

Unit 2: Audio Engineering Principles

Unit code:	J/600/6881
QCF Level 3:	BTEC National
Credit value:	10
Guided learning hours:	60

● Aim and purpose

This unit aims to provide knowledge in both analogue and digital audio principles. Learners will know the theory behind audio processing, current practices in interconnection and storage and be able to interpret equipment specifications.

● Unit introduction

Sound engineers should be familiar with the equipment they use in the studio and live work. It is important to know the underlying principles of both analogue and digital technology, how equipment is used and what processes audio can go through. This unit is intended for learners who wish to focus upon audio engineering and the more technical aspects of music technology and aims to establish knowledge of the principles of audio systems.

Analogue equipment such as microphones, power amplifiers and loudspeakers play an important role in the audio chain. Analogue circuitry is often favoured for front-end devices such as mixing consoles and pre-amps while storage, processing and manipulation of audio is generally done in the digital domain. Digital processing is quick and simple to implement often giving a choice of preset settings. While this is one of the strengths of digital systems, and can improve workflow, it is important to look closely at what is being done by the computer to gain a deeper understanding of the creative and sonic potential. Sound engineers who have experience of working with analogue equipment will understand that this is the best place to start really getting to grips with audio equipment and processing.

The decision as to what equipment is best suited to a particular application is one that requires an engineer to be able to interpret the equipment specifications produced by the manufacturer. Well written specifications help in the decision making process but will require an understanding of a wide range of audio principles if they are to be useful to an engineer when considering sound quality, compatibility and versatility.

● Learning outcomes

On completion of this unit a learner should:

- 1 Know the principles of digital audio
- 2 Know current practices involved in the application of audio systems
- 3 Know methods for processing audio
- 4 Be able to interpret audio equipment specifications.

Unit content

1 Know the principles of digital audio

Digital audio: digital theory; binary; MIDI messages; sample rate; bit depth; digital levels; decibels relative to full scale (dBfs); dither; aliasing; oversampling; error detection and correction; digital devices eg samplers, effects processors, mixing consoles, interfaces

2 Know current practices involved in the application of audio systems

Interconnection: eg types of connector (XLR, Jack, RCA etc); balanced and unbalanced connections; digital connection types and connectors (MIDI, USB, firewire, wireless etc) operating levels (mic level, line level, professional and domestic levels) signal loss; maximum cable lengths; impedance; digital clock; synchronisation; networks

Conversion and storage: eg sample and bit rate conversion, AD/DA conversion, compression codecs, storage types and standards, server systems, transfer rates, capacity, media types, memory types

3 Know methods for processing audio

Analogue processing: equalisation; filters; compression; limiting; gating; expanding; delay; modulation (chorus, phasing, flanging, tremolo)

Digital processing: reverberation; delay; pitch change; time-stretch; normalisation; change gain; silence; reverse; fade in/out; physical modelling (amp simulation, effects)

4 Be able to interpret audio equipment specifications

Equipment specifications: eg frequency range, frequency response, power bandwidth, sensitivity, signal-to-noise ratio, operating level, power rating/handling, RMS, peak, continuous, program, impedance; analogue devices eg microphones, pre-amps, crossovers, power supplies, amplifiers, filters, loudspeakers; analogue audio theory; Ohm's law; voltage; current; resistance, power; decibels (dBu, dBV, dB SPL etc)

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.

Assessment and 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 define the principles of digital audio [RL, SM]	M1 explain the principles of digital audio	D1 assess the principles of digital audio relating to specific digital audio equipment
P2 outline current practices involved in the application of audio systems [IE, SM]	M2 explain current practices involved in the application of audio systems	D2 assess current practices involved in the application of audio systems
P3 illustrate methods for processing audio [IE, SM]	M3 explain methods for processing audio	D3 assess methods for processing audio
P4 recommend equipment through the interpretation of audio equipment specifications with a degree of independence. [RL, SM]	M4 explain equipment recommendations through the interpretation of audio equipment specifications with no tutor input.	D4 justify equipment recommendations through the interpretation of audio equipment specifications by explaining the audio principles behind them.

