Unit 30: Telecommunications Principles

Unit code: D/601/3254

QCF Level 3: BTEC Specialist

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 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 principles of alternating currents (AC) circuits	1.1 explain: • reactance in circuits • impedance in terms of resistive and reactive components 1.2 describe the characteristics of series and parallel resonant circuits 1.3 calculate the resonant frequency of a circuit
2 Understand the effects of line impairments on a transmitted signal	2.1 explain: • decibel (dB) as a unit of loss • dBm as a unit of power 2.2 define signal-to-noise ratio as applied to transmission lines 2.3 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 • signal-to-noise ratio
3 Apply the characteristics of transmission lines	3.1 explain the effect of the primary line constants R, G, L & C on the characteristic impedance of transmission lines 3.2 define the concept of angular frequency as applied to transmission lines 3.3 calculate, using the primary line constants, the characteristic impedance of: • finite and infinite line lengths • a parallel pair of wires • co-axial cable 3.4 produce an equivalent circuit model of a transmission line in terms of resistance, capacitance and inductance 3.5 calculate the bandwidth of a transmission line in terms of frequency between half power points

Learning outcomes	Assessment criteria
4 Understand the transmission of digital signals over transmission media	4.1 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 4.2 explain the concepts of bit rate and bit error rate (BER) 4.3 explain digital signal impairments in terms of: • delay • jitter • binary errors 4.4 demonstrate the effects of delay, limited bandwidth and jitter on the extraction of binary information from a digital signal
5 Understand the process of modulating an analogue carrier frequency using digital signals	5.1 explain the following methods of digital modulation using analogue frequency carriers: • 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) 5.2 describe the purpose of, and produce constellation diagrams 5.3 calculate the practical channel capacity using: • Shannon-Hartley formula C=B log2 (S/N+1) • Shannon formula C=2B log2 (n) 5.4 explain the need for filters and their effect on digitally modulated signals 5.5 calculate the baud rate of a given link states using given values

Learning outcomes	Assessment criteria
6 Be able to apply the process of multiplexing digital and analogue signals over transmission media	6.1 explain the following type of multiplexing: • frequency division • synchronous time division • asynchronous time division • digital time division • code division • wavelength (coarse and dense) division

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 impedence

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

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.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments. The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction to the unit
Understand the principles of alternating current (AC) circuits: • whole-class exercise – tutor presentation on reactance and impedance, followed by individual exercises • whole-class exercise – tutor presentation on resonance, in series and parallel circuits, followed by individual exercises.
Assignment 1 - An alternate way of looking at circuits
Understand the effects of line impairments on a transmitted signal: • whole-class exercise – tutor presentation decibels, followed by directed research • whole-class exercise – tutor presentation on signal to noise ratio and signal loss calculations, followed by individual exercises.
Assignment 2 - Sending a clear message
Apply the characteristics of transmission lines: • whole-class exercise – tutor presentation on the primary line constants, followed by directed research • whole-class exercise – tutor presentation on characteristic impedence, followed by individual exercises • whole-class exercise – tutor presentation on equivalent circuit models, followed by individual exercises • whole-class exercise – tutor presentation on bandwidth, followed by individual exercises.

Topic and suggested assignments/activities and/assessment
Assignment 3 - What's stopping it? **Assignment 4** - A model answer
Understand the transmission of digital signals over transmission media: • whole-class exercise – tutor presentation on encoding systems, followed by individual exercises • whole-class exercise – tutor presentation on signal impairment, followed by directed research and individual exercises.
Assignment 5 - Coding for dummies
Understand the process of modulating an analogue carrier frequency using digital signals: • whole-class exercise – tutor presentation on modulation methods, followed by directed research. • whole-class exercise – tutor presentation on constellation diagrams, followed by individual exercises • whole-class exercise – tutor presentation on filters, followed by directed research • whole-class exercise – tutor presentation on channel capacity, followed by individual exercises.
Assignment 6 - How to modulate **Assignment 7** - A few facts and figures
Be able to apply the process of multiplexing digital and analogue signals over transmission media: • whole-class exercise – tutor presentation multiplexing, followed by directed research.
Assignment 8 - Multiple multiplexing methods

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.

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	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.	Web pages. Presentation. Posters.
2.1, 2.2, 2.3	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.

Criteria covered	Assignment title	Scenario	Assessment methods
3.1, 3.2, 3.3, 3.5	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.
3.4	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.	Web pages. Presentation. Posters.
4.1, 4.2, 4.3, 4.4	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.

Criteria covered	Assignment title	Scenario	Assessment methods
5.1, 5.4	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.	Report.
5.2, 5.3, 5.5	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.

Criteria covered	Assignment title	Scenario	Assessment methods
6.1	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.	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
	Telecommunications Principles	Telephony Voice Systems Operation
	An Introduction to Telephony Systems	Communication Technologies
	Telecommunications Technology	Telecommunication Systems

This unit maps to some of the underpinning knowledge from the following areas of competence in the Level 3 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.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
Mathematics - Analysing	
Apply a range of mathematics to find solutions	calculating channel capacities.