A-LEVEL Electronics: 5 Specification Content

5.1 Module 2526: Foundations of Electronics

N3.1, N3.2, N3.3. PS3.1, PS3.2.

Recommended Prior Knowledge

understand the concepts of conductors and insulators in terms of the mobility of charge;	
understand voltage as a measure of the energy of charge at a point in a circuit;	
understand current as the rate of transfer of charge past a point in a circuit;	
know of the need for suitable power supplies to drive a current round a circuit;	
recognise the conversion of energy from electrical to other forms as charge moves round a circuit.	

5.1.1 System Components

Content

Capacitors and their uses in storing charge;	
Diodes and diode-resistor networks. The Zener diode;	
Mains transformers, assumed to be ideal and loss-free;	
Input transducers: push switch, potentiometer, potential divider incorporating LDR or thermistor, audio microphone, series resistor and visible or IR photodiode;	
Output transducers: loudspeaker, lamp, visible and IR LEDs, relay, d.c. motor, heater;	
Measuring instruments: voltmeter, ammeter and ohmmeter, CRO.	

Learning Outcomes

Candidates should be able to:

5.1.1a	define resistance (R = V/I) and the ohm;	
5.1.1b	distinguish between ohmic and non-ohmic devices; characteristics of LDRs and ntc thermistors;	
5.1.1c	recall and use formulae to calculate the total resistance of resistors in series and parallel;	
5.1.1d	recall the definition of capacitance (C = Q/V) and the farad;	
5.1.1e	use capacitors to store charge;	
5.1.1f	use diodes regarded as one-way conductors with a constant voltage drop in the forward direction once biased, and zero leakage current in the reverse direction;	
5.1.1g	recall that the voltage across a forward biased diode is 0.7 V for a silicon diode, 0 V for a germanium diode and 2.0 V for an LED; the breakdown voltage of a Zener diode is constant;	
5.1.1h	design simple circuits using diodes as rectifiers and clamps (including protection diodes in relay circuits);	
5.1.1j	select and incorporate in circuits suitable input and output transducers (regarded as named sub-system ‘black boxes’) from the list in the content part of this section;	
5.1.1k	select and use appropriate measuring instruments;	
5.1.1m	incorporate the system components listed above as sub-systems in simple electronics systems.	

5.1.2 Fundamentals of Circuit Building

Content

All circuits may be regarded as systems which in turn may be considered as a set of mutually interacting sub-systems. A system which is to perform a particular task may be synthesised in many different ways.

Simple analysis of practical circuits;	
RC networks;	
Power and energy transfer in circuits;	
Power supplies.	

Learning Outcomes

Candidates should be able to:

5.1.2a	use the concepts of voltage as a means of driving a current through a conductor, and current as a rate of transfer of charge;	
5.1.2b	recall and use the defining equations for resistance and capacitance (R = V/I and C = Q/V);	
5.1.2c	recall and use the rules for the behaviour of currents at junctions (Kirchhoff’s first law) and how voltage changes from one part of a circuit to another (V = IR);**	
5.1.2d	recall and use RC networks to generate time delays and pulses; use appropriate formulae to calculate the voltage across components as a function of time when a capacitor is charged or discharged through a resistor from a constant voltage source; ***	

5.1.2 Fundamentals of Circuit Building - Learning outcomes ctd.

5.1.2e	recall that current flow in a circuit implies energy transfer; recall and use the equations to calculate energy and power dissipation in d.c. circuits: Q = It, energy = VQ, P = VI = I2R;	
5.1.2f	recall the relationship between peak and r.m.s. values for sinusoidal a.c.;	
5.1.2g	explain the operation of power supply circuits containing mains transformers, diodes and a capacitor to produce a smoothed, unstabilised d.c. supply, to include calculation of peak voltage and ripple voltage;	
5.1.2h	design simple power supply circuits using both full-wave and half-wave rectification and stabilised by a Zener diode or by a voltage regulator chip;	
5.1.2j	design and construct simple systems;*	
5.1.2k	find and correct faults in simple systems.*	

* These outcomes will not be assessed in Unit 2526 examinations.