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
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Essential guidance for tutors

Delivery

The technical aspects of this unit form the foundation for a wide range of areas of study including sound recording, live sound engineering, acoustics, synthesis and sampling. All of the concepts and principles involved lead learners to investigate the equipment and technology available to engineers, producers and recording musicians.

This unit and *Acoustics Principles for Musicians* give learners confidence in their understanding and control over the technology. Tutors might wish to integrate aspects of this unit with some of the other more practical units and those units that have a system specification design element.

While most of this unit will need to be delivered using a lecture-style approach it is essential that the theory be established through practical experience of the equipment it relates to. For example, when investigating digital theory learners could be introduced to a hardware sampler or digital recording device.

Music software can be used to visually show audio processes and effects. For example, when comparing the waveform of a sound before processing and again after processing learners will become used to seeing the processes happen and will then be able to relate this to what is happening sonically. For example, a tremolo effect will show a visible rise and fall in amplitude and an EQ can be seen working especially when combined with the use of a real time audio analyser. An oscilloscope can be used to show waveforms and together with audio testing equipment can be used to test the frequency response of audio recording equipment. Access to equipment manuals and technical specifications is essential as is access to online resources such as manufacturer websites where technical details, diagrams and pictures can be downloaded.

The use of diagrams to show how audio effects and audio processes work is a great method for visual learners. They should be encouraged to work in small groups in drawing these diagrams and the present them to the rest of the group. In this way a large range of different effects and processes can be covered.

It is preferable to vary the delivery approach to avoid overloading learners with technical concepts. The grading criteria are concerned with the main principles involved in analogue and digital audio not necessarily the physics, mathematics and electronics behind those principles.

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 unit and assessment.
Tutor input sessions covering audio principles – introductory overview, audio theory, sound, analogue/digital signals, frequency, sound levels, Ohm's law, S/N ratio.
Tutor input sessions covering Digital audio principles – binary, sample rate, bit depth. Digital studio equipment.
Assignment 1: Digital Audio Glossary – P1, M1, D1 <ul style="list-style-type: none">• Practical use/testing of equipment.• Writing up time.
Tutor input sessions covering Interconnection – cables, connectors, and signal types. Conversion – AD/DA, sample rate, bit depth. Storage – media types, file sizes, transfer, compatibility. Current practices – discussion, practicalities and moving between studios.
Assignment 2: Studio Plan – P2, M2, D2 <ul style="list-style-type: none">• Investigation/use of studio equipment.• Writing up time.
Tutor input sessions covering Audio processing – typical equipment found in a studio rack (EQ, compression, gates, effects) – diagrams, visual explanation. Digital processing – typical functions of audio editing software (normalise, time-stretch, fade, silence). Digital 'models' of audio effects – comparison, visual representation of effects, seeing the sound on screen, amp simulation.
Assignment 3: Effects and Processing – P3, M3, D3 <ul style="list-style-type: none">• Investigation/use of studio equipment.• Writing up time.
Audio principles – revision. Technical specifications – relate to audio principles, equipment specification sheets – recommendations, explanation and justifications.
Assignment 4: Equipment Specifications – P4, M4, D4 <ul style="list-style-type: none">• Time constrained assessments.

Assessment

When setting a more practical assignment to assess learning tutors should be careful that the tasks generate the correct evidence to meet the grading criteria. In most cases sets of questions could be generated to help learners focus on the theory behind what they are doing. It would be good practice to have regular question and answer sessions or quizzes to help keep learners focused and monitor the learning process prior to the main assignments. It may be suitable in some cases to set questions as part of 'time constrained assessments' alongside the practical and more contextualised assessments. Tutors should not, however, rely solely on tests to produce the evidence for this unit. Where assessment is based on a practical activity and/or presentation, assessors should ensure that appropriate documentation is provided for learners' evidence, for example, tutor observation record, witness statement or a/v recording.

