How the LC/C90 Charging System Operates

By Drjones18LC

Many of us that own an LC/C90 will most likely at some point be victims of the well known charging issues associated with these bikes. We are also lucky in that there have been folks who have identified the trouble spots and come up with modifications to remedy those problems. We owe a debt of thanks to them for sharing their knowledge and experience.

That spirit continues on the Suzuki 1500LC / C90 Owners Group forum.

So...what's the purpose of this article?

Though most folks are aware of the trouble spots and fixes for the charging system, there seems to be little understanding about *how* the charging system actually does what it does. I decided to search the Internet and find a link with some good pictures and clear, easy to understand text that would explain how our permanent magnet charging systems operate, so that when someone had a question they could go and see for themselves how it works. You know what I found? *Nothing.*

OK...maybe *nothing* isn't accurate. What I found were very basic block diagrams that labeled each part...or something like,"The stator produces AC and the Rectifier turns it into DC and charges the battery."...Which although accurate, tells you absolutely nothing about how the process actually works. In some cases. I found diagrams that had components mislabeled. In one case, the text I read explained how the regulator worked, then showed a schematic of a different system which didn't jive with the explanation.

The Internet is a giant cesspool of regurgitated misinformation.

I decided I'd do it myself. After all...how hard could it be to make some pictures and describe what's going on? As it turns out, a whole lot harder than I ever thought it would be. It's very hard to balance too little information with too much information. Engineers may have a stroke if they read this article. Oh lord how they(we) hate when things are simplified...lol

The purpose of this article is to give you the basic idea how the charging system in the LC/C90 operates. This is not intended to be a repair guide. For that you have the service manual and the good folks that make up the best damn motorcycle forum on the entire information super highway!

First Things First

This article assumes you have at least a very basic understanding of AC and DC electricity. I will keep it as simple as I possibly can. I will do my best to give very simplified explanations and examples so that everyone has the best chance at understanding what's going on.

DC electricity is fairly easy to understand when it comes to motorcycles. This is due to the voltage, load, and current being pretty steady in the circuits on a motorcycle. By contrast, AC electricity is incredibly complex because it changes constantly. Voltage increases and decreases, and constantly changes polarity. Depending on the circuit voltage can also lead, or lag current, etc.

Since AC electricity is so complex the examples I'll give will be *somewhat technically incorrect* (engineers cringe here) in order to keep it as simple as possible. ***This is Purposeful***. Remember, the purpose of this article is to give the average person the general idea of how the charging system does what it does. It isn't an engineering course.

To keep things as simple as I can we are not going to use "current" in the examples. "Current" flows from positive to negative.

What we're going to concentrate on for our purposes here is ***ELECTRON FLOW***. (Hopefully it becomes clear why later on.) Electrons flow from a ***more negative place*** to a ***more positive place***. Using a battery and a light bulb as an example, if you connected a light bulb across a battery the electrons would flow from the negative terminal, through the light bulb, and to the positive terminal.

If you can picture that electrons flow from a ***more negative place*** to a ***more positive place*** then you have a good chance at understanding how the charging system works.

You also need to understand that whether something is positive or negative is also ***relative***. There are times when the positive battery terminal is more negative, and when the negative battery terminal is more positive. Don't worry. I will explain when the time comes.

So Why Do We Need A Charging System Anyway?

The battery is basically a warehouse for electrical charges. The more electrons (negative charges) packed into the negative side of the battery the more reserve muscle it has.

When you turn the bikes key (without starting the bike yet) electrons start flowing from the negative terminal of the battery, through the headlight and various other circuits, and then to the positive terminal of the battery. At this point their journey ends there. Then, you start the bike. When you hit the starter button a ***huge*** amount of those stored electrons also flow from the negative battery terminal, through the starter, and continue on to the positive battery terminal in order to start the bike. Those electrons also stay at the positive battery terminal...that is until the bike starts. Once the bike starts it's the job of the charging system to move those electrons back around to the negative side to recharge the battery.

Once the bike starts the battery becomes a load, just like your headlight is a load. The charging system has to recirculate enough electrons to not only recharge the battery but supply the circuits as well. Once the battery has recovered (recharged) it is constantly refreshed by pulses from the charging system.

So How Does The Charging System Do That?

First, we need to define what each part does...again keeping it as simple as possible.

Battery: We've already stated that the battery is a big warehouse for electrical charges. To me, its primary function is to start the bike. (If it can't start the bike what difference does it make what else it's supposed to do?) Once the bike is running it's the job of the battery to supply a *steady* stream of electrons to power the circuits.

Lesser known is that it also acts as a heat sink

Stator: The stator generates AC electricity...which means the electrons within its coils of wire first move in one direction, then back in the opposite direction, as magnets in a rotor pass by the coils. A stator can either be wound so that the coils are all wound in the same direction, or that they alternate direction. If they are all wound in the same direction then the magnets in the rotor have to alternate polarity one from the next. If the coils are wound in alternating directions then the magnets in the rotor can either all be south poles, or all north poles. Either coil/magnet arrangement will generate alternating current.

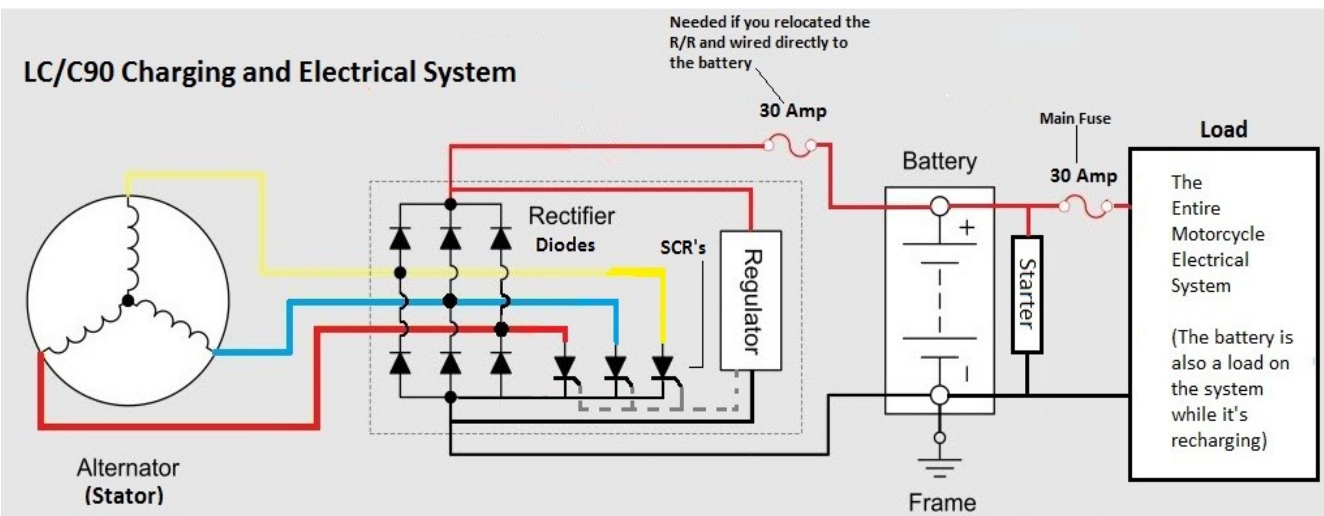
Regulator/Rectifier: Like the name suggests it actually has two different functions. The Rectifier part is made up of rectifier diodes, which are basically electronic one way valves. Electrons only flow through them in one direction. The Rectifier is where the AC from the stator gets transformed into DC. DC electricity flows in one direction only. The Stator and the R/R act as an electron pump.

The Regulator keeps the DC voltage from going over a preset limit. The regulator will turn the SCR's on many times a second to redirect the unneeded electrons that are flowing from the stator to ground, *back* into the stator instead of going to the battery/loads.

