FACTFILE:
GCE TECHNOLOGY & DESIGN

1.12 SAFETY

Rewarding Learning

Safety

Learning outcomes

Students should be able to:

- demonstrate knowledge and understanding of the safety issues and procedures involved in the production, testing and use of electronic and microelectronic control systems in an educational environment;

Course content

The specification focuses on safety relating to electronic and microelectronic control systems in an educational environment.

Designing of electronic and microelectronic control systems

Component Values and Ratings

The production of an electronic system starts at the design stage. Here the correct design of circuits and choice of components is important in ensuring the safe use of the system. An obvious example would be the choice of resistor for a particular application. The power dissipated in a resistor can be calculated using:

$$P = V^2/R$$

We can see from this that:

1. The power is proportional to the square of the voltage. By working with low voltages we reduce the power used in the resistor.
2. The power is inversely proportional to the value of resistor. This is to be expected since small value resistors will allow large currents to flow and hence a large power dissipation. By designing circuits with larger value resistances, the power used in the resistor will be reduced.

Worked Example

1. In designing a circuit you are using a 9 V supply. The resistors that you are supplied with have a power rating of 0.25 W. What is the smallest value of resistor that you could safely use across a 9 V supply.

Answer: Using $P = V^2/R$ and substituting we obtain
$0.25 = 9^2/R$
$R = 81/0.25 = 324\Omega$

Of course it may be necessary to use a smaller value of resistor in this circuit. If so, then either ensure that the maximum voltage across the resistor is smaller than 9 V or obtain a resistor with a higher power rating.

2. In his project, a pupil requires a voltage divider across the 10 V power supply and has chosen a 10 Ω variable resistor with a power rating of 1 W. Determine if this is a safe choice and if not, suggest an alternative.

Answer: Using $P = V^2/R$ and substituting we obtain $P = 10^2/10 = 10$ W

Since this is much higher than the power rating of the variable resistor, it is likely to overheat. In most cases, the actual value of resistor used in a voltage divider is not critical as long as it is not too large. By substituting in the equation you will see that the value of the smallest 1 W variable resistor that may be used across a 10 V supply is 100 Ω. In practice a 1 kΩ resistor is probably a good choice.

The same principle applies in selecting other components. It is probably true to say that most components in an electrical circuit generate some heat. A few simple calculations will avoid component overheating.

Another cause of problems may be the polarity of the component. Whilst resistors can be placed in a circuit either way round, the orientation of polarised components is critical. This includes electrolytic and tantalum capacitors, diodes of all types including LEDs, transistors, thyristors, integrated circuits and output devices such as some types of buzzers, piezo transducers and displays. This is important not only to ensure that the circuit functions correctly but safely.

Besides components overheating, it is possible for capacitors to explode if the voltage rating is exceeded or if connected the wrong way round.

If the circuit is drawn using a good modelling computer application, incorrect components will sometimes "explode" on screen which is safer than this happening in real life.

If the circuit is required to supply particularly high currents, it may be necessary to include fuses or thermal cut-outs within the design.

Production of electronic and microelectronic control systems

Having designed a circuit that meets your requirements, you may wish to manufacture a printed circuit board for your circuit. The two main methods used for pcb production currently are etch tanks and cnc routers. Care must be taken when using etch tanks. The chemicals used in etch tanks are dangerous and so CNC routers are very safe to use since the router will not operate when the door is open. The main safety requirement would probably be to keep hands clear of the cutting tool when inserting or removing the pcb.

