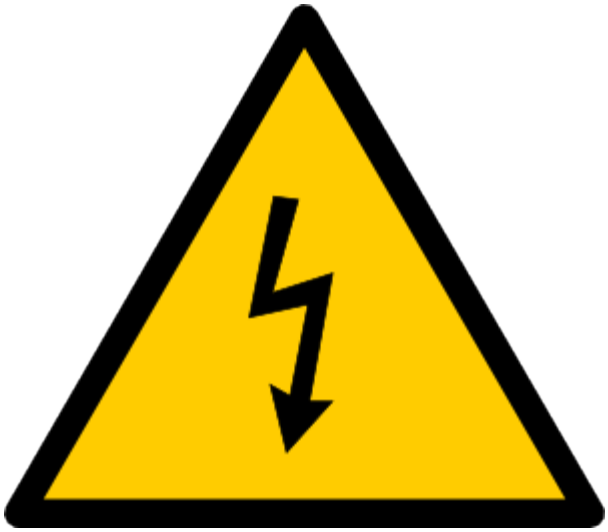
Electrical Safety – Part I



Mains voltage electricity is extremely dangerous. There is a significant risk of death through electrocution if mains voltage electricity is allowed to pass through the body. There can also be a risk of fire and explosion if electricity is not cabled and fused correctly. Therefore precautions must be taken when using mains electricity or similar.

There is a lot that can go wrong with electricity with potentially dire consequences. Some of these are obvious - NEVER use your finger to test for the presence of a mains voltage! - but others may not be such as heat-sinks that are connected to the high voltage connector of a triac. Read this page in full and ensure you think about all the aspects when designing your next circuit. **If in any doubt seek out the advise of a qualified person**.

This section gives advice relating to domestic mains electricity and lower voltages. Higher voltages such as electrical substations and railway gantries are much more dangerous. Never approach any high-voltage cables or anyone having suffered a shock from a very high voltage unless you have confirmation that the supply is disconnected.

Electrocution

The most obvious risk from electricity is electrocution through contact with a live circuit. This is where an electrical current flows through the body which can result in the heart stopping to work (cardiac arrest).

What is a dangerous voltage?

It's actually the current that is important rather than the voltage, but due to the resistance of the body you can't get a dangerous current without there being sufficiently high voltage. You can work this out yourself using ohms law, but the important thing as far as this is concerned is to remember the safety principles. **Generally you are relatively safe dealing with voltages of less than 50V, but anything above that can be dangerous**.

You are generally safe from electrocution on most electronic circuits that run off domestic batteries, including 12v car batteries. There may however be batteries in your home that can pose a real danger, such as the output from a UPS (uninterruptible power supply) for a computer, or if you have a home energy system such as solar panels.

Even if you equipment is designed to run at less than the dangerous voltage for electrocution it may still pose a risk of burns, fire or even explosion - so keep reading.

AC vs. DC

You may have heard some people say that AC is more dangerous than DC power, or vice-versa. Rather than get into too much debate over one vs. the other **both AC and DC at high voltages can be lethal**. AC is considered to be more likely to cause cardiac arrest by interrupting with the electrical signals controlling the heart, but DC can cause burns and both can still kill so debating the differences is pretty academic. Just remember **electricity can kill if it has sufficient voltage and current whether it's AC or DC.**

The following are ways to reduce the risk of an electrical shock.

Avoid mains electricity

The safest way is to completely avoid using mains voltage in a computer circuit. Most electronic circuits work on low voltages and can be powered by batteries or an external plug-in transformer. The safest way to use a transformer is to use a power-brick (such as the power adapters normally used with laptop computers) or a plug transformer (known as a wall wart in the US) such as those used to power your mobile phone. These will convert the voltage down to a safe voltage that the electronic circuit will work at (eg. 6v to 12v for the Arduino) and in most cases also convert the signal from AC (as supplied from a mains socket) to DC (used for most electronic circuits). These transformers will usually be double-insulated and have no high-voltage parts that are accessible by a user. Make sure that the transformer is suitable for the type of circuit (eg. voltage and current rating) and for the power supply it is being plugged into.

You should still check for any physical damage to the transformer as you should prior to plugging anything into mains electricity.

If you need high power then an external power supply may not always be an option in which case extra care should be taken.

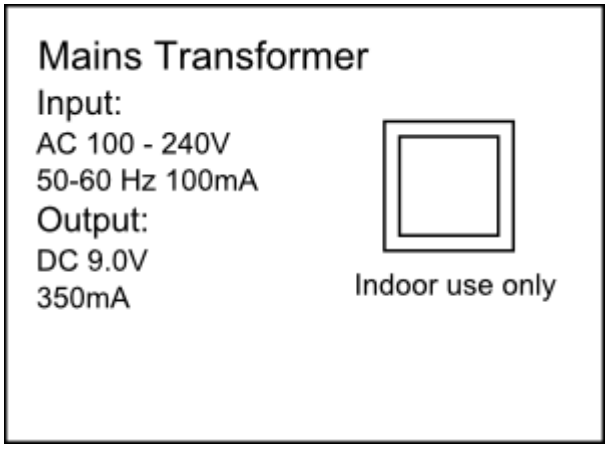
Isolate from mains when working

If you've ever seen equipment that says "high-voltage do not remove cover", or "disconnect mains supply before removing cover" then there is a risk that there are unprotected mains voltages inside. If you have removed a cover from a mains electrical device where possible that cover should be fixed back into place before connecting back to the mains.

Earth the case of mains equipment

If you do use mains voltage in a project then you should normally use a metal case and earth the case. This is done by taking a wire from the earth terminal and connecting this to an exposed metal part of the case. Sometimes there is a special connector in the case for connecting the earth, but if not then it can be connected to a metal screw holding the parts of the case together. You should then perform appropriate testing to make sure that all the metal / parts of the case is properly earthed.

A risk with mains voltage is that a live connection (eg. a loose wire) comes into contact with a metal case and then someone touches the case creating a path for the current to go through the person to earth. If this happens then it can pose a risk to any user of the equipment. If the case is earthed then if a live wire comes into contact with the case this will provide a direct route to earth and blow the fuse for the equipment. If you find that your fuse keeps blowing then check for a short circuit to the case. If using a mains connector to bring the electricity into the case then a 3-pin connector will need to be used such as an IEC C13 connector (2-pin connectors do not have earth and are therefore not suitable). **Always use an appropriate sized fuse to the equipment (eg. in the plug) to ensure that if there is a connection to earth that the fuse blows**. The fuse can be within the plug (standard in UK domestic plugs) or a combined connector and fuse module can be used.



An alternative to using a metal case is to use a plastic insulated case, however if you do you need to ensure that

there are no metal connections that are not earthed that go from the inside to the outside of the case that could come into contact with the mains voltage. This includes any switches, or any screws used to hold the circuit board in place and any external connectors. This is difficult to achieve in DIY projects which is why I recommend use an earthed metal case. On commercially made electrical equipment you can often see the double-insulated symbol to signify that full insulation is used rather than earthing.

When using mains voltage you also need to ensure that it is not possible to come into contact with any high voltage parts by entering through the case. This is best achieved by ensuring that there are no holes in the case, but sometimes it is necessary to include holes in the case for ventilation purposes. In this case the finger test should be used to ensure that it is not possible for a finger placed into the hole to come into contact with any mains electricity. Obviously if you are actually testing this you should do this with the electricity disconnected. Also consider that some people (especially children) will have smaller fingers.

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