SCR's: SCR stands for Silicon Controlled Rectifier. These are also electronic one way valves, but they are switched on and off differently than the rectifier diodes are. Electrons only flow through them in one direction. They are switched on by the Regulator as needed.

OK...Let's Look at Some Pictures

I based these pictures on a diagram someone else did. I tried searching but couldn't find where the original came from. I did change some things, but I surely would have given that person a mention. If you're out there and reading this, thank you for the template to work from.



The diagram above shows the LC/C90 charging system. Over at the far right you will see the box labeled **LOAD**. It is everything on the motorcycle that uses electricity. The Starter is also a load, but is shown separately because schematically it is between the battery and the main fuse. Everything to the left of the battery is the charging system.

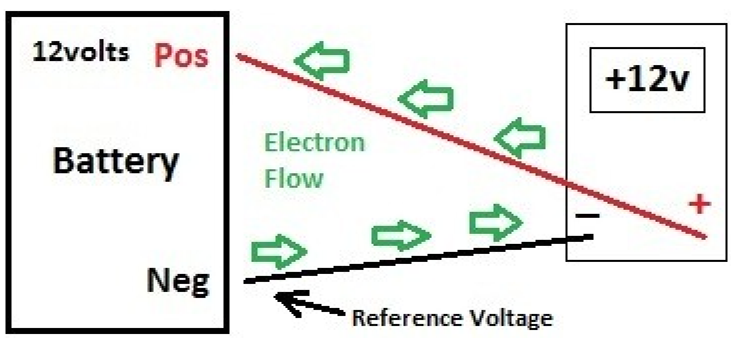
In the following diagrams the green lines/arrows will denote Electron Flow. Remember...electrons flow from a place that is ***more negative*** to a place that's ***more positive***.

<u>So What Exactly is *More Positive*?</u>

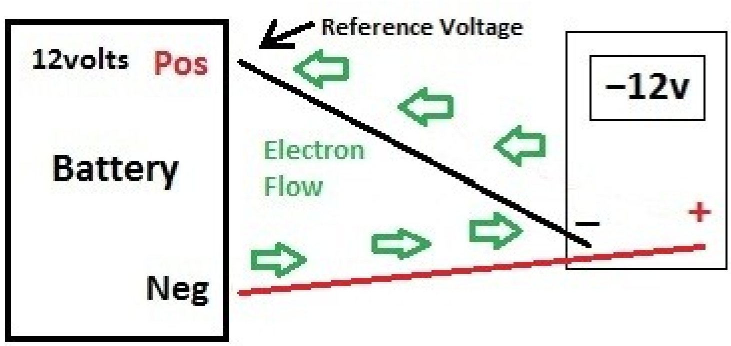
The negative terminal of the battery is at zero volts. The negative terminal is also the bikes "Ground". Anything connected to the negative terminal (engine block, frame, etc.) will also be at zero volts. What this means is if you took your multimeter and put the negative probe on the negative battery terminal, then also put the positive probe on the negative battery terminal, or anything it is connected to like the engine block, etc., your meter would read zero volts. They are said to be at the same *Potential.* Zero volts is also our **Reference Voltage.**

Reference Voltage

It's important to understand what ***reference voltage*** means. The reference voltage is what we are comparing any voltage we measure, *against*. For instance, if we measure battery voltage you put the negative probe on the negative battery terminal and the positive probe on the positive terminal. Say your meter reads 12 volts. 12 volts compared to what? It's compared to our reference voltage which in this case is zero volts. The positive terminal is at a higher potential than the negative terminal. You can also say it is at a higher potential in a more positive direction. The electrons are traveling from the negative terminal, through the negative probe, through the meter, and finally to the positive battery terminal.



But what happens if you reverse the probes?



If you put the positive probe on the negative battery terminal, and the negative probe on the positive battery terminal, it will also read 12 volts...but the meter will display a minus sign by the number (-12).

Remember... you're measuring DC voltage which is polarized and the electrons only travel in one direction. When you reverse the probes the electrons are now entering the positive probe from the negative battery terminal, flowing through the meter in the opposite direction, and leaving through the negative probe to the positive terminal.

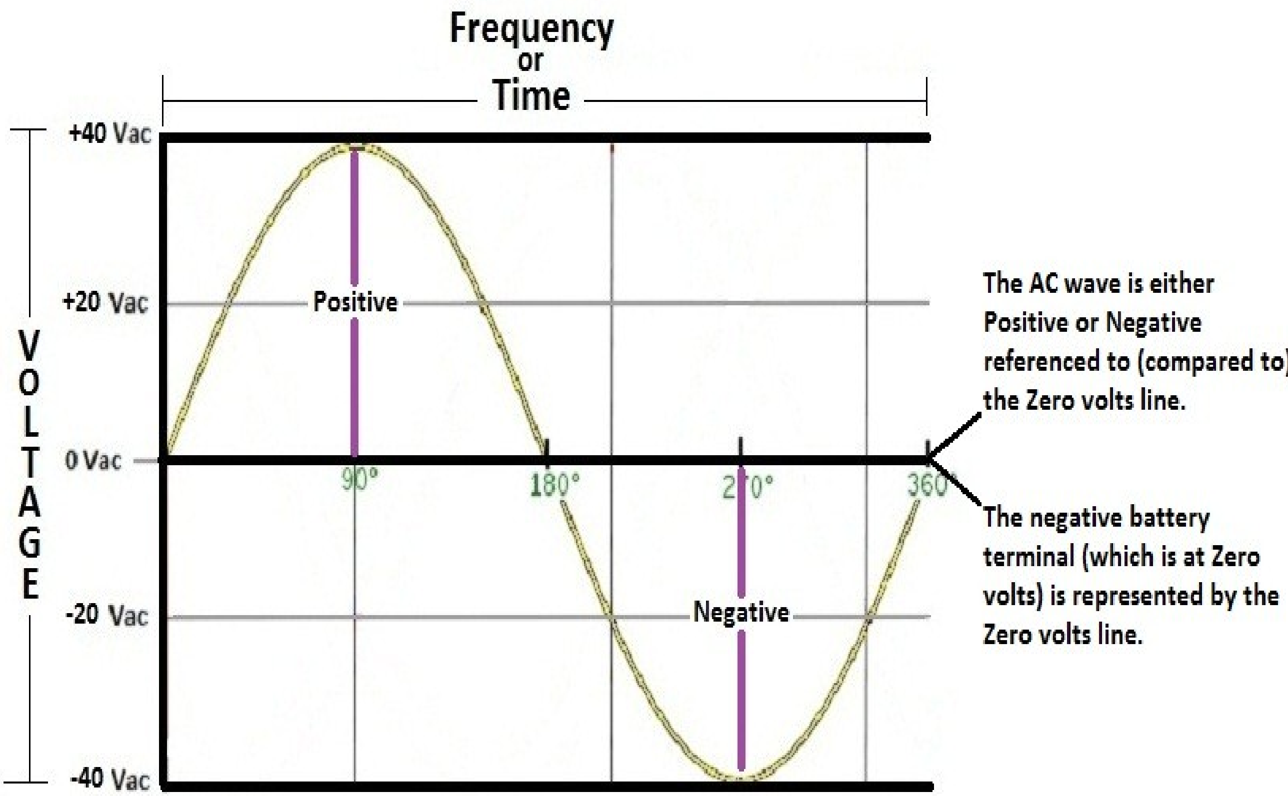
So why does the meter display a minus sign when measuring the opposite polarity? Because wherever you put the negative probe of the meter measuring DC that becomes your ***reference voltage***. Since you put the negative probe on the positive battery terminal your reference voltage is now the +12 volts at the positive battery terminal. When you put the positive probe on the negative battery terminal and see the minus sign the meter is telling you you're measuring a point that is at a lower potential ***relative*** to your +12 volt voltage reference. Zero volts is lower than +12 volts. Zero volts is in a more negative direction compared to +12 volts.

The concept of reference voltage is very important. Reread the above section a few times if you need to.

