WACL Electronics Course

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0.1 Electronics basics

Understanding of the electronics behind processes or sensors used in the field can really help within research. Whether this is in the repair of equipment, design of a system to automate data measurement, or to help understand why read data is significantly different than expected. This course will try to take you through the basics, while linking it to examples important for Chemistry related research. By the end of the course, you should have an understanding of basic electronics theory and practice, an understanding of terminology, and should be able to build a basic system using a sensor and control loop. There will be opportunity to learn theory, seeing how this relates to practice, with specific Chemistry examples, and chance to use and view simulation to help to solidify knowledge. Then as your confidence grows, you will get opportunity to put this learning into practice.

Where it would be beneficial, there will be references to chemistry theory, to have another way of looking at some theory.

We will start with the basics of electronics. There are a range of ways in which it can be represented, but starting with the physics can be helpful.

Electronics involves a flow of electrons, for a transfer of energy over time (i.e. power). This is represented through voltage and current. If this was to be represented as or letters in a mail network, voltage is the magnitude/ number of letters each mailperson recieves, where current is the rate at which a new batch are delivered. A component or drop off point along the network will have a resistance, which is the number of letters they will pick up from each mailperson.

Regarding physics, electronics works through the transfer of electrical energy, which goes through a conversion process in components. A resistance will cause a heat conversion/ heatloss, where a capacitance and inductance which will be discussed in further detail later is due to a conversion to electric potential and magnetic potential.

Focusing just on resistance for now, this can be represented as several key physics equations, important for physics based electronic theory and practice.

$$V = IR, P = IV, P = I^2R, P = E/T$$

As can be seen, $P = I^2R$ can be derived by rearranging and putting $V = IR$ into $P = IV$.

Voltage is represented with V, with the unit volt. Current is represented with I, with the unit Amp. Resistance is represented with R, with the unit Ohm (with the greek letter Ω). Power is represented with P, with the unit Watt. Time is represented with T and is usally in seconds.

Now the basics have been covered a small quiz might be helpful to consolidate knowledge.

Quiz

1. What does resistance demonstrate?

a) The rate of flow of electrons.

b) The energy in each "packet" or electron.

c) Conversion of electrical to thermal energy/ heat.

2. Demonstrate how you would go from $P = I^2R$ to $P = IV$.

You can wire a circuit with parallel and series elements. A series circuit has a single loop, with components connected one after another, sharing a single voltage. A parallel circuit can have more than one loop branching out, with each loop having a voltage equivalent to the input, and the current will be split between them, based on their resistance.

Therefore, the voltage in a series loop will be distributed based on the voltage ratios. An example being, if there is a 10ohm resistor and a 5ohm resistor, where 9v is travelling through the loop, there would be a voltage drop of 6v through the 10 ohm resistor and a drop of 3v through the 5ohm resistor. With a total resistance of 15ohm, we can calculate the current to be $V = IR$, $I = V/R$, $I = 9/15 = 0.6A$.

A parallel circuit on the other hand has equal voltage across each path, with the current being split. Because of this, resistors in parallel path will represent a resistance, lower than the lowest resistance of a path. There is the below equation that can be used to figure this out-

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

Therefore, an example with the following circuit with 2 resistors of 3ohm and 7ohm, in parallel with a single resistor of 15ohm. You first add the series resistors, therefore R_1 can be represented as 10ohm and R_2 as 15ohm. Therefore, putting it into the equation gives us the below-

$$\frac{1}{R_{total}} = \frac{1}{10} + \frac{1}{15}$$

$$\frac{1}{R_{total}} = \frac{1}{6}$$

$$R_{total} = 6\Omega$$

0.1.1 Resistors

What are Resistors?

Now that the basics have started to be discussed, it would be important to look at resistors.

Resistors are components which are rated to have a specific resistance. Therefore depending on the circuit, there will be varying levels of losses seen from them. They can be quite important components to use when a part needs a specific voltage close to that of the source/ input, or as a way of limiting current flow.

