understand how an analogue signal is converted to a digital signal	4.1 identify different ways of converting an analogue signal to a digital signal 4.2 describe linear and non-linear forms of encoding 4.3 calculate signal to noise quantisation errors 4.4 explain aliasing in telecommunications terms and how it can be overcome 4.5 explain the use, and limitation, of the Nyquist rule in signal sampling
5 Demonstrate an understanding of signal multiplexing	5.1 describe the following methods of signal multiplexing: <ul style="list-style-type: none"> • frequency • synchronous time • asynchronous time

Unit content

1 Understand the electromagnetic spectrum as applied to telecommunications

Electromagnetic radiation: physical properties, the wave model, $v = f\lambda$

Electromagnetic spectrum: principle bands and wavelengths, radio, microwave, infrared, visible, ultraviolet, X-rays and gamma rays

Applications: microwave, satellites, GPRS, 3G, wireless internet access, optical fibre (multi-mode, single mode), radio and television broadcasting

2 Know the relationship between telecommunication circuits and transmission lines and their effect on a digital signal

Alternating current (AC) circuits: resistance, capacitance, inductance and leakage, effects on transmission lines

Equivalent circuit models: Thevenin model, Norton model

Characteristic impedance: open circuit, short circuit and matched termination

3 Know how binary information is transmitted as a digital signal

Digital signals: properties, frequency, mark space ratio and triggered timing; advantages, regeneration, accuracy and recovery

Modulation: reasons for modulation; keying, phase shift, frequency shift, amplitude shift

4 Understand how an analogue signal is converted to a digital signal

Digital – analogue modulation: two-state signals, binary, bits, pulse amplitude modulation, digitisation, pulse code modulation, encoding/decoding (linear and non-linear), synchronisation; signal to noise quantisation; aliasing, problems and solutions; Nyquist rule, uses and limitations

5 Demonstrate an understanding of signal multiplexing

Multiplexing in telecommunication networks: mesh connections; multiplexing/de-multiplexing eg space, frequency, time division hierarchies; analogue and digital networks eg dial-up, leased line services, contention based, mobile

Methods of multiplexing: frequency, synchronous time, asynchronous time

Essential guidance for tutors

Delivery

This unit is designed to develop the underpinning knowledge and skills of learners in the fields of telecommunications systems and computer networking.

Delivery of the theoretical aspects should focus on the most up-to-date technology available, including all the latest developments in mobile communications such as third generation technology.

The practical aspects of the unit should be opportunities to use the main technologies listed in the unit content, such as 3G hardware and fibre optic technology. Ideally, the tutor should try to secure as many of these technologies as is feasible. For those that the centre cannot provide, it is recommended that the tutor tries and sources outside examples of this form of technology to demonstrate to learners.

In addition to the practical element, it may be useful for learners to have some input from an IT communications technology specialist who can give an insight into career progression within this sector, as well as providing up-to-the-minute technical knowledge that learners can draw on.

Topic and suggested assignments/activities and/assessment
Introduction to the unit
<p>Understand the electromagnetic spectrum as applied to telecommunications:</p> <ul style="list-style-type: none"> • whole-class exercise – tutor presentation on the electromagnetic spectrum, properties and principle bands, followed by directed research • whole-class exercise – tutor presentation on the use of the electromagnetic spectrum in telecommunications, followed by directed research
Assignment 1 - On the right wavelength
<p>Know the relationship between telecommunication circuits and transmission lines and their effect on a digital signal:</p> <ul style="list-style-type: none"> • whole-class exercise – tutor presentation on alternating current(AC) and AC circuit properties, followed by individual exercises • whole-class exercise – tutor presentation on equivalent circuit models, followed by practical exercises • whole-class exercise – tutor presentation on characteristic impedance, followed by individual exercises
Assignment 2 - Transmission, the basic facts
Assignment 3 - A super model
<p>Know how binary information is transmitted as a digital signal:</p> <ul style="list-style-type: none"> • whole-class exercise – tutor presentation the properties and advantages of digital signals, followed by individual exercises • whole-class exercise – tutor presentation on modulation, followed by directed research.
Assignment 4 - Why go digital?

Topic and suggested assignments/activities and/assessment
<p>Understand how an analogue signal is converted to a digital signal:</p> <ul style="list-style-type: none"> • whole-class exercise – tutor presentation on types of digital – analogue modulation, followed by directed research • whole-class exercise – tutor presentation on signal to noise quantisation and aliasing, followed by individual exercises
<p>Assignment 5 - The key to the solution</p> <p>Assignment 6 - A bit of error creeps in</p> <p>Assignment 7 - Alas an alias causes problems</p>
<p>Demonstrate an understanding of signal multiplexing:</p> <ul style="list-style-type: none"> • whole-class exercise – tutor presentation multiplexing, followed by directed research
<p>Assignment 8 - Multiple multiplexing methods</p>

Assessment

It is suggested that this unit is assessed using the eight assignments summarised in the Programme of suggested assignments table.

Finding a scenario which covers all aspects of all criteria is difficult, but the one suggested in the programme of suggested assignments table is acceptable. It may be appropriate to use prepared exercises to provide evidence for some of the criteria in this unit, but it is recommended that where possible these exercises be set in a vocational context. These exercises could be included in one or more assignments to be completed to a deadline, but centres are advised that timed tests or examinations would be outside the scope of the unit, which does not require calculations to be completed against the clock.