The Stator and AC Electricity

In the following graphs you will notice at the left of the graphs there are "Voltage" numbers. These numbers were basically chosen at random. The service manual says the "unloaded" stator voltage @ 5000 RPMs is 80 volts. The maximum voltage the stator puts out when it's "loaded" is most likely less than half of the 80 volt "unloaded" spec. We needed some numbers to use in the examples so I picked some. They are for reference only. The actual voltage the stator puts out at any given time has to do with load, engine RPM, etc..

The stator has three wires emerging from it. Each wire will output AC electricity. Let's look at one cycle of AC electricity and give you an idea of what's happening during it.



At the beginning of the wave we are at zero volts. As you follow the wave it climbs in a positive direction until it reaches it's peak and begins to fall back to zero. Any point above the zero volts line is said to be positive.

As you continue to follow the wave it now goes below the zero volts line until it reaches its peak and continues back to the zero volts line. Anything below the zero volts line is said to be negative.

Earlier we talked about the negative battery terminal being at Zero volts. Since the voltage at the negative battery terminal does not change and will always be Zero volts, you can think of the Zero volts line in the above graph as the negative battery terminal.

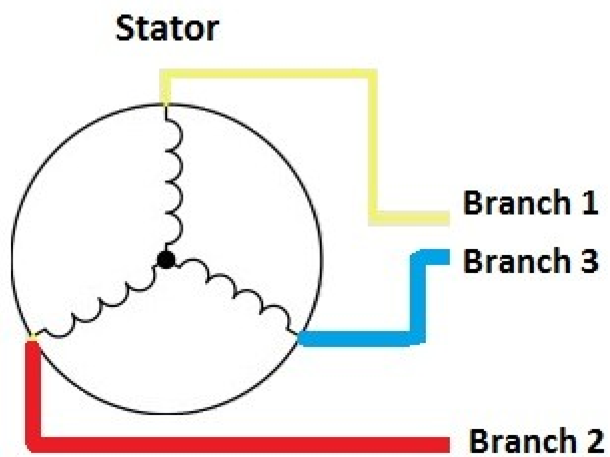
The higher the peak the higher the voltage, whether it's in a positive or negative direction. Take note of the voltage numbers at the left of the graph. +40 volts peak above the zero volts line, -40 volts peak below the zero volts line. (or 80 volts "peak to peak") Remember, those numbers are purely for reference only.

You will also notice at the top of the graph it says Frequency or Time. The graph shows one AC cycle. The number of cycles that occur in one second is the AC Frequency, and is expressed in Hertz. (Hz) The frequency of AC electricity produced by the stator depends on engine RPM. The higher the RPM's the higher the Stator AC frequency.

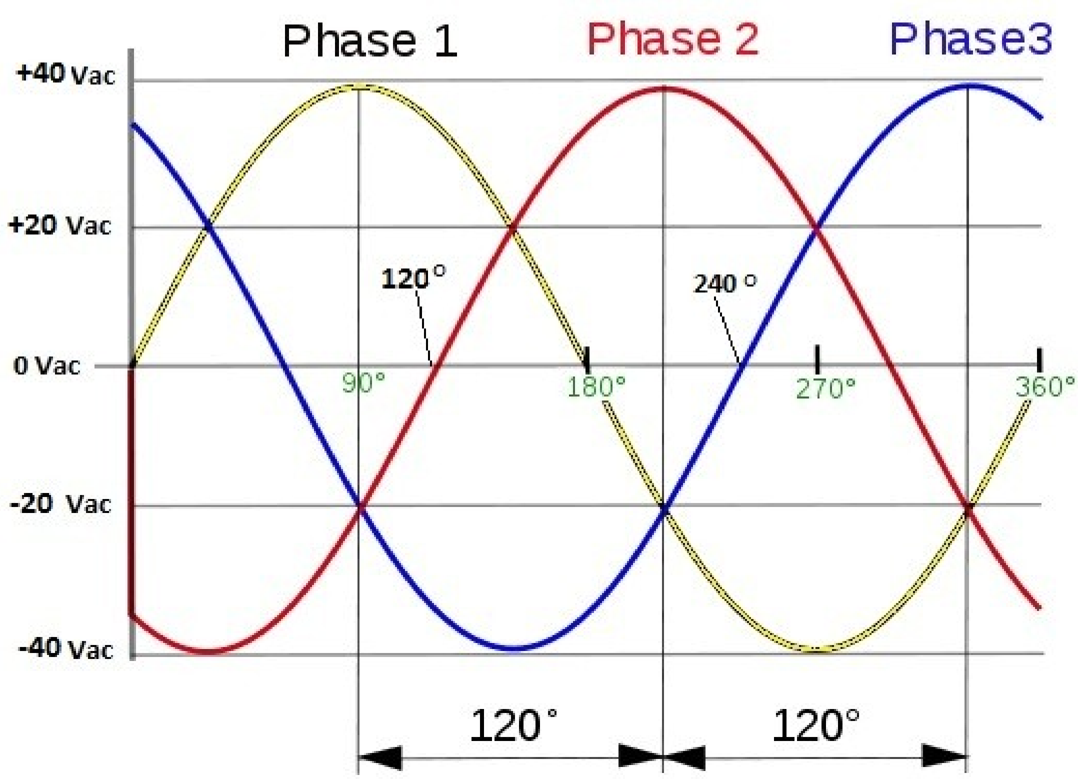
The 120vac available in the outlets in your home has a frequency of 60Hz. (in North America) That AC cycle in the above graph literally happens 60 times a second.

Three Wires From the Stator

The above graph showed only one AC cycle from one stator wire, but there are three wires. Each of those three wires are connected to a series of coils. Each wire and series of coils we will call a branch.



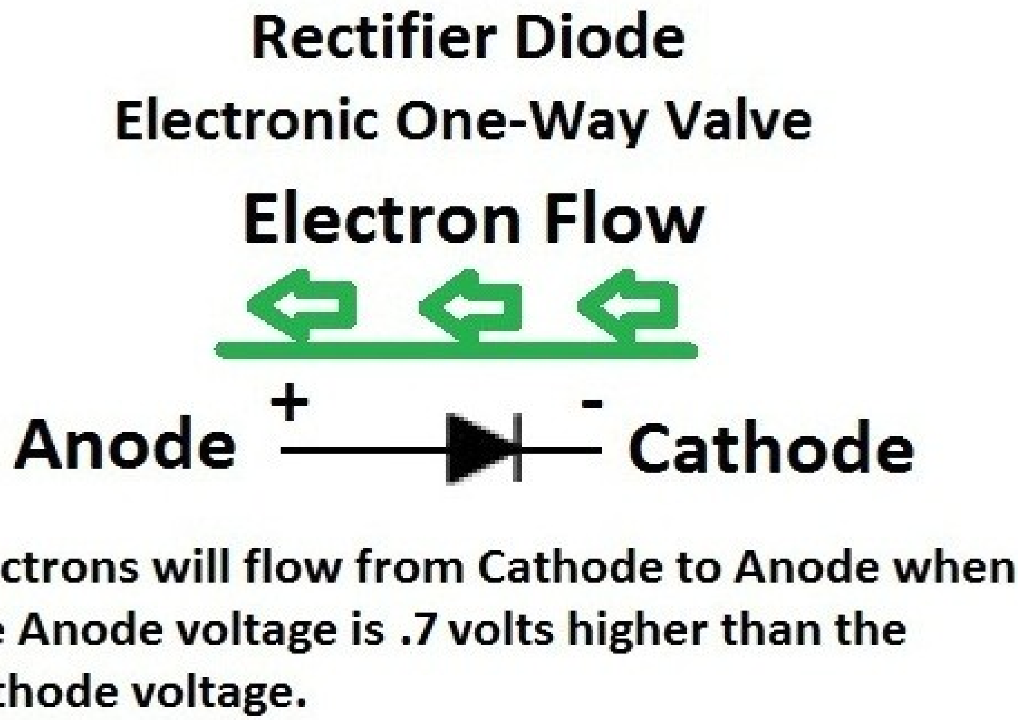
Each branch outputs an AC voltage, but they are not all in sync with each other. Each branch is 120 degrees *out of phase*. The graph below shows each phase of the three branches.