Below is a basic circuit, with wires, a resistor and a battery, to demonstrate V=IR.

https://tinyurl.com/27gj49kj

In the specific example, we have a resistor of 1 Ohms and a voltage of 5V. Therefore, using $V = IR$, we can rearrange to find a current of $I = 5/1 = 5A$. This can then be used to find a power of $P = IV = 5 * 5 = 25W$. Each of these discussed can be seen on the simulation. Feel free to play around with it and alter values. Instructions in use of the simulation program can be found (here).

Example circuits etc

As this is early on, there aren't too many example circuits just using the above knowledge alone. One example though would be if a project required use of a heater. Given that you know the input voltage that you have avaliable, and the required thermal load, you can calculate the resistance of the heating element that you require.

0.1.2 Capacitors

What are Capacitors?

Capacitors are another key component worth discussing. They store energy in Electric Potential, with their voltage increasing towards the voltage of the circuit, as they are charged. Therefore, the charge and discharge curve is non linear, more following an exponential curve.

The unit for capacitance is Farad, with typical values depending on capacitor type but usually in the uF units or below.

Capacitance can be related through a range of physics based equations, which will be touched upon now.

Due to capacitors being related to how its plates are charged relating to its voltage, there is the following basic equation- $q = CV$. There is also the energy formula, for calculating the energy stored within a capacitor, with the following basic equation- $E = 1/2 * C * V^2$.

A resistor is usually placed in series with a capacitor to limit the inlet current provided to the capacitor. As it charges, the ratio between its voltage and the supplies voltage decreases, and as does the charge current, in a curve in the reverse direction to the voltage.

https://tinyurl.com/2erbz4jy

One of the built in simulation circuits from Falstad is helpful for showcasing the charge and discharge characteristics of a capacitor, by flicking the switch.

Example circuits etc

0.1.3 Inductors

What are Inductors?

Inductors are the other main energy storage passive. These store energy within the magnetic field, and have a range of uses, usually in power electronics.

The unit for inductance (L) is Henry, with typical values depending on inductor type but usually in the uH or mH units or below.

Inductance can be related through a range of physics based equations, which will be touched upon now. There is the following basic equation- $L = \frac{\Phi(i)}{i}$. There is also the energy formula, for calculating the energy stored within an inductor, with the following basic equation- $E = 1/2 * L * I^2$.

Example circuits etc

0.1.4 Sensors

What are Sensors?

Sensors are likely going to be one of the key components/ modules that you will use in your research, so understanding how they work and what options you have is important. There could be a lot of detail that this goes into, so the key aspects will be discussed initially, and maybe more will be written into the further reading. It will purposely use parts which are a combination of through hole, and SMD, with option to pick which you would like to choose, incase there is a limit to what you can do. There

will be pinheaders which you can bridge/ a solder bridge I need to think, if all the parts are soldered.
This will be split into several sections, covering some of the major sensors, with more detail on sensors likely to be used within Chemistry related projects.
Temperature sensing can be done with a range of different methods, and is likely to be quite important. The most common sensors are analogue ones, where the components resistance changes along with a temperature change, although there are digital sensors for this too. There are 4 main categories of temperature sensor, which we will quickly touch upon each. There are Thermocouples, RTDs, Thermistors and specific digital ICs.
Thermistors are one of the more common types, and can be divided into NTC and PTC, with NTC being more common. NTCs have a decreasing resistance compared to temperature, and will have a resistance rating for 25C typically along with a value for how much their resistance changes per degree. Therefore, utilising a circuit to measure this resistance allows for a relatively accurate temperature to be read.
Photoresistors use a similar method but for light, where there is usually a resistance associated for them for pitch black, and a resistance for light, so an estimated light measurement can be attained from this.
There are a range of movement based sensors, which will quickly be touched upon. This will not be in great depths, as you are unlikely to require the use of these too much.
One of the main cheap and widely used range/ movement sensors is an Ultrasonic sensor, which has an ultrasonic transmitter and reciever, which using knowledge of the speed of sound, measures the amount of time it takes for sound to hit a surface and reflect back, to then calculate a distance value.
There are also LiDar sensors, which are similar but known to have higher precision, which uses a singular beam of light, and calculates its time of travel, these are also known as Time of Flight (ToF) sensors.