LO1 requires that learners know the principles of digital audio. They should be encouraged to relate this theory to specific examples of equipment such as samplers and recording devices.

LO2 requires that the learners have a working knowledge of current practices but also the issues relating to storage, connection and conversion. The connections within a small recording studio would make a good case study and the basis for an assessment.

LO3 requires that the learners know a range of audio processes. In most cases audio processes are best explained using well-labelled and annotated diagrams. In this way learners will see what is happening to the audio and will be able to relate this to what they hear while working in the studio or at a DAW.

LO4 requires that learners are able to interpret technical specifications. This will require tutors to supply examples of audio specifications that necessitate the coverage of a broad range of audio principles and suitable questions that ask for explanation and technical reasoning. It is the use of and understanding of audio principles in these specifications that is important so it should not be seen as an exercise in finding examples of poorly written specifications.

To achieve P1 the learners need to define the principles of digital audio as set out in the unit content. This should be technically correct but can be brief. For example a simple glossary of terms could be produced to meet this criteria.

For M1, learners should explain four or more topics within the unit content. They should include sample rate and bit depth and a choice of two or more other topics. Diagrams should be used to help explain topics.

For D1, evidence must be produced that assesses the quality of digital equipment. This is likely to follow on from and expand upon the explanation and include discussion of frequency response relating to sample rate and signal to noise ratio relating to bit depth. If an assignment is used that combines LO1 and LO4 then it is appropriate for learners to combine the two areas in their comparisons of equipment. For example learners could compare audio quality of a digital recording system to that of an analogue audio system.

To achieve P2 the learner must outline current practices in sound equipment interconnection, how sound/data is stored and what is involved in the conversion of sound/data. Evidence is likely to be brief and factual and include labelled diagrams, lists of connector types, lists of cable types, examples of digital data storage and a brief outline of AD/DA conversion.

For M2, evidence should include explanation of four or more specific examples as outlined in the unit content. Diagrams should be used to help explain topics.

For D2, learners will assess topics such as audio quality, use of high sampling rates, compatibility between systems, digital transfer, signal loss when using long cable lengths, improving workflow in the studio and future developments.

To achieve P3 learners must produce illustrations that represent the range of effects and audio processes as outlined in the unit content. Diagrams should be technically accurate and be a good representation of the process being illustrated.

For M3, learners will explain how the effects or processes work. This will be a more detailed look at four or more examples including dynamic processing and modulation effects. Verbal explanation may be suitable evidence if it is detailed and accurate enough to be sufficient.

For D3, learners will assess the effects and processes. This could involve looking at specific effects within a software package and assessing their features, degree of control and sound quality. Comparisons should be made, for example between similar effect types and/or analogue and digital units/processors.

To achieve P4 learners will produce evidence that they can recommend equipment through correct interpretation of audio specifications. It would be expected that a microphone, power amplifier and loudspeaker be included to allow coverage important principles relating to common specifications such as frequency, decibels, power and impedance. Evidence is likely to be brief but should explain what each specification means. Evidence should be produced during classroom sessions to allow proper assessment against the grading criteria.

For M4, the learner will need to show they can explain the audio principles behind the specifications. This will involve producing written or verbal evidence that explains a wider range of audio specifications as outlined in the unit content. Work should be collected under supervision during a classroom session and should not be taken home to complete. The use of sources of information such as the internet should be controlled. Learners should be encouraged to use their own notes.

For D4, the learner will need to show they can justify their recommendations using their knowledge of the audio principles behind the specifications. There should also be a deeper understanding of the specifications and a more thorough approach when explaining each item of audio equipment.

Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading 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 method
P1 M1 D1	Digital Audio Glossary	You have been asked to write a glossary of digital audio principles and assess the quality of digital equipment.	<ul style="list-style-type: none"> • Written report. • Web page. • Presentation.
P2 M2 D2	Studio Plan	You are designing a small music studio. Produce diagrams and explanation to show the interconnections, conversion and storage.	<ul style="list-style-type: none"> • Booklet. • Web page. • Presentation.
P3 M3 D3	Effects and Processing	Produce diagrams that illustrate and explain a range of audio effects and processing.	<ul style="list-style-type: none"> • Booklet. • Web page. • Presentation.
P4 M4 D4	Equipment Specifications	You are given a range of audio equipment and asked make recommendations based on the technical specifications.	<ul style="list-style-type: none"> • Time constrained assessment.

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

This unit forms part of the BTEC Music and Music Technology sector suite. This unit has particular links with the following unit titles in the BTEC Music and Music Technology suite:

Level 1	Level 2	Level 3
	Exploring Computer Systems Used by Musicians	Acoustics for Musicians
		Live Sound Techniques

This unit also has links with the following National Occupational Standards:

Technical Theatre

- CPD1 – Improving your skills
- CPD2b – Ensure that you and your team keep up to date with the technical and production areas of the live arts
- HSI – Working safely
- TP2.4a – Contribute to developing and refining ideas for sound (C1)
- TP2.4b – Developing and refining ideas for sound (C1).

Essential resources

This unit can be delivered entirely through classroom or lecture activity but a great deal of the required learning can, and should, take place in a practical environment where possible. Access to a suitable range of audio equipment such as compressors, effects units, EQ as well as music software will be essential in the development of knowledge and in putting the theory into context. Music software can show visually what analogue equipment may not (eg EQ) while real hardware allows a hands on approach. Access to signal generators, oscilloscopes and audio test equipment would be an advantage as this would allow learners to see test results for specifications such as frequency response, SPL readings and distortion. Equipment specifications and manuals will be necessary for comparative purposes.

Employer engagement and vocational contexts

Technical roles within the industry offer a wide scope for employment. This unit gives the learner the underpinning knowledge that will help them move into areas such as live sound, analogue electronics, DSP, product design and manufacture.

Indicative reading for learners

Textbooks

Davis G and Jones R – *The Sound Reinforcement Handbook* (Hal Leonard, 2008) ISBN 9780881889000

Eargle J and Foreman – *JBL Audio Engineering for Sound Reinforcement* (Kendrick Books, 2008)
ISBN 9780634043550

McCartney T – *Recording Studio: Technology, Maintenance and Repairs* (McGraw-Hill Education, 2004)
ISBN 9780071427265

Moscal T – *Basics of Sound and Sound Systems* (Hal Leonard, 1994) ISBN 9780793535590

Pohlmann K – *Principles of Digital Audio* (McGraw Hill, 2005) ISBN 9780071441568

Rumsey F and McCormick T – *Sound and Recording: an introduction* (Focal Press, 2005)
ISBN 9780240519968

Stark H – *Live Sound Reinforcement* (Course Technology, 2005) ISBN 9781592006915

White P – *Creative Recording 1: Effects and Processors* (Sanctuary Publishing, 2003) ISBN 9781860744563

Zolzer U – *Digital Audio Signal Processing* (Wiley Blackwell, 2008) ISBN 9780470997857

Delivery of personal, learning and thinking skills (PLTS)

The following table identifies the PLTS opportunities that have been included within the assessment criteria of this unit:

Skill	When learners are ...
Independent enquirers	researching information sources online and in textbooks
Reflective learners	using technical information to assess audio equipment
Self-managers	managing own time to meet assessment deadlines set by the centre.

Although PLTS opportunities are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Creative thinkers	exploring audio effects for creative possibilities
Team workers	working with musicians in creative recording situations
Effective participators	bringing audio solutions to creative situations.

● Functional Skills – Level 2

Skill	When learners are ...
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	presenting technical information to the student group
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading technical information and selecting information that is relevant to the topic area
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing explanations of the topic area and presenting wide range of technical information in an understandable format.