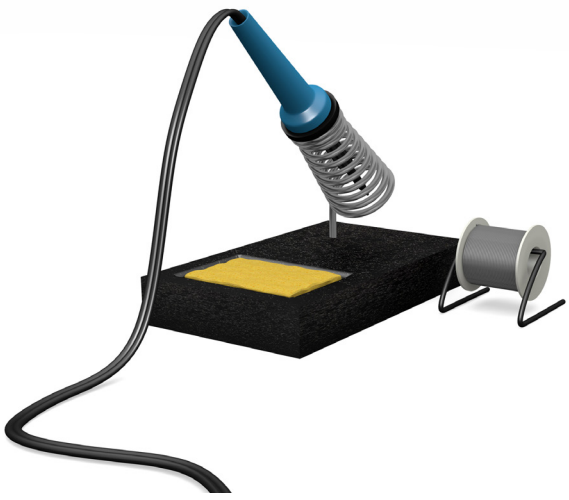
One advantage of the CNC method of pcb production is that the router may be programmed to drill the component holes. If any non-standard holes are required or if the etching method is used, then holes may have to be drilled using a pcb drill. Although perhaps not as dangerous as using a pedestal drill, it is possible cut a hand or finger on the drill bit or to be hit by a broken bit. Safety precautions would include wearing safety glasses and tying back long hair to avoid entanglement.

The final stage of pcb production is the soldering of components. As with all practical activities, it is important that risk assessments are carried out by teachers before any activities are carried out. The Scheme of Work for this specification lists a number of safety documents relating to soldering.

These highlight a number of dangers:

- The risk of severe skin burns since the melting point of solder is over 180 degrees Celsius so soldering irons operate at temperatures up to 400 Celsius;
- The risk of eye damage caused by the solder "spitting";
- Fumes produced by the rosin in the solder flux in some solders;
- The solder itself which may contain lead;

The electrical cable connected to the soldering iron may be damaged carelessly of maliciously.



Precautions include:

- Only solder in a well-ventilated room;
- Wear safety glasses and tie back long hair when soldering;
- Check cables for damage before commencing;
- Avoid over-heating components;
- The soldering iron should not be left lying on the bench. It should be "in the stand" or "in your hand".

Testing of electronic and microelectronic control systems

It is important to test completed electronic circuits thoroughly. Before connecting the battery or power supply, it is a good idea to carry out a visual check to ensure that components have been connected according to the circuit diagram and that there are no short-circuits or dry joints, perhaps due to poor soldering. A good power supply is likely to "cut-out" in the event of a short circuit which can avoid damaged components. It is also a good idea to connect the circuit board to a power supply before inserting any integrated circuits. If there is a short circuit at this stage, it is important to fix it before proceeding. In some cases the circuit may work correctly first time. In others, it may be necessary to use a multimeter to check if the voltage levels correspond to those in the circuit diagram or on the computer screen.

During the testing process, look out for components which become excessively hot. Even if the circuit does work first time, "bench-testing" under full load conditions may be necessary to ensure that the circuit does not fail when in use.

Students should not be working with circuits where there is any possibility of an electric shock. It is however possible for a large voltage to be generated in a low voltage electronic circuit, for instance when an inductive load such as a relay is de-energised. However this is not likely to cause an electric shock. (This principle is used in some emergency exit lights where a 6V battery powers 240V lights during a power cut.)

Use of electronic and microelectronic control systems

If a circuit has been correctly designed, produced and bench-tested, we would expect that it would continue to work reliably. However we are all aware that even professionally manufactured products have to be recalled due to safety concerns. When using a product, some safety precautions need to be observed. It is important to check that mains power cables for power supplies, oscilloscopes and other test equipment are not damaged in any way. The mains equipment should be fitted with fuses of an appropriate value and the mains circuits should include fuses or RCB circuit breakers.

All fixed and portable mains appliances used in schools are tested regularly and faulty equipment removed from service. The environment in which a product is used may affect its performance and safe use, in particular if it is used in a damp or wet environment. The location of the nearest fire extinguisher, suitable for electrical fires, should be known when using electrical equipment.

Revision Questions

1. State **two** general safety features that can be incorporated into electronic circuits and explain how these features improve safety. [4]
   Source CCEA AS May 2009 Q9

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2. Describe **two** safety issues associated with electronic and microelectronic control systems. [2]
   Source CCEA AS Jan 2011 Q 9 (b)

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3. Describe **two** main safety issues that should be considered when working with electronic systems. [2]
   Quality of written communication [1]
   Source CCEA AS Jan 2012 Q 10(c)

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