5.1.3 Operational Amplifier Systems

Content

Although candidates should be aware of the non-ideality of a commercial operational amplifier, most of the following systems may be treated as ideal with infinite open-loop gain and infinite input impedance. Systems should be considered as 'black boxes' with outputs defined as a function of the input.

Comparator and switch;	
Negative feedback;	
Inverting and non-inverting amplifiers;	
Voltage follower.	

Learning Outcomes

Candidates should be able to:

5.1.3a	recall and use the op-amp as a switch with voltage controlled differential inputs;	
5.1.3b	use the concept of the potential divider to allow input transducers to activate the op-amp switch;	
5.1.3c	use the concept of negative feedback to stabilise the output of an op-amp and to define its closed-loop gain when not saturated, in terms of the external components in the feedback loop;	
5.1.3d	recall and use the concept of a virtual earth for an inverting amplifier;	
5.1.3e	derive and use the appropriate formulae for the closed loop gain of both inverting and non-inverting amplifiers when not saturated;	
5.1.3f	understand the use of a voltage follower as a buffer amplifier.	

5.1.4 Digital Systems

Content

AND, OR, NOT, NAND, NOR and EOR gates;	
Combinational logic systems and truth tables involving up to 16 states;	
Binary arithmetic, the use of half adders and full adders;	
Bistables and latches;	
The D-type flip-flop;	
Sequential logic analysed from timing diagrams.	

Learning Outcomes

Candidates should be able to:

5.1.4a	recall that, unless otherwise stated, logic 1 = +5 V, logic 0 = 0 V and use truth tables and transfer characteristics of NOR, NAND, NOT, AND, OR and EOR gates;	
5.1.4b	synthesise each of these gates from dual-input NAND gates or dual-input NOR gates;	
5.1.4c	explain the operation of simple combinational logic systems such as binary-to-decimal and binary-to-seven-segment decoders; half and full adders, using truth tables;	
5.1.4d	recall and describe the operation of bistable (latch) circuits made from two cross-coupled NAND gates or two cross-coupled NOR gates;	
5.1.4e	recall and describe the operation of a rising edge triggered D-type flip-flop;	
5.1.4f	interpret simple sequential logic circuits in terms of timing diagrams.	

5.2 Module 2527: Signal Processing

C3.1a, C3.1b; N3.1, N3.2, N3.3. WO3.1, WO3.2, WO3.3; PS3.1, PS3.2.

5.2.1 Negative Feedback

Content

Operational amplifiers and their characteristics;	
The summing amplifier;	
Active filters.	

Learning Outcomes

Candidates should be able to:

5.2.1a	recall and interpret the characteristics of an 081 (741 compatible) op-amp neglecting offset adjustments;	
5.2.1b	recall and use the concept of negative feedback to stabilise the output of an amplifier circuit and to define its output state solely in terms of its input and the values of external components;	
5.2.1c	design and use summing amplifier circuits to add or mix multiple inputs;	
5.2.1d	explain the use of the capacitor as a frequency-dependent impedance;	
5.2.1e	design and use simple filter circuits constructed around an inverting amplifier circuit; suitable filters would include bass and treble cut, bass and treble boost, and bandpass filters;	
5.2.1f	recall and use the formula to calculate the break frequency of a filter;	
5.2.1g	draw log-log plots of the gain of the filter circuit as a function of frequency, using the straight line approximation.	

5.2.2 Positive Feedback

Content

Schmitt trigger circuits;	
Ramp generator (integrator) circuits;	
The signal generator.	

Learning Outcomes

Candidates should be able to:

5.2.2a	recall and use the concept of positive feedback to convert an amplifier into a device with only two stable states;	
5.2.2b	design and use both inverting and non-inverting Schmitt trigger circuits using op-amps;	
5.2.2c	calculate the trigger thresholds for both inverting and non-inverting types and also create asymmetrical threshold levels;	
5.2.2d	design and use an op-amp as a ramp generator or integrator;	
5.2.2e	combine a ramp generator and a Schmitt trigger to make a ramp/square wave generator;	
5.2.2f	calculate the frequency of the ramp/square wave generator.	

