# APPENDIX A

## Equations in electronics

(a) In solving quantitative problems, learners should be able to use correctly the following relationships using standard SI units, without them being provided:

| | |
|---|---|
| voltage = current × resistance | $V = IR$ |
| power = voltage × current | $P = VI$ |
| power = (current)$^2$ × resistance | $P = I^2 R$ |
| energy transfer = power × time | $E = Pt$ |

| | |
|---|---|
| $R = R_1 + R_2$ | resistors in series |
| $R = \frac{R_1 R_2}{R_1 + R_2}$ | resistors in parallel |

(b) In addition, learners should be able to select correctly from a list and apply the following relationships:

| | |
|---|---|
| $V_{OUT} = \frac{R_2}{R_1 + R_2} V_{IN}$ | voltage divider |
| $P = \frac{V^2}{R}$ | power dissipated in a resistor |
| $I_D = g_M (V_{GS} - 3)$ | MOSFET |
| $I_C = h_{FE} I_B$ | current gain of a junction transistor |
| $f = \frac{1}{T}$ | frequency, period relationship |
| $T = 1.1RC$ | time delay of a monostable |
| $f = \frac{1.44}{(R_1 + 2R_2)C}$ | frequency of an astable |
| $\frac{T_{ON}}{T_{OFF}} = \frac{R_1 + R_2}{R_2}$ | mark/space ratio of an astable |
| $G = \frac{V_{OUT}}{V_{IN}}$ | amplifier voltage gain |
| $G = 1 + \frac{R_F}{R_1}$ | non-inverting op-amp circuit voltage gain |
| $G = -\frac{R_F}{R_{IN}}$ | inverting op-amp circuit voltage gain |
| $V_{OUT} = -R_F \left( \frac{V_1}{R} + \frac{V_2}{R} + .... \right)$ | summing amplifier output voltage |

$$\overline{A + B} = \overline{A}.\overline{B}$$

$$\overline{A.B} = \overline{A} + \overline{B}$$

Boolean identities

# APPENDIX B

## SI units used in electronics

Learners should recognise, carry out calculations and be able to communicate using:

(a) The following SI units:

ampere (A), second (s), hertz (Hz), joule (J), watt (W), volt (V), ohm (Ω);

(b) The following SI multipliers:

p, n, μ, m, k, M, G, T.

# APPENDIX C

## Mathematical requirements and exemplification

In order to be able to develop their skills, knowledge and understanding in electronics, learners need to have been taught, and to have acquired competence in the following areas of mathematics indicated in the table below.

The table illustrates where these mathematical skills may be developed and could be assessed. The list of examples is not exhaustive. These skills could be developed in other areas of the specification content.

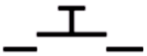
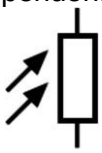
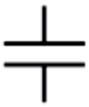
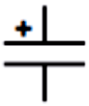
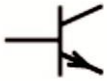
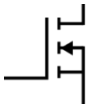
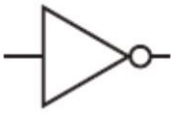
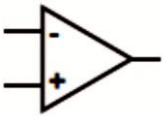
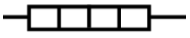
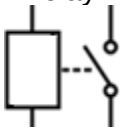
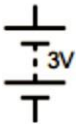
| | **Mathematical skill** | **Exemplification of mathematical skill (assessment is not limited to the examples given below)** |
|---|---|---|
| **1 – arithmetic and numerical computation** | | |
| a | Recognise and use expressions in decimal form | Convert between units with different prefixes, e.g. A to mA<br>Identify the correct units for physical properties such as Hz, the unit for frequency |
| b | Recognise and use expressions in standard form | Use frequencies expressed in standard form such as $2.5 \times 10^7$ Hz |
| c | Use fractions, ratios and percentages | Calculate the fraction of the charge lost from a capacitor in a given time |
| d | Calculate squares and square roots | Calculate the power rating required for a resistor |
| **2 – handling data** | | |
| a | Use an appropriate number of significant figures | Report calculations to an appropriate number of significant figures<br>Understand that calculated results can only be reported to the limits of the least accurate measurement |
| b | Find arithmetic means | Calculate a mean value for repeated experimental findings |
| c | Make order of magnitude calculations | Evaluate equations with variables expressed in different orders of magnitude, e.g. 150 kΩ and 2.6 mA |

