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 both analogue and digital audio principles. Learners will know the theory behind audio processing, current practices in interconnection and storage and will 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 on audio engineering and the more technical aspects of music technology and it aims to give learners 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, dBSPL 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	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

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 *Unit 1: Acoustics 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 some of this unit may 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 it learners will become used to seeing the processes happen and will then be able to relate 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.

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.

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.

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 • Practical use/testing of equipment. • Portfolio development.
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 • Investigation/use of studio equipment. • Portfolio development.
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 • Investigation/use of studio equipment. • Portfolio development.
Audio principles – revision. Technical specifications – relate to audio principles, equipment specification sheets – recommendations, explanation and justifications.
Assignment 4: Equipment Specifications – P4, M4, D4 • Time-constrained assessments.

Assessment

Where assessment is based on a practical activity and/or presentation, assessors should ensure that appropriate evidence is provided, for example video recordings.

Learning outcome 1 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.

Learning outcome 2 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.

Learning outcome 3 requires that learners know about 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 it to what they hear while working in the studio or at a DAW.

Learning outcome 4 requires that learners are able to interpret technical specifications. Tutors will need 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 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, 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 criterion.

For M1, learners should explain some of the aspects identified within the unit content including sample rate and bit depth. Diagrams could be used to help explain topics.

For D1, learners will assess the principles of digital audio relating to specific equipment. This is likely to follow on from and use detailed examples to expand on the explanation and include discussion of frequency response relating to sample rate and signal to noise ratio relating to bit depth.

To achieve P2, learners 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.

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

For D2, learners will assess current practices in the application of audio systems 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. 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.

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 make recommendations for audio equipment based on interpretation of specifications. It is expected that a microphone, a power amplifier and loudspeaker be included to allow coverage of 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.

For M4, learners will need to show they can explain the audio principles behind the specifications, covering a range of audio specifications as outlined in the unit content.

For D4, learners will need to show they can justify their recommendations using their knowledge of the audio principles behind the specifications, using effective and logical reasoning for items selected.

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 Pearson 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.	• 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.	• Booklet. • Web page. • Presentation.
P3, M3, D3	Effects and Processing	Produce diagrams that illustrate and explain a range of audio effects and processing.	• Booklet. • Web page. • Presentation.
P4, M4, D4	Equipment Specifications	You are given a range of audio equipment and asked to make recommendations based on the technical specifications.	• Time-constrained assessment.

Links to other BTEC units

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
		Acoustics for Musicians
		Live Sound Techniques

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 and 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.

Delivery of personal, learning and thinking skills (PLTS)

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass 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.

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 learner 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 a wide range of technical information in an understandable format.