0.1.5 Diodes

Diodes are widely used in electronics with a range of purposes. The basic principle of a diode can be thought of as a device/component which limits how current can flow within a circuit, such as restricting current flow to one direction. This makes them beneficial for a range of circuits such as protection circuits, preventing unwanted reverse current flow which could damage other components or cause unwanted side effects. They are one of the simplest examples of applications of semiconductors.
There are also LEDs, which work through the same principles, but emit light of a set or alternating spectra depending upon selection. There is a voltage drop associated with this, but with considerably lower heat output, compared to filament bulbs, which worked by heating a filament to the point at

which it begins to glow.

0.1.6 Switches

Switches are widely used within electronics, and are what has led to the field of digital electronics. Microcontrollers may use millions of switches on a single silicon die, where discrete switches tend to be used for power electronics now.

Switches are important to have control of a circuit. These will be discussed in greater depth later on, but they usually have a gate which is triggered externally, which closes a circuit. So you can think of a switch as a tap allowing or restricting water to flow. The vast majority of these are semiconductor based, due to the low losses involved, although they are limited to DC function.

This document will quickly talk over the main types in some detail, so you can understand why each may be used, or why the surrounding circuit looks like it does.

There are current controlled switches and voltage controlled. BJTs are an example of a current controlled switch, where a flow between the gate pin and the emitter allows for a higher current to flow between the emitter to the collector. There is a voltage drop though, which can mean losses are fairly significant at lower voltages. They have the benefit of being quite easy to use in a circuit, after calculation of values.

Then there are voltage controlled switches, the main example of this being MOSFETs. These have a gate which is allow current to flow after the voltage is higher than a threshold value. They are more complex to use, since the gate acts as a capacitor, so has to be charged, so may not function well without a properly considered gate charge circuit. Losses are related to the MOSFETs internal resistance though, which can get very low, so they are typically fairly efficient.

There are other types, but these tend to be for power electronics, so we do not need to go into that level of depth.

Relays are an alternate form of switch, which use an electromagnet to cause a switch to open or close. These are particularly useful for AC applications, as most switches are limited to working with DC.

0.1.7 Opto-isolators

Opto-isolators, otherwise known as optocouplers, are components that use light to transfer electrical signals between two isolated circuits. This is important if the two circuits run at differing voltages, or need to stay isolated.

They work through the use of an LED and a photo-sensor/ photo-transistor, so it is light that transmits the data, to keep them electrically isolated. They are useful for measuring AC using DC electronics, so have uses within AC-DC power conversion/ supplies.

0.2 555 timer

555 timers are fairly adaptable circuits, for a range of timing technqiues, that may not require a whole microcontroller. Although understanding the internal structure of a 555 timer is out of the scope of this course, understanding how and why they are used could be beneficial. Depending on how it is connected to, it can be used for outputting waveforms of different frequencies, or as a timer.

0.3 Communication protocols

Communication protocols are important to interface with different devices and equipment, so a base understanding of some of the major ones would be important.

Communication protocols are a set of rules which devices follow to transfer information, allowing coherent data transfer at set speeds, depending on the usecase.

They can first of all be split into two main kinds, with inter system protocols being those used to have communication between devices, where intra system communication protocols are meant for between component communication.

Therefore you may have to use a combination of the two, depending on what is being done.

USB and UART are the main examples of inter system protocols, where SPI, I2C and CAN are some of the main intra system protocols. It is worth remembering that although these are some of the main protocols, it is not a definitive list, with more niche or proprietary protocols also being around which can often have specific benefits, or are just used to limit use of other companies chips for a given application.

Master and Slave are still fairly common terms used within communication protocols, so you need to be aware of the terms, although there is a shift to alternate terms such as controller and responder, although there is not yet a set standard. Other alternatives could be on the lines of primary and secondary, leader and follower and source and sink, although the latter of which already is widely used within electronics.

0.4 Electronics test equipment

There are a range of pieces of equipment that can aide you with electronics, which some may seem overwhelming at first. But understanding what they do, and why/ if they are needed are important!