5.2.3 Boolean Algebra and Synchronous Counters

Content

The rules for AND and OR operations;	
De Morgan's theorem, the redundancy theorem and the race hazard theorem;	
The use of Boolean algebra to simplify combinational logic systems;	
Sychronous/Asychronous Counters.	

Learning Outcomes

Candidates should be able to:

5.2.3a	generate simple Boolean algebra expressions and truth tables from a problem specification;	
5.2.3b	use De Morgan's theorem to simplify algebraic expressions to a form suitable for implementation in terms of basic logic gates (no knowledge of Karnaugh Maps is expected);	
5.2.3c	convert a circuit formed of one sort of gate into its equivalent in the other sort;	
5.2.3d	recognise the use of the redundancy theorem and the race hazard theorem,	
5.2.3e	construct truth tables for a combinational logic circuit and generate corresponding Boolean expressions;	
5.2.3f	construct and use timing diagrams to explain the operation of sequential logic circuits;	
5.2.3g	recall and describe the operation of a binary ripple up-counter made from D-type flip-flops;	
5.2.3h	design and construct binary counters which reset after n counts.	

5.2.4 Analysis of Systems

Content

Systems defined by their transfer characteristics, input and output impedance, the ability to source and sink current;	
Analysis of systems in terms of block diagrams;	
The audio amplifier;	
Digital systems.	

Learning Outcomes

Candidates should be able to:

5.2.4a	interpret the performance of a system from its transfer characteristic;	
5.2.4b	recall and use the concepts of input impedance and output impedance to solve problems of power and signal transfer between systems and sub-systems;	
5.2.4c	recall that outputs can act as both sources and sinks of current;	
5.2.4d	explain the operation of a complete audio amplifier system in terms of blocks representing pre-amplifier, equaliser, volume and tone controls, and power amplifier;	
5.2.4e	design and explain the operation of simple systems, such as quiz referee, combination lock and simple decimal keypad, made up from components and sub-systems;	
5.2.4f	apply skills learned in this module to design and explain the operation of related systems.	

5.4 Module 2529: Communication Circuits

N3.1, N3.2, N3.3. PS3.1, PS3.2.

5.4.1 Resonant Circuits

Content

Inductors and capacitors;	
The parallel resonant circuit.	

Learning Outcomes

Candidates should be able to:

5.4.1a	describe the effects of incorporating ideal inductors (i.e. neglecting resistance and self-capacitance) and ideal capacitors (i.e. neglecting leakage resistance and self-inductance) in circuits;	
5.4.1b	recall and use the parallel resonant circuit as a frequency dependent impedance with a maximum impedance at f = 1/(2 Pi rt(LC));	
5.4.1c	recall that Q describes the sharpness of the resonance and is determined by the resistance in the circuit;	
5.4.1d	appreciate the effect of Q in designing circuits for selecting a small range of frequencies out of the frequency spectrum.	

5.4.2 Transistor Circuits

Content

NPN and PNP transistors;	
Transistor voltage amplifiers;	
The complementary emitter follower;	
The n-channel MOSFET as a high impedance amplifier;	
The n-channel MOSFET as a voltage controlled resistor.	

Learning Outcomes

Candidates should be able to:

5.4.2a	recall and interpret the transfer characteristics of both NPN and PNP transistors;	
5.4.2b	recall that for a transistor, the dc current gain hFE is assumed to be constant, VBE is taken as 0.7 V and VCE (saturation) is taken as zero for a conducting transistor;	
5.4.2c	recall and design NPN transistor voltage amplifier circuits using single resistor base bias circuits full dc stabilisation;	
5.4.2d	recall the use of blocking capacitors on inputs and outputs of amplifiers;	
5.4.2e	calculate the voltage gain of a fully stabilised transistor amplifier;	
5.4.2f	recall the use of a transistor as a buffer, emitter follower or power amplifier with unity voltage gain; recall that the power gain is the ratio power out/power in;	
5.4.2g	recall the use of a PNP-NPN pair of transistors as a complementary emitter follower to drive a current in both directions from a dual supply, through a load;	
5.4.2h	recall the causes of, and methods of correction (using op-amps) for, cross-over distortion and clipping in complementary emitter followers;	
5.4.2j	recall the characteristics of a n-channel MOSFET;	
5.4.2k	recall the use of the n-channel MOSFET in high impedance amplifier and voltage follower circuits;	
5.4.2m	recall the use of the n-channel MOSFET as a voltage controlled resistor in automatic gain control circuits and amplitude modulation circuits and as an analogue switch.	