Any exercises used must be assessed by the tutor against the relevant criteria in the learning outcomes and assessment criteria table, informed by the range of unit content and must not be marked in terms of numerical (eg x/10) or percentage achievement. Where the unit content asks for a particular set of calculations to be completed, then all calculations must be completed successfully and it is expected that workings be shown where appropriate. Care must be taken that activities are completed individually and that there is no scope for the sharing of answers between learners.

All of the learning outcomes could be assessed in a similar way, with learners producing material for technical audiences specified either by learners or the tutor.

There are several acceptable ways in which learners might present the assessment material. Learners should be encouraged to vary their work and use a variety of different methods. These could be decided on by the learner or set by the tutor.

Some of the criteria could be assessed by learners being observed when undertaking practical tasks or giving oral presentations. In which case, tutors must keep comprehensive documentation to support the assessment process.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass criteria in the outcomes and assessment grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment methods
1.1, 1.2, 1.3	On the right wavelength	<p>A company asks you to provide training material that describes the use of the electromagnetic spectrum in telecommunications.</p> <p>The material should be suitable for someone who is new to the industry and should explain what electromagnetic radiation is, which parts of it are used for telecommunications and by which devices.</p>	<p>Web pages.</p> <p>Presentation.</p> <p>Posters.</p>
2.1, 2.3	Transmission, the basic facts	<p>The company asks you to prepare a presentation on the characteristics of transmission lines.</p> <p>The presentation must include information about:</p> <ul style="list-style-type: none"> the effects of AC current on transmission lines characteristic impedance in transmission lines. <p>The presentation should be suitable for training new employees.</p>	<p>Web pages.</p> <p>Presentation.</p> <p>Posters.</p>
2.2	A super model	<p>Your supervisor asks you to demonstrate your understanding of equivalent circuit models by producing a design based on the specifications of a given transmission line.</p>	<p>Brief report with a circuit diagram.</p>
3.1, 3.2	Why go digital?	<p>The company asks you to prepare a presentation on the topic of digital signals.</p> <p>The presentation must include information about:</p> <ul style="list-style-type: none"> the properties of digital signals the advantages of digital signals. 	<p>Web pages.</p> <p>Presentation.</p> <p>Posters.</p>

Criteria covered	Assignment title	Scenario	Assessment methods
3.3, 3.4, 4.1, 4.2	The key to the solution	<p>Your supervisor asks you to demonstrate your understanding of modulation.</p> <p>You are asked to produce a report with a series of annotated diagrams to explain the process of modulation by keying digital signals.</p> <p>The report should include a brief discussion of modulation methods, including linear and non-linear encoding, and an explanation of why modulation is needed.</p>	Illustrated report.
4.3	A bit of error creeps in	<p>Your supervisor asks you to demonstrate your understanding of quantisation errors.</p> <p>You are asked to produce a brief report that explains how quantisation errors occur.</p> <p>The report must include a set of error calculations based on figures given to you.</p>	Brief report. Mathematical calculations.
4.4, 4.5	Alas an alias causes problems	<p>The company asks you to prepare a presentation on the topic of aliasing.</p> <p>The presentation should be suitable for training a new employee and must cover the problem of aliasing during signal sampling and how the Nyquist rule is applied to help overcome the problem.</p>	Web pages. Presentation. Posters.
5.1	Multiple multiplexing methods	<p>You are asked to produce a concise, illustrated guide to multiplexing.</p> <p>The guide must show the similarities and differences between frequency, synchronous time and asynchronous time multiplexing.</p>	Web page. Poster.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC in IT sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
	An Introduction to Telephony Systems	Telecommunications Principles
	Telecommunications Technology	Telephony Voice Systems Operation
		Communication Technologies
		Telecommunication Systems

This unit maps to some of the underpinning knowledge from the following areas of competence in the Level 2 National Occupational Standards for IT and Telecoms Professionals (ProCom):

- 4.7 Systems Design
- 5.1 Systems Development
- 5.3 IT/Technology Solution Testing.

Essential resources

Learners will need access to practical resources and suitable technology. They can also use simulators or multimedia tools to gain experience before handling 'live resources'.

Employer engagement and vocational contexts

There is a range of organisations that may be able to help centres to engage and involve local employers in the delivery of this unit, for example:

- Learning and Skills Network – www.vocationallearning.org.uk
- Local, regional business links – www.businesslink.gov.uk
- National Education and Business Partnership Network – www.nebpn.org
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm
- Work experience/workplace learning frameworks – Centre for Education and Industry (CEI University of Warwick) – www.warwick.ac.uk/wie/cei

Indicative reading for learners

Textbooks

Dodd A — *The Essential Guide to Telecommunications –4th edition* (Prentice Hall, 2005)
ISBN-10: 0131487256 ISBN-13: 978-0131487253

Goleniewski L — *Telecommunications Essentials – 2nd edition* (Addison Wesley, 2006)
ISBN-10: 0321427610 ISBN-13: 978-0321427618

Plevyak T, Sahin V - *Next Generation Telecommunications Networks, Services, and Management* (IEEE Press Series on Network Management) (WileyBlackwell, 2010) ISBN-10: 047057528X ISBN-13: 978-0470575284

Websites

www.allaboutcircuits.com

www.doctrionics.co.uk/signals.htm

www.its.blrdoc.gov/fs-1037

Functional Skills – Level 2

Skill	When learners are ...
ICT - Finding and selecting information	
Use appropriate search techniques to locate and select relevant information	preparing presentations and training material
Select information from a variety of sources to meet requirements of a complex task	preparing presentations and training material
ICT - Developing, presenting and communicating information	
Combine and present information in ways that are fit for purpose and audience	preparing presentations and training material
Mathematics - Analysing	
Apply a range of mathematics to find solutions	calculating quantisation errors