A very common piece of equipment is a multimeter. These are used to measure current, voltage and resistance. When measuring current, the multimeter needs to be connected in series with what you are attempting to measure, where to measure voltage or resistance, you place the probes in series with the component or circuit segment you are looking to measure.

A more complex piece of equipment which you may or may not use is an oscilloscope, which is again for measuring voltage and current, but comparing this against time, so graphs can be viewed/ produced using them. The software sometimes used within this course Falstad, uses scopes, which are a representation of what you would view through an oscilloscope probing a specific component or element of the circuit. It can be particularly helpful to check if the circuit is working as intended, or as an easier way to troubleshoot.

For electronics prototyping, breadboards are seen to be pretty important, as they allow you to connect up DIP components quickly for prototyping. They have many rows of 5 pins which are interconnected, so you can create an array of complex circuits with them, to quickly test out ideas. It is important to consider that they may not produce the most stable of circuits, and would not be recommended for the field due to loose connections.

The next stage from here is either a protoboard design, such as using vero or strip board, or the design of a custom circuit board, or use of existing modules suitable for the design. The cost of custom printed circuit boards have come down considerably over the past few years, through sites such as JLCPCB, so it has now become more of a viable option for designs for use in the field. In the further reading section, there may be small amounts of detail on PCB design or resources helpful for doing this, but it is not the focus of this course.

0.5 Necessary software

Throughout this document, you are encouraged to check simulations through Falstad. Falstad is a web-based, simple to use but relatively powerful circuit simulation program. It was designed orginially by Paul Falstad and is completely free to use.

It has been selected due to its ease of use, and ability to represent information about the circuit in a clear and helpful way.

LabVIEW will be required for the practical element of this course. LabVIEW is a graphical programming plaform, specifically intended for Test and Measurement, so was selected as a suitable program for testing out the skills developed through this course. This will need to be installed, using the Universities licence, which the steps can be found through the following resource- Link

0.6 Electronics safety

Safety is something that is a key consideration when doing anything with electronics. If you are unsure, it is always best to ask rather than to assume.

As has been discussed beforehand, current can be related to voltage and resistance through $V = IR$. The body has a resistance which can vary depending on length etc, but is relatively high. Therefore, as voltage increases, so will current if the resistance stays the same. It is always good practice to take caution when using electronics, but especially when dealing with higher voltages, as it can be fatal. It is likely that the voltages used for the in person practical elements will be low voltages.

Something that might not be initially considered is ratings of components. This is something that is very important, to ensure that a selected part can take the expected power loss without damage. Therefore it is important when selecting a resistor to calculate its estimated power drop, and select a resistor with a power rating clearly above the max predicted power losses. It is important to add a safety buffer, as circuits in reality are not ideal, so may react slightly different than expected, such as a component having a resistance value that differers from its value. Regarding differing values, a tolerence can be found, which is the percentage at which a value can differ. This is usually under 20% (it can be considerably smaller). If you are unsure, it is better though to add a safety buffer, x2 the calculated value is fairly common, as it helps to account for how the tolerences of other components affect that one.

It is important to consider that all components have losses, including wire, so this needs to be considered, with a wire or connector of suitable ratings selected. With this waste heat, also comes a voltage drop, which may also be a factor, as if high enough, can cause issues with the circuit itself.

For wires, you have different wire gauges, and sometimes different materials. Typically wires will be copper, but sometimes they could be aluminium, which has a resistance around 64% higher than copper, so looking at wire gauge alone isn't always enough. Again it is helpful to keep the chosen wire a fair bit above the power rating you require, considering that only just meeting those ratings will lead to considerable losses in the wire. And if there are cost constraints, it is important to consider that a thinner wire which is initially cheaper may end up costing more due to electrical losses.

There are a range of types of connectors too, depending on the application, each of which that have their own rating. Mechanically connected, such as screw terminals are likely to have a resistance higher than directly soldered, but can give more flexibility to make alterations.

You should be careful when handeling components, as built up static can cause damage. Grounding yourself, such as touching a metal surface can help to reduce this static potential.