You will notice at the zero volts line the yellow branch is the first to start its upward swing. At 90 degrees it reaches it's peak. At 120 degrees of the yellow branches wave take a look at the zero volts line. You will see that the red branch is now starting its upward swing. 120 degrees after the red branch starts its upward swing (240 degrees after the yellow branch) the blue branch now starts its upward swing. This process continues over and over. The three phase system is very efficient.

The Rectifier Diode

The rectifier diode is a one-way electronic valve. When it is *forward biased* (which in this case means “turned on') electrons will flow into the cathode (or negative end) through the diode, and emerge at the anode (or positive end). So how does it get turned on? Electrons will flow through it when the voltage on the anode (or positive end) is roughly .7 volts ***more positive*** than the cathode (or negative end).

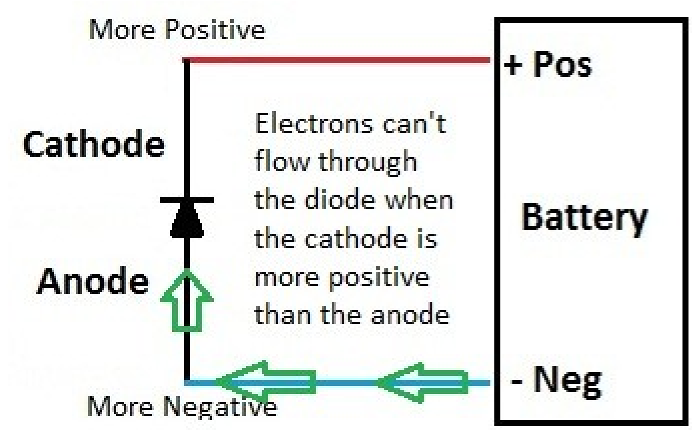


Remember, we said electrons will flow from cathode to anode when the anode voltage is .7 volts *more positive*. For example, if the cathode was at zero volts, in order to forward bias the diode the anode would have to be at least +.7 volts for the electrons to start flowing through the diode. If the cathode was at +12 volts then to forward bias the diode the anode would have to be at least +12.7 volts.

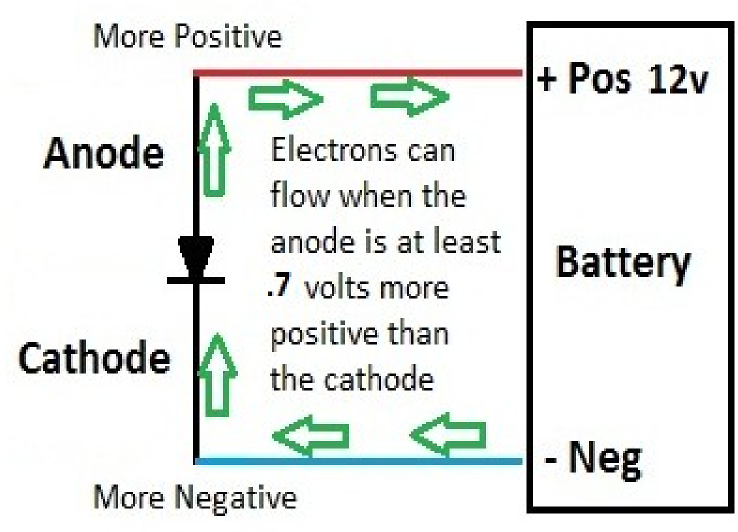
Remember when we were discussing reference voltage? We said wherever we put the negative probe of the voltmeter that became our reference voltage. If we put it on the negative battery terminal then zero was our reference voltage. When we put the negative probe on the positive terminal (+12) then *that* became our reference voltage. Think of the cathode of a diode as the negative probe of the voltmeter. Wherever it is, that becomes its reference voltage. As long as the anode is at least .7 volts *more positive* than the cathode electrons will flow through the diode.

Let's look at a simple rectifier diode circuit.

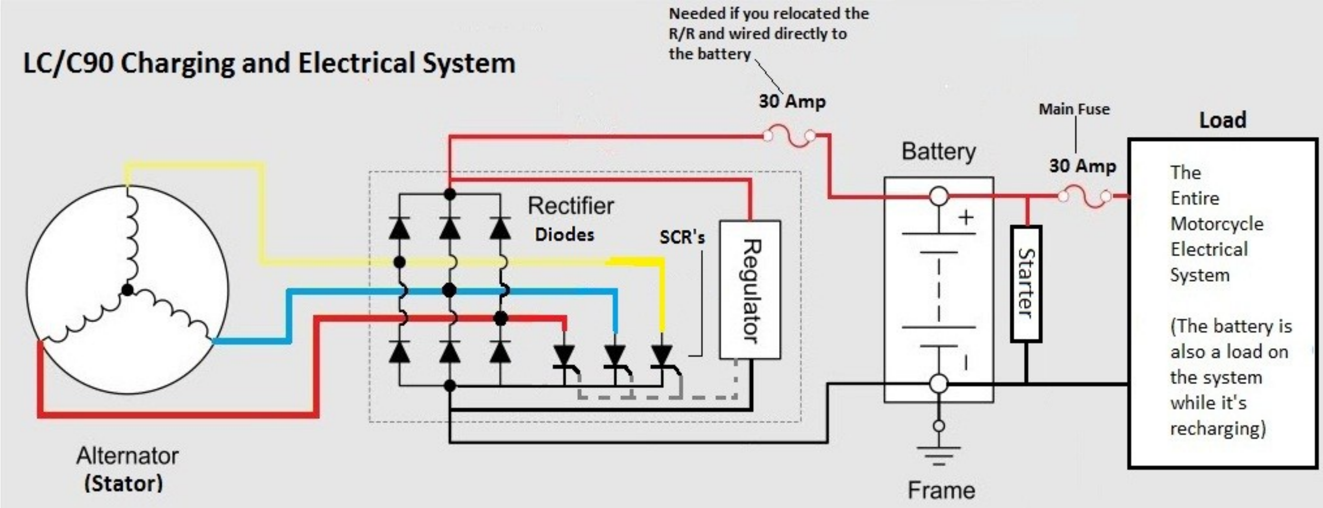
Simple Rectifier Diode Circuit



In the circuit above the electrons cannot flow from the negative battery terminal to the positive battery terminal because the diode is "off". It is off because the the cathode is more positive than the anode. Let's turn the diode around and look at it again.



