Unit 144: Telecommunications Principles

Unit Code: D/601/3254

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 80

Aim and Purpose

This unit provides knowledge of further principles underpinning telecommunications including alternating circuits, line impairments, transmission line characteristics, transmission of digital signals, modulation 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.

Most of the unit 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 AC circuits and then moves on to telecommunications circuits and the way in which binary information is transmitted. Learners will look at the characteristics of transmission lines and become familiar with calculations based on those characteristics.

This leads into the problems of encoding systems, converting analogue signals into digital signals, and of multiplexing the signals.

Learning outcomes

On completion of this unit a learner should:

1 Understand the principles of alternating currents (AC) circuits

2 Understand the effects of line impairments on a transmitted signal

3 Apply the characteristics of transmission lines

4 Understand the transmission of digital signals over transmission media

5 Understand the process of modulating an analogue carrier frequency using digital signals

6 Be able to apply the process of multiplexing digital and analogue signals over transmission media

Unit content

1. **Understand the principals of alternating current (AC) circuits**

   Reactance: capacitive, inductive, phase relationship

   Impedance: Ohm's law substitution, complex representation, phasors; impedence in resistors, capacitors, inductors

   Resonant circuits: inductor-capacitor (LC) circuit; series and parallel LC circuits, resonant frequency calculations

2. **Understand the effects of line impairments on a transmitted signal**

   Decibels: dB and dBm, signal to noise ratio calculations, signal loss calculations

3. **Apply the characteristics of transmission lines**

   Primary line constants: resistance (R), inductance (L), capacitance (C), conductance (G); effects of RLCG on characteristic impedance

   Transmission line calculations: frequency and angular frequency; characteristic impedance for finite and infinite line lengths, a parallel pair of wires, co-axial cable; equivalent circuit models using resistance, capacitance and inductance; bandwidth, half power point/cutoff frequency

4. **Understand the transmission of digital signals over transmission media**

   Encoding systems: non-return to zero (NRZ), synchronisation requirement, uni-polar NRZ, bipolar NRZ; return to zero (RTZ); bi-phase encoding (Manchester, Differential Manchester)

   Signal impairments: bit rate and bit error rate (BER), delay, jitter, binary errors, limited bandwidth

5. **Understand the process of modulating an analogue carrier frequency using digital signals**

   Modulation methods: amplitude shift keying (ASK & OOK), frequency shift keying (FSK), phase shift keying (PSK), bi-polar shift keying (BPSK), quadra-phase shift keying (QPSK), quadrature amplitude shift keying (QAM); representing modulation by constellation diagrams; filter requirements and effects

   Channel capacity: Shannon–Hartley theorem, Shannon's law, calculation of Baud rate / symbol rate

6. Be able to apply the process of multiplexing digital and analogue signals over transmission media

Multiplexing methods: frequency division, synchronous time division, asynchronous time division, digital time division, code division, wavelength (coarse and dense) division

Assessment and Grading 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 for a pass grade describe the level of achievement required to pass this unit.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P1 explain reactance in circuits and impedance in terms of resistive and reactive components P2 describe the characteristics of series and parallel resonant circuits P3 calculate the resonant frequency of a circuit P4 explain decibel (dB) as a unit of loss and dBm as a unit of power P5 define signal-to-noise ratio as applied to transmission lines P6 calculate using dBs and dBms the: • total loss of a system from individual losses • total loss of a system from input and output signal levels • output signal level from total loss and input signal level	M1 calculate the resonant frequency of a resonant circuit and confirm the prediction using appropriate test equipment M2 describe the modulation techniques used by three given applications that operate in different frequency bands of the electromagnetic spectrum M3 describe the use of a combination of modulation and multiplexing in one example application	D1 justify the use of a particular modulation technique in three different frequency bands of the electromagnetic spectrum D2 compare the modulation techniques used by two different applications, giving reasons for their use in those particular applications

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Grading criteria		
• signal-to-noise ratio P7 explain the effect of the primary line constants R, G, L & C on the characteristic impedance of transmission lines P8 define the concept of angular frequency as applied to transmission lines P9 calculate, using the primary line constants, the characteristic impedance of: • finite and infinite line lengths • a parallel pair of wires • co-axial cable P10 produce an equivalent circuit model of a transmission line in terms of resistance, capacitance and inductance[CT1] P11 calculate the bandwidth of a transmission line in terms of frequency between half power points P12 explain the concepts of bit rate and bit error rate (BER) P13 explain digital signal impairments in terms of delay, jitter & binary errors P14 demonstrate the effects of delay, limited bandwidth and jitter on the extraction of binary information from a digital signal P15 explain the following methods of digital modulation using analogue frequency carriers:		

Grading criteria		
• amplitude shift keying (ASK & OOK) • frequency shift keying (FSK) • phase shift keying (PSK) • bi-polar shift keying (BPSK) • quadra-phase shift keying (QPSK) • quadrature amplitude shift keying (QAM) P16 demonstrate the following representations of binary information and explain the advantages of each type: • non-return to zero (NRZ) digital encoding from given values • return to zero (RTZ) digital encoding from given values • bi-phase digital encoding (Manchester) from given values • bi-phase digital encoding (Differential Manchester) from given values P17 describe the purpose of, and produce constellation diagrams[IE4]		