Soldering may be something that is required for a project. There are health risks associated with all forms of soldering, so it is best to solder in a well ventilated area with the suitable equipment. If possible, although slightly harder to work with, it would be recommended to use lead free solder, reducing health risks and allowing for safer use in the field. Within solder, there is flux which helps solder to flow better, but the evaporation of this produces a vapour which can be harmful if inhaled. Many soldering iron setups have extraction next to the iron, to minimize this chance of inhaling it.

0.7 Component footprints

It is important to be aware of the fact that components can be sourced in a range of footprints, which may be necessary to look into for electronics design or repair. Imperial measurement is most commonly used for surface mount resistors, capacitors and inductors, with values associated with mils, which represent 1000th of an inch. In many cases surface mount components will be used with commercial products, so use of one may be required in replacement of a faulty part. Understanding their size, and your ability to solder them is important, and it is often a challenge that people follow to trial their ability. You may be able to access a soldering oven, which can help make this process easier, considering that as solder melts, it can somewhat help to pull a component into place, if it is minorly offcentered. It is important to consider that components are only rated to take a certain amount of heat, so care should be taken to not break components through thermal damage. If a component with multiple pads are being done, there could be time between the pins to allow a cooling period, to prevent large heat build up which has the potential to do damage.

0.8 Further reading

This section is here to provide some further reading into more advance topics. Although you may not need to make a circuit using the below, understanding of them may come in beneficial. Some of the below circuits also will help to solidify your understanding of the key components mentioned above.

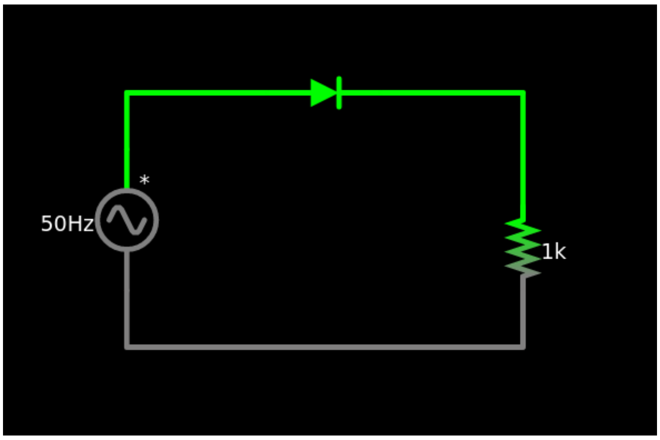
0.8.1 Rectification

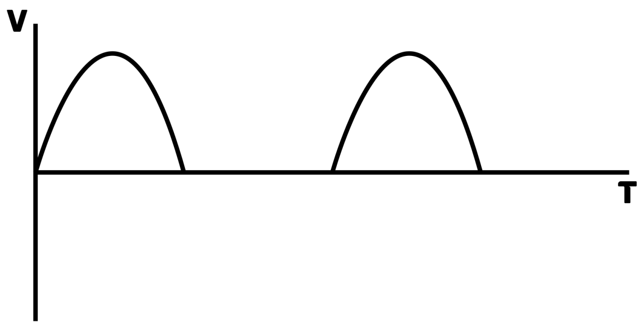
What is Rectification?

Rectification is the process of converting AC to DC, commonly used in power supplies, such as a phone or laptop charger. This is very important due to digital electronics requiring DC to function. Although repair/ diagnosis of AC circuitry should not be undertaken without the necessary training, understanding of how AC circuits function is important for safety and to better understand the use of different components.

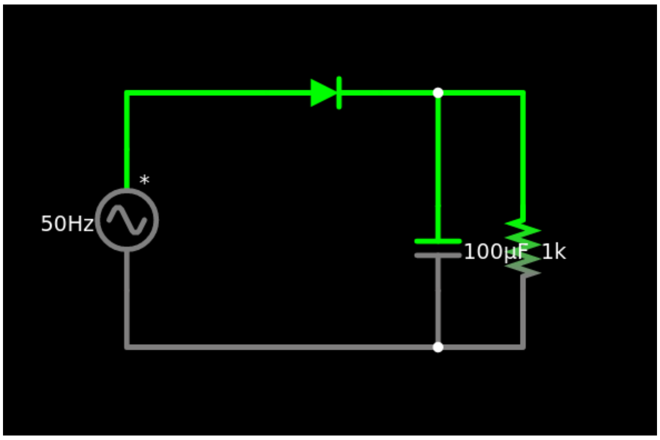
This circuit uses components which have already been discussed earlier in this document, so for further explanation refer back to the appropriate sections.