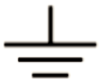
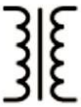
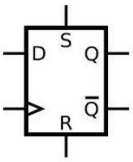
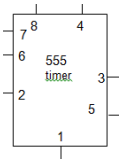
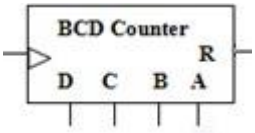
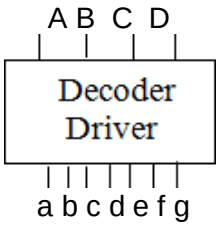
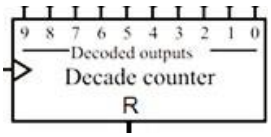
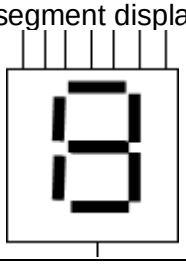
| | **Mathematical skill** | **Exemplification of mathematical skill (assessment is not limited to the examples given below)** |
|---|---|---|
| **3 – algebra** | | |
| a | Understand and use the symbols: =, <, <<, >, >>, ∝, ~ | Recognise the significance of the symbols in the expression: $V_{IN} < 0.7$ V the npn transistor is off |
| b | Change the subject of an equation | Rearrange $P = \frac{V^2}{R}$ to make R the subject |
| c | Substitute numerical values into algebraic equations using appropriate units for physical quantities | Calculate the frequency of a 555 astable by substituting the values for $R_1$, $R_2$ and C into the equation: $f = \frac{1.44}{(R_1 + 2R_2)C}$ |
| d | Solve simple algebraic equations | Find a capacitor value for a given time delay and resistance in a 555 monostable |
| e | Use simple Boolean identities | Simplify a logic system |
| **4 – graphs** | | |
| a | Translate information between graphical, numerical and algebraic forms | Measure the ripple voltage from output graphs for rectified power supplies |
| b | Plot two variables from experimental or other data | Plot I-V characteristics of a diode |
| c | Draw an appropriate trend line onto plotted data | Drawing a trend line for ntc thermistors resistance against temperature |
| d | Interpret data presented in graphical form | Reading data from an amplifier's voltage gain graph |
| e | Determine the slope of a graph | Calculate a resistance value from a V-I graph |
| f | Calculate the rate of change from a graph showing a linear relationship | Calculate the slew rate from a V-t graph |
| g | Draw and use the slope of a tangent to a curve as a measure of rate of change | Calculate the gain of an amplifier from the transfer characteristic |

# APPENDIX D

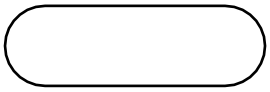
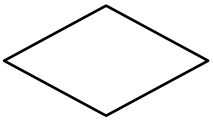
## Electronic symbols

Learners should recognise and be able to use the following electronic symbols:

| | | | |
|---|---|---|---|
| Switch (latching)  | Switch (non-latching)  | Light dependent resistor  | Thermistor  |
| Photodiode  | Microphone  | Variable resistor  | Potentiometer  |
| Resistor  | Capacitor  | Electrolytic capacitor  | Inductor  |
| NPN transistor  | N channel MOSFET  | Diode  | Zener diode  |
| AND gate  | OR gate  | NOT gate  | NAND gate  |
| NOR gate  | Op-amp  | Schmitt inverter  | Ammeter   |
| Voltmeter   | Buzzer  | Speaker  | Light emitting diode  |
| Signal lamp  | Filament lamp  | Heater  | Motor   |
| Relay  | Cell  | Battery   | AC supply  |

| | | | |
|---|---|---|---|
| Earth  | Transformer  | D type flip flop   | 555 timer   |
| Binary counter   | Decoder driver   | Decade counter   | 7 segment display  |

Circles can be put on S and R inputs for D types, and on CK and R inputs for counters (or bars over the letters) when inverted.

| Terminator | Input/output | Process | Decision |
|---|---|---|---|
|  |  |  |  |