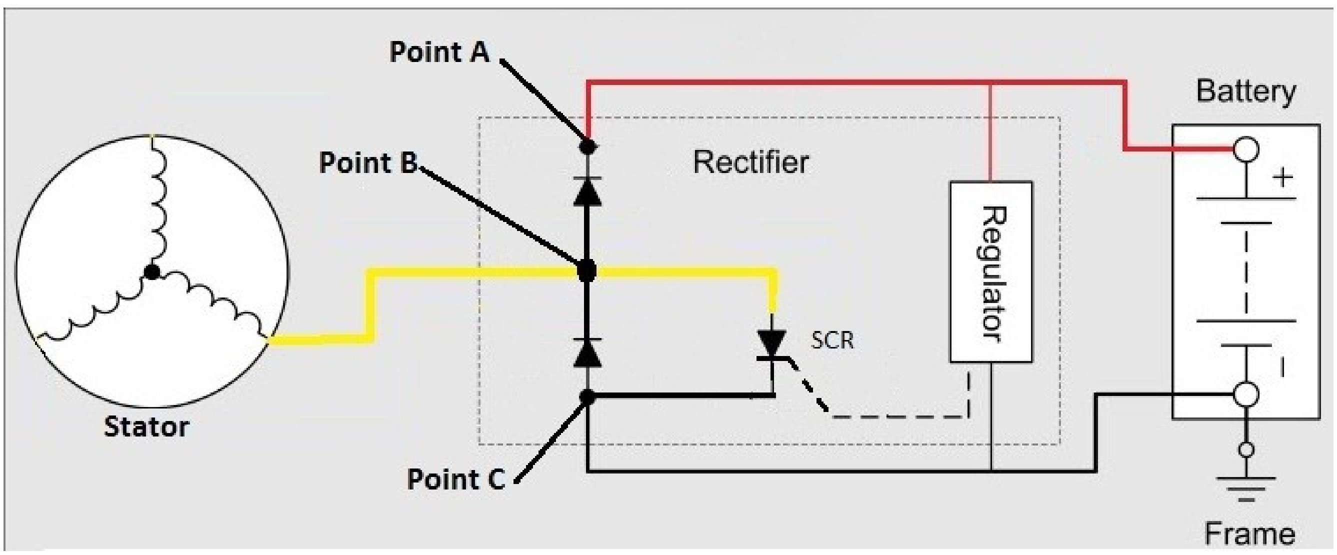
In this circuit the anode is now more positive than the cathode by +12 volts. The diode is now "on" and the electrons can flow freely. Let's take another look at the rectifier diodes and the battery from the charging system diagram.



As you can see the cathodes are towards the positive battery terminal and the anodes are towards the negative battery terminal. The electrons cannot flow from the negative battery terminal to the positive battery terminal because the diodes are not "turned on" when oriented this way in the circuit.

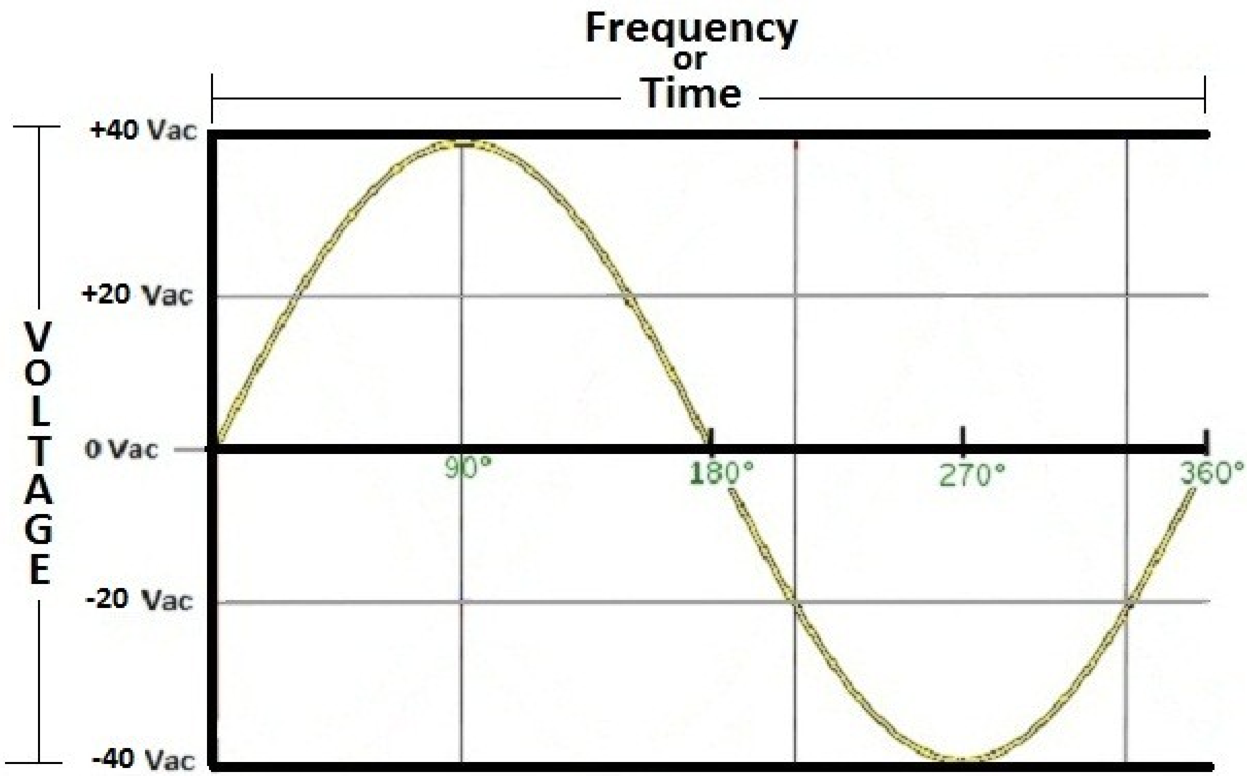
Remember, on the "Load" side of the battery electrons are flowing from the negative battery terminal, through the "loads", and back to the positive battery terminal. On the charging system side we want the electrons to flow from the positive battery terminal back to the negative battery terminal.

Let's look at a simplified charging system diagram.



Above is the stators yellow branch of the charging system. Look closely at points A, B, and C. Point B is where the two diodes connect (anode of the top diode, cathode of the bottom diode) and also where the yellow branch of the stator connects to the two diodes. The top diode is tied to the positive battery terminal at Point A. We will call this diode the positive diode. It will only get turned on when the stator AC voltage goes positive. Likewise, between Point B and Point C is what we will call the negative diode since it is connected to the negative battery terminal. It will only get turned on when the stator AC voltage goes negative.

Remember, the stator generates AC electricity. Let's look at one cycle of AC electricity generated from the yellow branch of the stator.



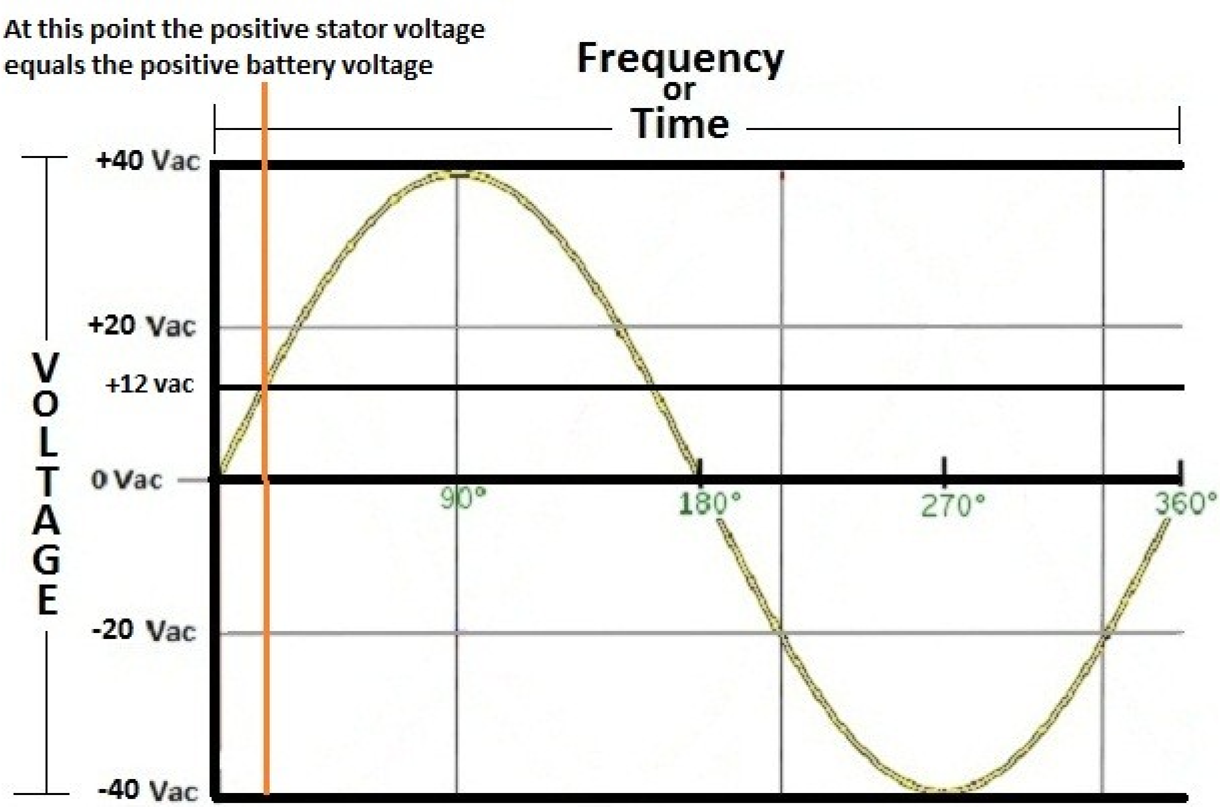
*** The voltage numbers at the left of the graph are for reference only, and were chosen to keep things simple. The voltage the stator puts out at any given time varies with engine RPM, load, etc.***

As we stated earlier, starting at the zero volts line anything above the zero volts line is positive, anything below the zero volts line is negative. As we go from left to right on the graph we can chart a specific moment in time. We will do this with a vertical orange line.