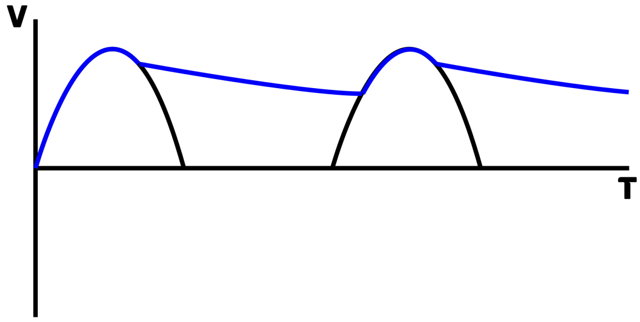
For this AC-DC conversion, the alternating current needs to be converted to flow in just one direction. Therefore a key component in this process is a diode (This will provide a hyperlink to the diode section). The most basic form of circuitry is a half-bridge (otherwise known as half-wave) rectifier. This uses a single diode in series with the load, to only allow current flow in one path. Therefore, the output wave will be only the positive side of the sinusiodal wave, meaning that the average voltage seen at the output would be around half of the RMS voltage, although in a form likely unsuitable for most DC circuits.



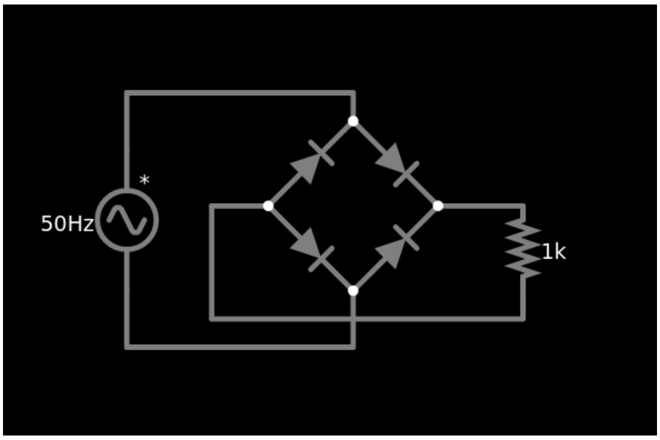


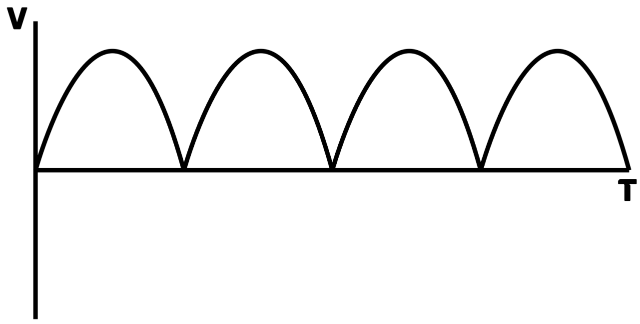
A half-bridge circuit can be improved through use of filtering, with the addition of a capacitor to smooth the output voltage. This capacitor is added in parallel, where it is charged by the voltage, which it will then output this when the output drops below its own voltage. This means that the output voltage can get closer to being a smooth DC voltage. As previously mentioned, even if perfectly smoothed, the max voltage that could be attained is half the RMS voltage.