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Grading criteria		
P18 calculate the practical channel capacity using: • Shannon-Hartley formula C=B log2 (S/N+1) • Shannon formula C=2B log2 (n) P19 explain the need for filters and their effect on digitally modulated signals P20 calculate the baud rate of a given link states using given values P21 explain the following type of multiplexing: • frequency division • synchronous time division • asynchronous time division • digital time division • code division • wavelength (coarse and dense) division		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	**IE – independent enquirers** **CT – creative thinkers**	**RL – reflective learners** **TW – team workers**	**SM – self-managers** **EP – effective participators**

Essential guidance for tutors

Delivery

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

Delivery of the theoretical aspects should focus on the most up-to-date technology available.

As an 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.

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, they be set into a vocational context. 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.

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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
P1 P2 P3 M1	An alternate way of looking at circuits	A company asks you to prepare a presentation on the principles of alternating current circuits. The material should be suitable for someone who is new to the industry and should explain reactance, impedance and resonance. The material must also contain some worked examples showing how to calculate the resonant frequency of a circuit. Could be confirmed using appropriate test equipment.	Web pages Presentation Posters
P4 P5 P6	Sending a clear message	Your supervisor asks you to demonstrate your understanding of signal loss. You are asked to prepare a short report on signal loss and complete a set of signal loss calculations based on figures given to you.	Brief report Mathematical calculations
P7 P8 P9	What's stopping it?	Your supervisor asks you to demonstrate your understanding transmission line characteristics. You are asked to prepare a short report on angular frequency and characteristic impedance and complete a set of impedance and bandwidth calculations based on figures given to you.	Brief report Mathematical calculations

Criteria covered	Assignment title	Scenario	Assessment methods
P10 P11	A model answer	The company asks you to prepare a presentation on equivalent circuit models. The presentation must explain what they are and how they are used. It must also contain some worked examples showing how equivalent circuit models are calculated and the bandwidth of transmission lines.	Web pages Presentation Posters
P12 P13 P14 P16	Coding for dummies	The company asks you to prepare some training material about types of digital encoding. The material should be suitable for someone who is new to the industry and must cover: • non-return to zero (NRZ) • return to zero (RTZ) • bi-phase (Manchester) • bi-phase (Differential Manchester) The material must include information about error rates and causes of signal impairment.	Web pages Presentation Posters

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Criteria covered	Assignment title	Scenario	Assessment methods
P15 M2 D1 D2	How to modulate	Your supervisor asks you to demonstrate your understanding of modulation. You are asked to produce a report that explains: • amplitude shift keying (ASK and OOK) • frequency shift keying (FSK) • phase shift keying (PSK) • bi-polar shift keying (BPSK) • quadra-phase shift keying (QPSK) • quadrature amplitude shift keying (QAM) The report must explain the need for filters and their effect on digitally modulated signals. For M2, learners need to describe the modulation techniques used by three given applications that operate in different frequency bands of the electromagnetic spectrum. This could be by asking learners to describe the basic principles of telecommunications systems, which transmit in three particular frequency bands. If learners then justified the use of the modulation techniques in the bands under discussion, then D1 would have been demonstrated. If learners were to compare the modulation techniques used by two of the applications giving reasons for their use, D2 would also be demonstrated.	Report

Criteria covered	Assignment title	Scenario	Assessment methods
P17 P18 P19 P20 P21	A few facts and figures	Your supervisor now asks you to demonstrate your ability to handle mathematical aspects of modulation. You are asked to calculate practical channel capacities and Baud rates from a given set of figures. You are also asked to construct some constellation diagrams.	Mathematical calculations Diagrams
P22 M3	Multiple multiplexing methods	You are asked to produce a concise, illustrated guide to multiplexing. The guide must show the similarities and differences between: • frequency division • synchronous time division • asynchronous time division • digital time division • code division • wavelength (coarse and dense) division. If learners extended this topic to describe an application that used both modulation and multiplexing, merit criterion M3 could also be demonstrated.	Web page Poster

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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
	Telecommunications Principles	Telephony Voice Systems Operation
	An Introduction to Telephony Systems	Communication Technologies
	Telecommunications Technology	Telecommunication Systems

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.animations.physics.unsw.edu.au/jw/AC.html

www.doctronics.co.uk/signals.htm

its.bldrdoc.gov/fs-1037

www.telecom.tbi.net/index.html

Functional Skills – Level 2

Skill	When learners are …
ICT - Finding and selecting information	
use appropriate search techniques to locate and select relevant information	preparing training material on digital encoding
select information from a variety of sources to meet requirements of a complex task	preparing training material on digital encoding
ICT - Developing, presenting and communicating information	
combine and present information in ways that are fit for purpose and audience	producing a report on modulation

Skill	When learners are …
Mathematics – Analysing	
apply a range of mathematics to	calculating channel capacities

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Skill	When learners are …
find solutions	