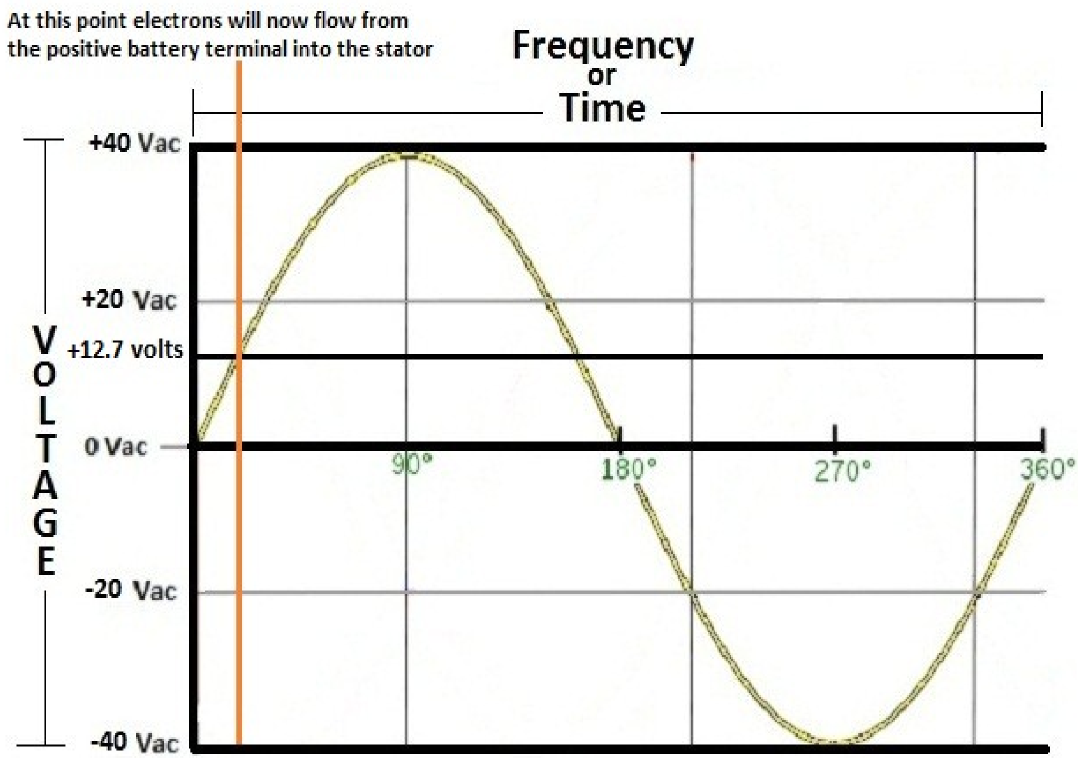
At zero volts on the graph no electrons are flowing in the yellow branch of the stator, but what happens once the stator voltage starts to rise in a positive direction?

To keep things simple we will say the positive battery terminal is at an even +12 volts.

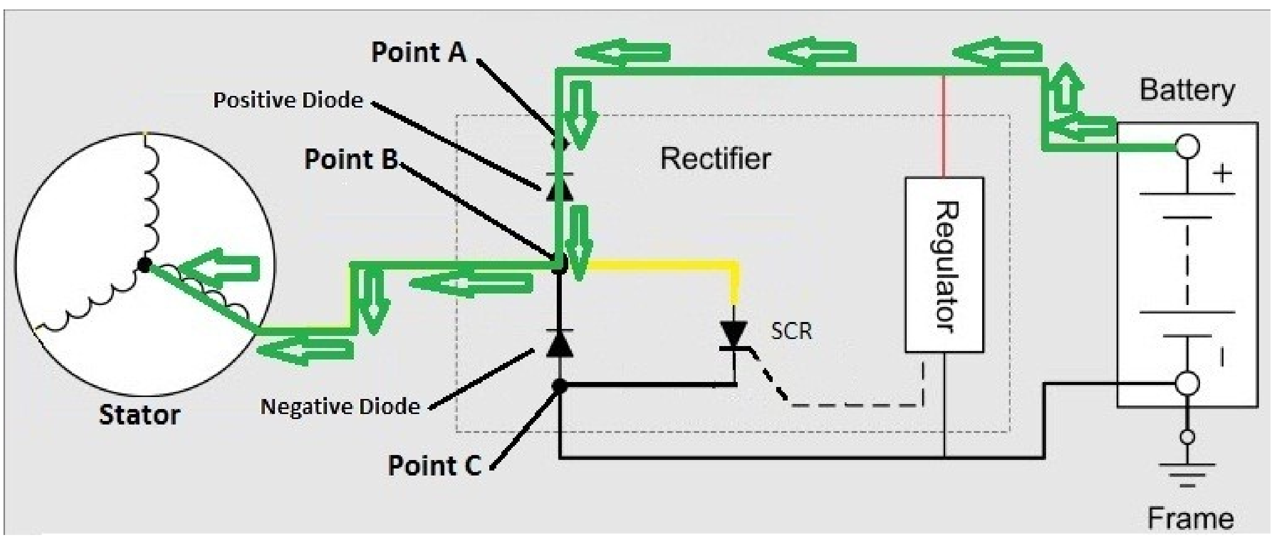
As the stator AC voltage climbs it eventually hits +12 volts. At this point the positive stator voltage equals the positive battery terminal voltage. The orange vertical line on the graph below dissects the wave at the +12 volts point.



From this point on the yellow branch of the stator will be *more positive* than the +12 volts at the positive battery terminal. Once the stator voltage at the anode of the positive diode hits +12.7 volts the positive rectifier diode will "turn on" and electrons will start flowing from the positive battery terminal , through the positive diode, and into the yellow branch of the stator.



