Pearson BTEC Levels 4 Higher Nationals in Engineering (RQF)

Unit 19: Electrical and Electronic Principles

Unit Workbook 4

in a series of 4 for this unit

Learning Outcome 4

Digital & Analogue Electronics

Contents

INTRODUCTION

Explain the difference between digital and analogue electronics, describing simple applications of each.

Analogue concepts:

Analogue quantities, examples of electrical representation of, for example, audio, temperature, speed, or acceleration.

The voltage amplifier; gain, frequency response, input and output resistance, effect of source and load resistance (with source and amplifier output modelled as Thevenin equivalent).

Digital concepts:

Logic circuits implemented with switches or relays.

Use of voltages to represent logic 0 and 1, binary counting.

Logic Gates (AND, OR, NAND, NOR) to create simple combinational logic functions.

Truth Tables.

SIMULATOR DOWNLOADS

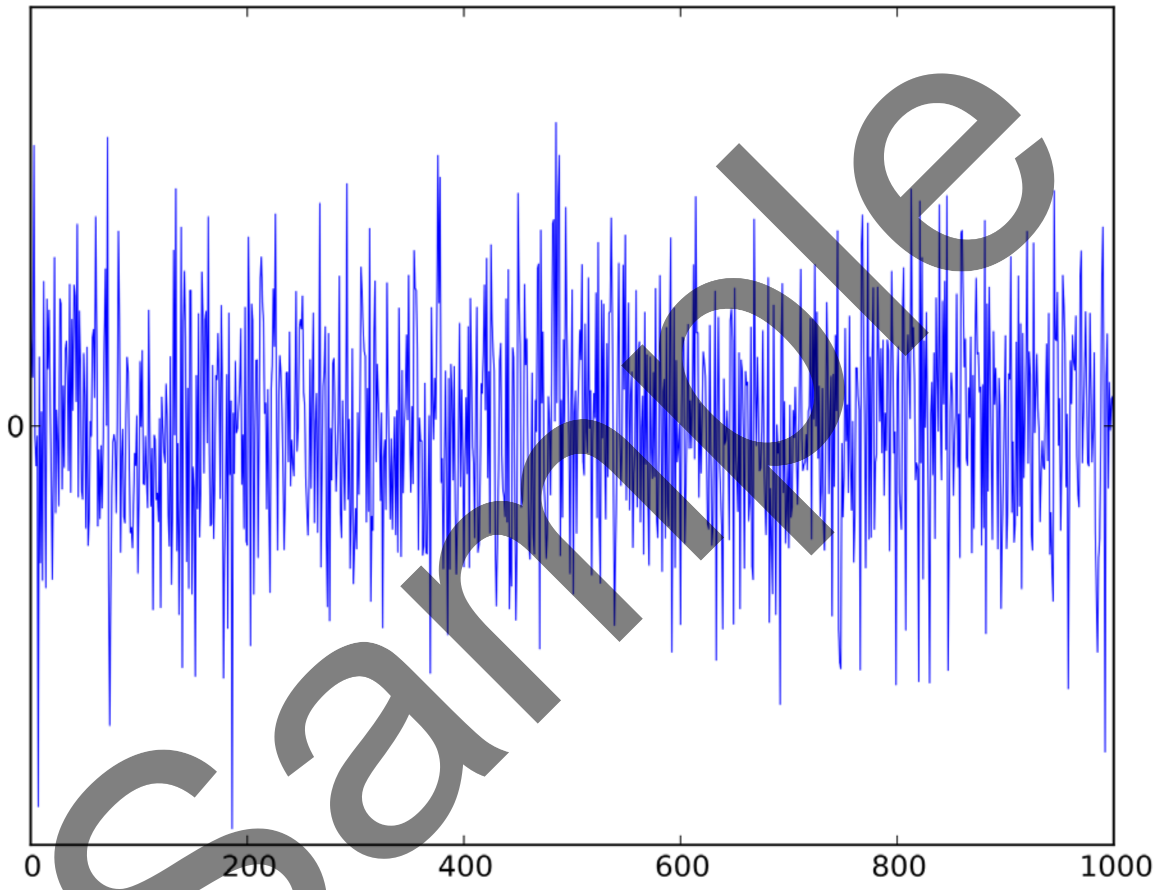
MicroCap

TINA-TI

Analogue concepts:

Analogue quantities

An analogue signal is one which has a continuous track through time. It can vary continuously both in amplitude and frequency. An audio signal is a very good example of an analogue signal…



Amplifier Characteristics

Ideal Characteristics

Amplifiers are used in the vast majority of electronic and fibre-optic systems. There are many types of amplifier, as you shall see later, but there are some ideal characteristics which are common to all varieties;

Gain

This is the amount that the amplifier boosts the input signal. The input signal is typically a voltage or a current, and the output is a larger (or smaller) version of this signal. The ideal case is that the gain can be any value we wish, without side effects.