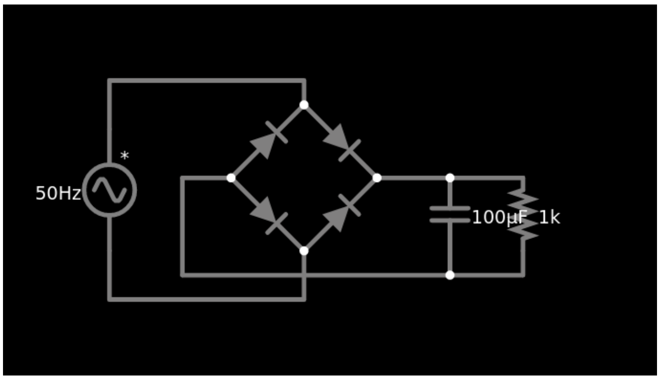


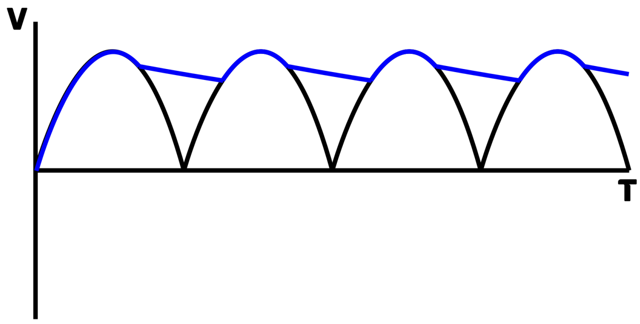


The next step to improve a half-bridge circuit is to make it a full-bridge rectification circuit, which utilises four diodes, meaning that whichever way the current flows at the input of the rectifier, it will be fixed at the output. Therefore there will be a sinusiodal voltage magnitude but only in the positive axis. This can again be smoothed with a capacitor, and if perfectly smoothed, can have a fixed output closely following the RMS voltage.









Example circuits, applications and considerations

This section will quickly look at applications of the above mentioned circuits.

Rectification circuits are used a considerable amount, especially for AC-DC power supplies, as an initial stage to convert AC to DC. Due to this, their main usage is within power supplies connected to the mains. Other applications though could include a dynamo torch, where the AC power generated from the motor needs rectification to suitably power an LED.

It is likely that in the majority of cases a full-bridge rectifier would be used rather than a half-bridge rectifier, unless initial costs were a major consideration.

Due to varience in the manufacturing process, even within a single product, it is commonly considered best practice to use a full-bridge diode package, where there are four equal diodes within one part.

Rectifiers are generally used as part of a more complex power system, usually as an earlier on stage.

Simulations

Below are several Simulations to have a play around with to help your understanding of Rectification.

Half-Bridge rectifier at 230V RMS, 50Hz- Link

Half-Bridge rectifier at 230V RMS, 50hz with capacitive smoothing- Link

Full-bridge rectifier at 230V RMS, 50Hz without smoothing- Link

Full-bridge rectifier at 230V RMS, 50Hz with capacitive smoothing- Link

Quiz

1. What is the main benefit of a full-bridge rectifier over a half-bridge rectifier.

a) It is cheaper to build.

b) It allows for full utilisation of the input voltage.

c) It uses less components.

2. Why are smoothing capacitors useful? (There may be more than one right answer)

a) They allow for a more constant output voltage.

b) They increase average power output.

c) They reduce output ripple.

3. True or False, it is known to be better to use several diodes individually rather than packaged together as a full bridge rectifier package.

4. True or False, rectifiers can be used to also convert DC to AC.

Challenge- Using Falstad or hand drawn, design a full-bridge rectifier with voltage variance/ ripple lower than 10%, working with an AC voltage of a peak value of 326V, at 50Hz.

Resources

There are many resources within electronics which can be helpful, both for learning more, but also for a range of different aspects. This will list some of the ones particularly worth looking into, and what they are for.

Suppliers-

Starting with several trusted parts suppliers.

Arrow Electronics- Europe based Electronics components shop.

RS Components- UK Based Electrical and Industrial components shop.

Mouser- US based Electronics components shop.

Farnell/CPC- Electronics components shop based in several regions.

LCSC- Electronics components shop based in China, with links to JLCPCB and EasyEDA, offering lower costs than most other suppliers for larger orders.

Digi-Key

Rapid- UK Based Electrical and Industrial components shop.

EuroCircuits- Lower cost PCB manufacturer based in Europe.

JLCPCB- Low cost PCB manufacturer based in China

Aisler- Lower cost PCB manufacturer based in Europe.