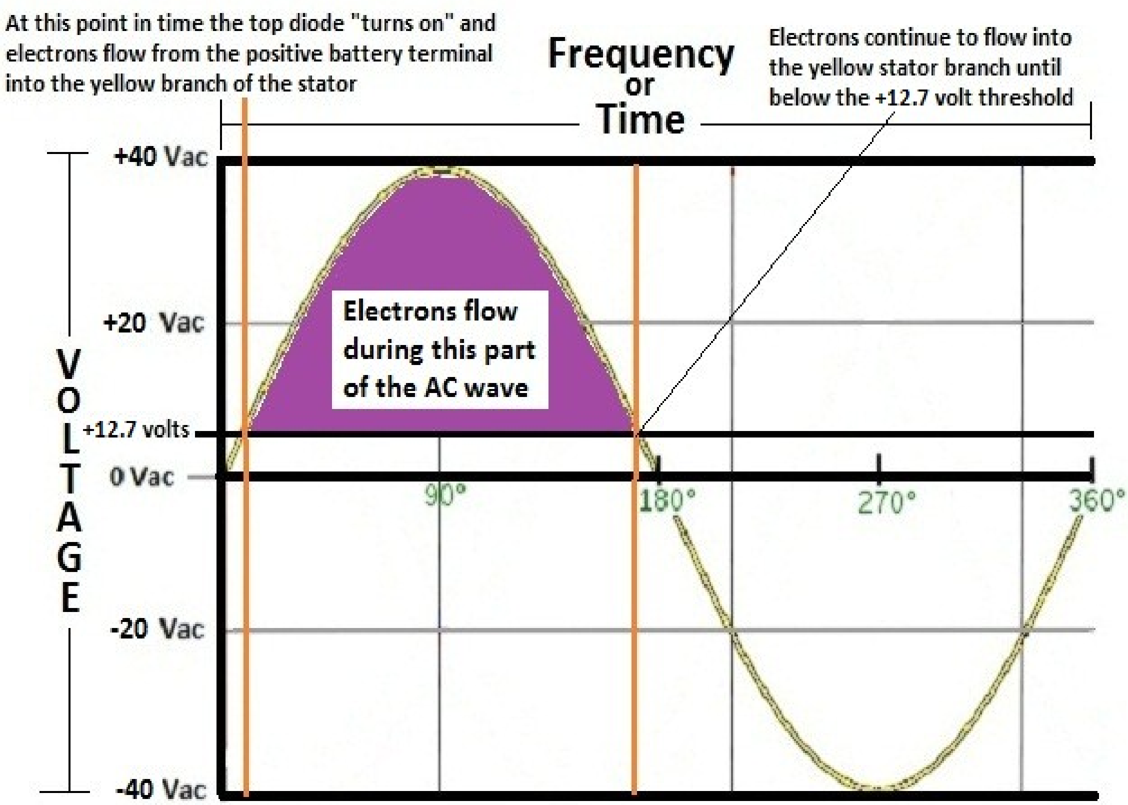
Here is the electron flow in the simplified charging system diagram.



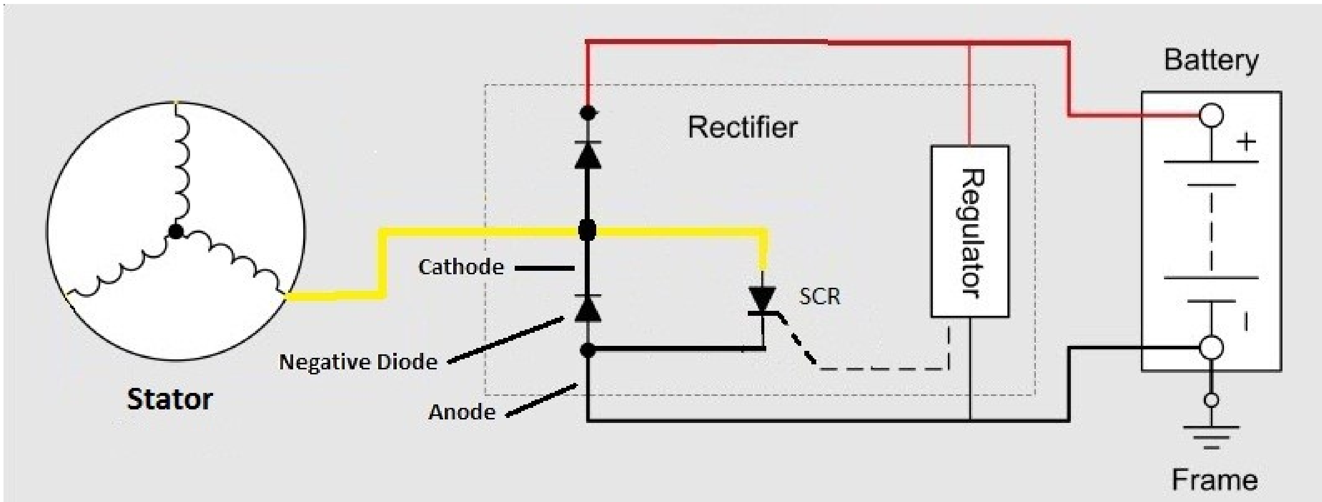
Take another look at the positive diode. You will notice that the cathode (Point A) is tied to the positive battery terminal. That means its reference voltage is the +12 volts at the positive battery terminal. Once the stator voltage at the anode (Point B) hit +12.7 volts the anode was now .7 volts more positive than the cathode. The positive diode turned on and electrons were able to flow from the positive battery terminal, through the positive diode, and into the stator. The positive battery terminal is now negative ***relative*** to the stator...and electrons flow from a more negative place to a more positive place.

Take notice that Point B is also tied to the cathode of the negative diode. At this point in time the stator voltage at Point B is positive. Since the anode of the negative diode is at zero volts and its cathode is more positive the negative diode is not turned on and electrons cannot flow through it.

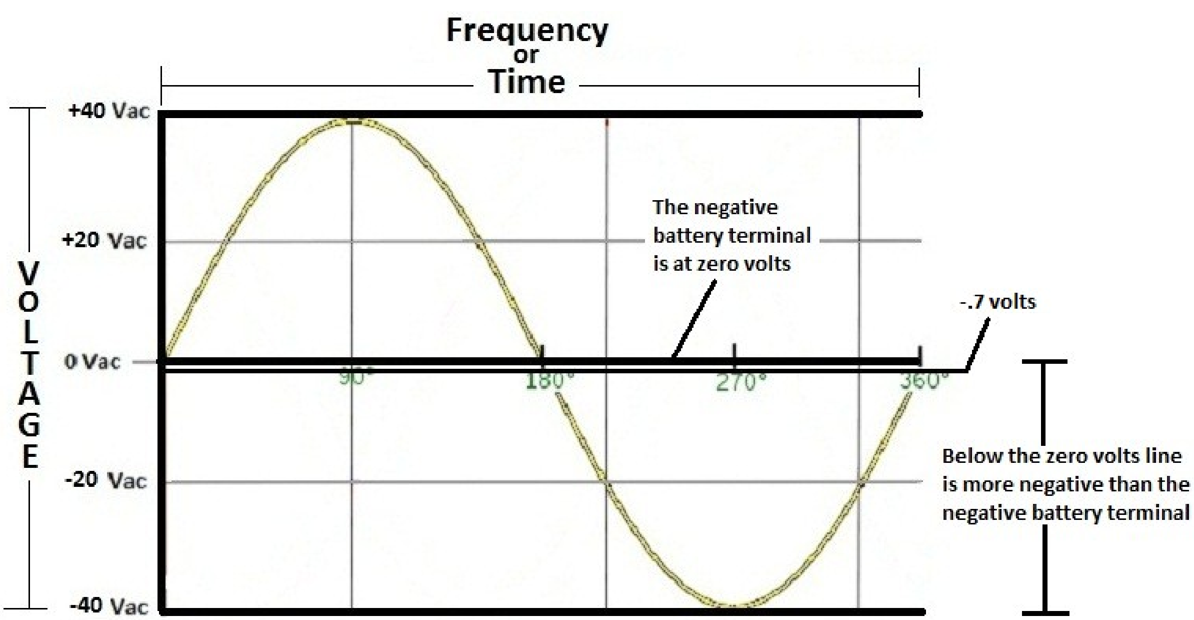
Electrons will flow from the positive battery terminal and into the stator until the positive stator voltage falls back below the +12.7 volt threshold. At this point the positive diode will not be forward biased and will turn off blocking electron flow.