5.4.3 Analogue Communication Systems

Content

Signal transfer on carrier waves;	
Amplitude Modulation (AM) and frequency modulation (FM) of carrier waves;	
Frequency division multiplexing of signals;	
AM and FM receivers.	

Learning Outcomes

Candidates should be able to:

5.4.3a	recall and describe the transfer of signals by various carriers (for example, radio, light and ultrasound);	
5.4.3b	describe and explain the use of AM and FM carriers to transfer analogue signals;	
5.4.3c	explain the effects of noise and information loss in carriers;	
5.4.3d	recall the frequency spectrum of AM carriers modulated by sine wave and square wave signals;	
5.4.3e	recall the bandwidth required to transmit FM signals is greater than for AM signals;	
5.4.3f	recall and describe the use of frequency division multiplexing to allow the simultaneous transmission of several signals;	
5.4.3g	describe and explain in detail the operation of a simple AM receiver using a parallel resonant circuit and a diode (assumed to be ideal) detector;	
5.4.3h	recall and explain how the shortcomings of the simple AM receiver may be overcome in t.r.f. and superhet systems (candidates will only be asked to supply block diagrams);	
5.4.3j	analyse the operation of a simple FM receiver, including why the signal-to-noise ratio can be much lower than in an AM system (no knowledge of phase-locked loops is expected).	

5.4.4 Television Systems

Content

Television receivers as converters of serial analogue electronic signals into analogue pictures (candidates will not be expected to reproduce block or circuit diagrams for television systems).	

Learning Outcomes

	Candidates should be able to:	
5.4.4a	recall the following terms as applied to the generation of pictures on a cathode ray tube: pixel, line, field, raster, interlacing, synchronisation signals, resolution, lines per field, fields per second, luminance and chrominance;	
5.4.4b	describe, at a simple level, the encoding of colours and the intermodulation of sound;	
5.4.4c	calculate the bandwidth required for a given picture.	

5.4.5 Digital Communication Systems

Content

Comparisons between analogue and digital information transfer	
Digital-to-analogue conversion (DAC) and analogue-to-digital conversion (ADC) based on DACs;	
The dependence of required bandwidth on bit rate for a digital system;	
Sub-systems of digital systems: shift registers, monostables, astables, Schmitt trigger circuits;	
Pulse code modulation and time division multiplexing;	
Asynchronous serial transmission.	

Learning Outcomes

Candidates should be able to:

5.4.5a	recall the comparative merits and demerits of analogue and digital systems;	
5.4.5b	use and explain the operation of the DAC using op-amps and resistor networks;	
5.4.5c	use and explain the operation of a single slope ADC based on a DAC;	
5.4.5d	recall the dependence of the required bandwidth on the bit rate for a digital system (for example, in telex systems and for picture transmission in television and other systems); minimum sampling rate greater than twice highest frequency;	
5.4.5e	recall and explain the operation of shift registers in the parallel & serial processing of binary words;	
5.4.5f	use shift registers as functional blocks or assembled from D-type flip-flops;	
5.4.5g	design and use pairs of NAND or NOR gates and RC networks to construct a monostable, a Schmitt trigger, and an oscillator which can be enabled;	
5.4.5h	recall and explain the use of pulse code modulation (p.c.m.);	
5.4.5j	recall and describe the use of time division multiplexing to allow the simultaneous transmission of several signals on the same channel;	
5.4.5k	analyse the operation of circuits for serial transmission and reception.	

5.5 Module 2530: Control Circuits

N3.1, N3.2, N3.3. PS3.1, PS3.2.