The majority of the above focus on singular components, which may not be what you are looking for. If you are looking more for modules or DIY components, there are a range of other trusted retailers.

HobbyTronics- UK Based hobbyist electronics shop.

Bitsbox- UK Based hobbyist electronics shop.

Adafruit- US Based company producing a range of boards/ modules.

Sparkfun- US Based company producing a range of boards/ modules.

Pimoroni- UK Based module maker and hobbyist electronics shop.

As almost a subset of suppliers, there are a couple of sites used to find stock of certain components across suppliers, while comparing their costs. Within these tools, there can be a range of other suppliers mentioned, quite a few of these coming under the reseller categories, where you may be paying more, but they often have a range of parts other suppliers may not have.

These could be thought of Electronic Part Search Engines.

Octopart

Findchips

OEMSecrets

EasyBom

Electronics Software-

There are several bits of Electronics Software mentioned below, whether it is for simulation or PCB design.

Falstad

LTSpice

TinkerCAD

MicroCap 12

KiCAD

EasyEDA

Supply Chain issues-

Since the Pandemic, there has been a range of issues coming up regarding supply shortages and stock issues. This has been further worsened by the fact that some companies/ institutions began to purchase components in excess to ensure they had what they needed. Being aware of this is key in electronics design, especially when a certain project may be replicated in the future.

It is important to consider stock at the beginning of a design project, and if you know yo may need a part, it is worth ordering it, rather than waiting for all the design to be done, as by that point it could be out of stock. The main issue is with specialized IC's and Microcontrollers, there isn't the same problems with passives/ discrete components, so these can likely be ordered once you know which are required. A similar mindset should be followed for modules though, as they often have parts with low stock, so should be bought when needed.

It is important to consider that the parts shortages started in 2020 are some of the worst that have been seen, mainly affecting silicon components. There was a combination of factors which kickstarted the particular problems. These included increase in demand for electronics, pandemic related shipping delays, natural disasters/ fires, vast increases in the price of silicon and trade disputes between China, US and Australia. The market naturally goes through periods of higher and lower supplies, so early 2020 was meant to be a period of lower supply anyway, which further worsened things. The situation has slowly been starting to improve though.

Tips could include to use discrete or widely avaliable parts over specific or niche ones where necessary, or modules where there are similar alternatives avaliable.

Environmental considerations- It is important to consider environmental considerations, this is in two respects. First regarding ensuring a product is suitable to the environment it is placed in, and also ensuring the design of the project has a limited carbon footprint or uses scarse, conflict materials or toxic materials.

It is important to source RoHS certified components, which should be the majority of components in the market. This certification restricts the use of harmful materials such as Lead within electronics. As previously mentioned, one of the main things that may not be RoHS certified is solder, as Lead based solder is still commonly seen especially in the prototype market. Lead based solder tends to be a mix of tin and lead, where lead free substitutes the lead for some of the following- copper, silver, nickel and zinc, as well as some others.

One way of somewhat reducing the carbon footprint could be choosing a smaller footprint, although for silicon products this would only make a minor difference, since it is likely that the silicon wafer itself is a high proportion of the carbon footprint.

There are not many steps that can be taken to reduce carbon footprint within sourcing, buying local will make an impact, but they have likely had to source these parts from long distances anyway. Therefore it is instead worth focusing on longevity and reusability of parts. If there is the design of a custom circuit board, use of pin headers for modules to slot into means that the modules can be reused, or if there are faults, the modules can easily be replaced rather than the whole unit.

There are a range of aspects regarding to where it is placed, such as whether waterproofing is required, or cooling. It is important to consider that rated temperature values are likely to be in ambient temperatures of around 25C, so an enclosed part with a poor thermal path, which is close to its rating could fail over time. Here is where it is important to consider whether active or passive cooling may be needed, such as a small copper or aluminium heatsink, along with a fan if active cooling is required. If a fan is to be used, the enclosure of the project should allow for an intake and outtake path for the air. Some component footprints may have heatsinks specifically built for them. Thermal design/ thermal relief can be factored into PCB design too, if needs be.