Bandwidth

When an amplifier is used across the frequency spectrum its design, and parasitic capacitance, will dictate how well it produces the desired gain at all frequencies. When the gain drops to provide half the ideal power then this marks a half-power point, commonly referred to as a '-3 dB' point. There will be such a point at a lower and upper frequency. The difference between the upper and lower -3 dB points is referred to as the 'bandwidth' of the amplifier.

For many amplifiers the ideal bandwidth will be infinite i.e. it performs equally well at all frequencies. Some amplifiers may be designed to work only within at a select band of frequencies, so infinite bandwidth will not be ideal in those cases.

Input Impedance

Very often the input impedance is desired to be high, so as not to load preceding circuitry. Some amplifiers would ideally have infinite input impedance, whilst others may need a finite input impedance to match the output impedance of a preceding amplifier or device.

Output Impedance

The output impedance of an amplifier is typically desired to be low, or zero. This will allow the amplifier to drive high currents to a connected load, such as a loudspeaker or other type of transducer.

Noise

Noise in an amplifier may originate from the amplifier itself (its components or design), the power supply, nearby circuitry, long conductors acting as antennae, or even external sources such as radio/CB broadcasts.

The ideal amplifier will not generate noise and will be immune from noise originating from outside sources.

Thermal Drift

When components age their temperature-specific characteristics change. This can result in diminished performance and drift from normal operation in an amplifier. The ideal amplifier will not be susceptible to thermal drift of any kind.

Common Notation

A table of common notation used in amplifiers is shown below. This workbook will explain all new notation as it arises in various sections.

Notation	Description
A_V	Voltage Gain
A_i	Current Gain
A_p	Power Gain
Z_{in}	Input Impedance
Z_{out}	Output Impedance
Q Point	The quiescent operating point
CE	Common Emitter (bipolar amp.)
CB	Common Base (bipolar amp.)
CS	Common Source (FET amp.)
h_x or h_{xx}	h-parameters used for amplifier analysis

DC and AC Behaviour

Bipolar transistor amplifiers (using npn or pnp transistors) tend to be biased with DC voltages in order to provide a steady operating point (Q-point) which is in the linear region of the transistor's characteristic performance. When an AC input is applied to such an amplifier then the DC conditions will preset the amount of AC gain produced. Bipolar transistors are current-controlled devices but the DC bias voltages set the conditions for these currents. Bipolar transistors will have a specific output current (collector to emitter) for any given input (base) current.

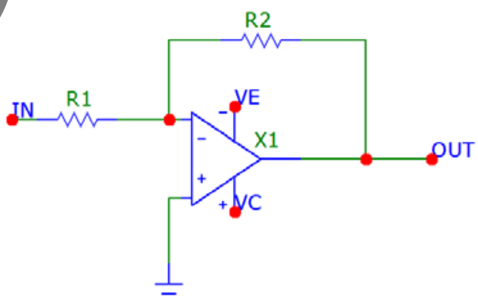
For field-effect transistors the situation is somewhat different. These devices are voltage-controlled and the current through the output terminals (source-drain) will be influenced by the voltage on the controlling input terminal (gate).

For any type of amplifier the DC conditions set the limiting parameters for the AC signal swing. Many modern systems use operational amplifiers to provide DC gain or AC gain.

OpAmp Basic Circuits

The two basic operational amplifier (OpAmp) circuits are the inverting and non-inverting types.

Inverting OpAmp



The circuit above is an example of an *inverting amplifier*. It takes this name because the input signal is presented to the inverting terminal of the OpAmp (via R1). When we analyse OpAmps we come to *assume that the voltage between the two input terminals of the OpAmp is zero*. This being so, we see that the RHS of R1 is *virtually* connected to ground. In that case it is clear that the input impedance of this inverting amplifier is R1 itself. The output signal is an inverted version of the input signal.