5.5.1 d.c. Servo Control Systems

Content

Control systems for position, temperature and rotational speed;	
On-off and proportional systems;	
The response of a system as a function of the characteristics of its sub-systems.	

Learning Outcomes

Candidates should be able to:

5.5.1a	recall and explain the operation of simple d.c. servo systems to control position, temperature and rotational speed.	
5.5.1b	distinguish between and design on-off and proportional systems for the above applications.	

5.5.2 Triacs

Content

Triacs used in simple control circuits;	
The triac to allow logic systems to control high voltage alternating currents.	

Practical work must not include access to mains voltages.

Learning Outcomes

Candidates should be able to:

5.5.2a	recall circuitry to allow logic systems to interface with triacs to control high voltage circuits;	
5.5.2b	recall and explain the use of opto-couplers and pulse transformers to isolate the one system from another (for example, a logic system from the high voltage side of a triac).	

5.5.3 Logic and Memory Systems

Content

Tri-states to link two or more logic outputs to drive the same line;	
The construction of RAM from D-type flip-flops, tristates and logic gates;	
The use of RAM to read and write binary words from a common data bus;	
The use of registers in the storage and processing of binary words.	

Learning outcomes

Candidates should be able to:

5.5.3a	recall and explain the use of tristates as devices which allow two or more logic systems to drive a common line;	
5.5.3b	explain the construction and operation of RAM using D-type flip-flops, tristates and logic gates as sub-systems;	
5.5.3c	recall and describe the use of RAM to read and write binary words from a common data bus;	
5.5.3d	recall and describe the use of registers in the storage and processing of binary words;	
5.5.3e	construct registers from D-type flip-flops.	

5.5.4 Microprocessor Systems

Content

Microprocessor systems treated as an assembly of sub-system blocks;	
The terminology of the operation of microprocessor systems;	
Using the microprocessor to carry out simple tasks by writing and analysing machine code software.	

Learning outcomes

Candidates should be able to:

5.5.4a	recall and describe the microprocessor as a programmable assembly of memory, tristates, latches, registers and logic gates;	
5.5.4b	explain the operation of a simple microprocessor in terms of a block diagram, including blocks for the clock, CPU, RAM, ROM, input and output ports;	
5.5.4c	explain the use of the following terms in the context of microprocessor systems:	
	bit, byte, word length,	
	clock, accumulator, arithmetic and logic unit,	
	instruction register, general purpose register, program counter,	
	fetch-execute cycle, program jumps and branching,	
	subroutines, look-up table,	
	direct and indirect addressing,	
	RAM and ROM,	
	8-bit input and output ports,	
	data bus, address bus, control bus,	
	flow chart, hexadecimal code,	
	interrupt, handshaking,	
	central processing unit,	
	memory, memory pointer;	
5.5.4d	recall and explain the use of interrupts to allow an external device to be serviced on request;	
5.5.4e	describe the use of the stack to store the contents of the program counter and other registers before the interrupt routine is started, and the restoration of the contents of the registers at the end of the interrupt routine;	
5.5.4f	write and analyse software in machine code using the instruction set for an imaginary 8-bit microprocessor system in Appendix E;	
	write and analyse software to accomplish the following tasks:	
5.5.4g	the control of up to 8 parallel output lines, including the generation of sequences of binary words with time delays between change;	
5.5.4h	driving a 7-segment LED display from a look-up table;	
5.5.4j	multiplexing several 7-segment LED displays from eight lines;	
5.5.4k	the switching of devices via relays and triacs;	
5.5.4m	the rotational control of a stepper motor, including causing single steps in either direction, a fixed number of steps and steps at a specified rate to produce a specified angular velocity;	
5.5.4n	the use of a digital-to-analogue converter to produce square, triangular and saw-tooth waveforms; no understanding of the construction of the DAC is required;	
5.5.4p	the use of switches to input data to a microprocessor system: the need for a handshaking flip-flop to synchronise the input device and the microprocessor;	
5.5.4q	sampling, storing and displaying an analogue signal with the aid of an analogue-to-digital converter; no understanding of the construction of the ADC is required;	
5.5.4r	control of external systems, using sensors connected to the input port and actuators connected to the output port.	