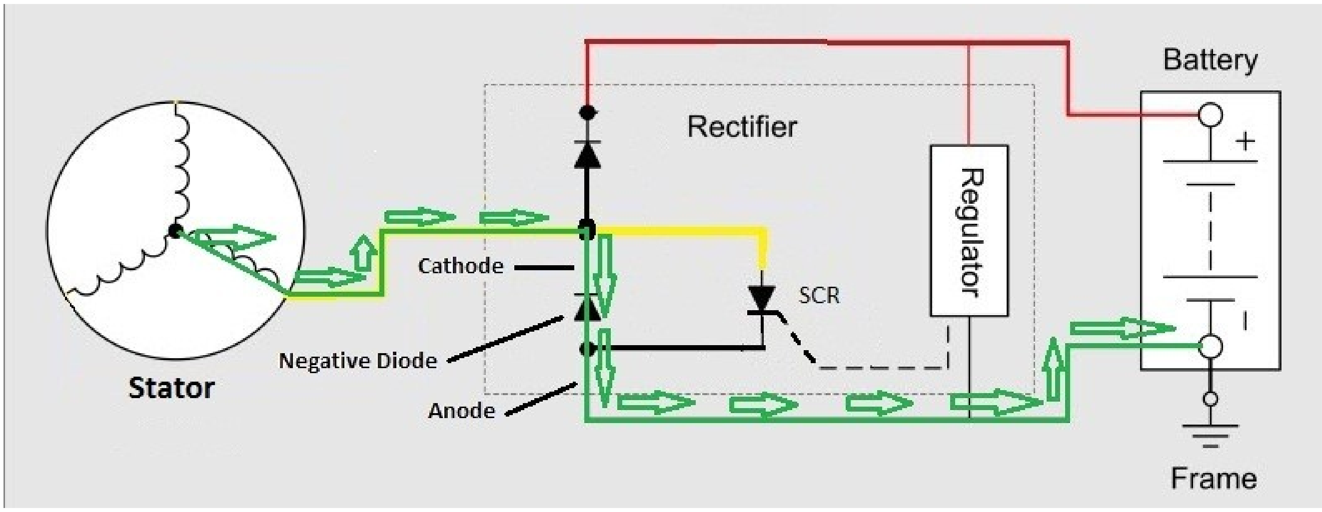
Now let's take a look at the Simplified Charging System Diagram again, focusing on the negative diode.



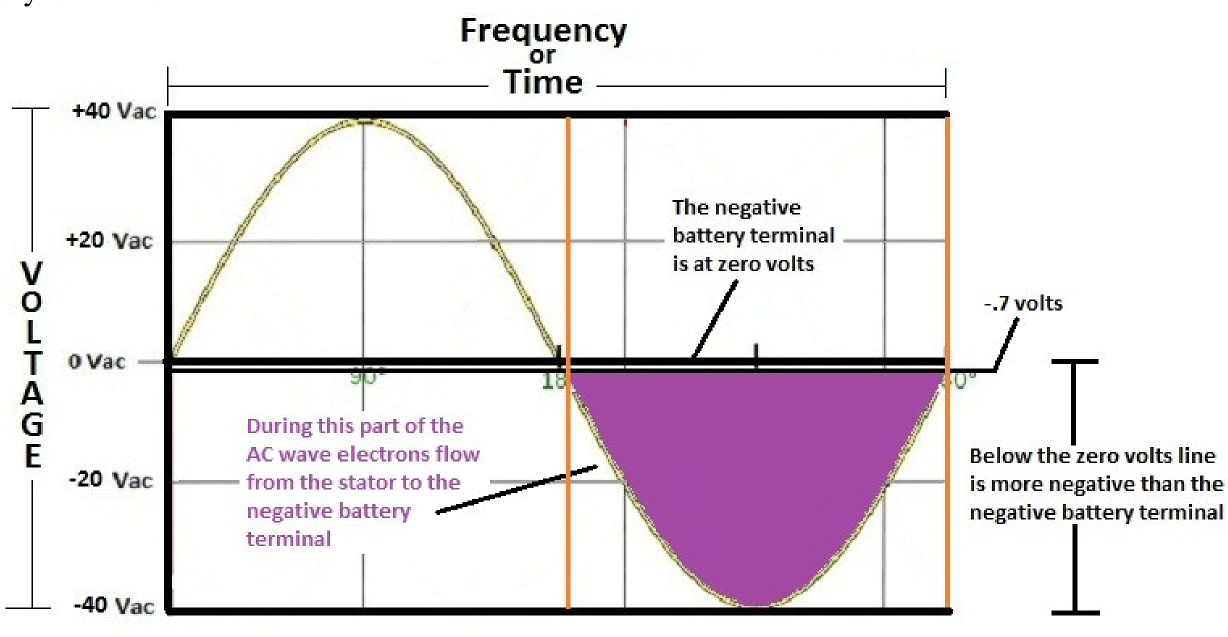
Looking at the negative diode you will notice that the anode is tied to the negative battery terminal, and we know that the negative terminal is at zero volts and does not change. How are we going to get the anode to be at least .7 volts more positive than the cathode if the voltage at the anode won't change? We will do it by making the cathode more negative instead! The diode doesn't care if the anode voltage goes up or the cathode voltage goes down. As long as the anode is at least .7 volts more positive than the cathode electrons will flow through the diode.



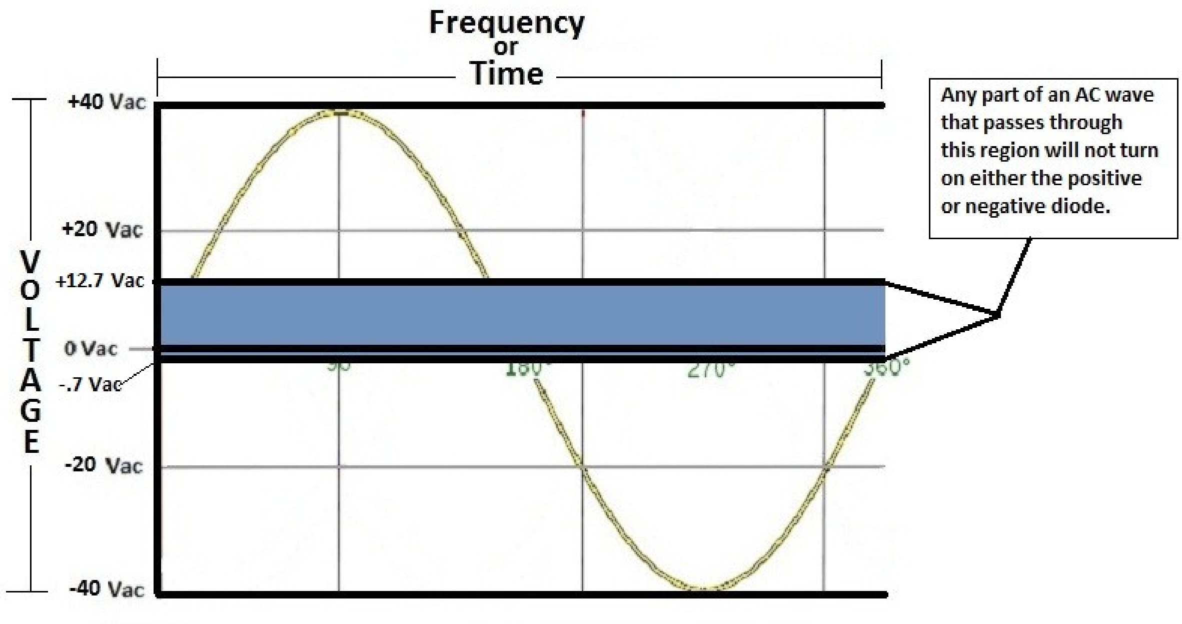
Once the stator voltage is -.7 volts the diode turns on and electrons flow from the stator to the negative battery terminal.



The electrons will flow from the stator to the negative battery terminal during the part of the AC wave that is at least -.7 volts more negative than the zero voltage the anode is tied to at the negative battery terminal.



So what happens during the part of the AC wave that passes in the area below +12.7 volts and above -.7 volts on the graph? Nothing. No electrons are flowing in the yellow stator branch during this time because neither the positive or negative diode is turned on.



Before we go any further, it's time for a little electrical theory.

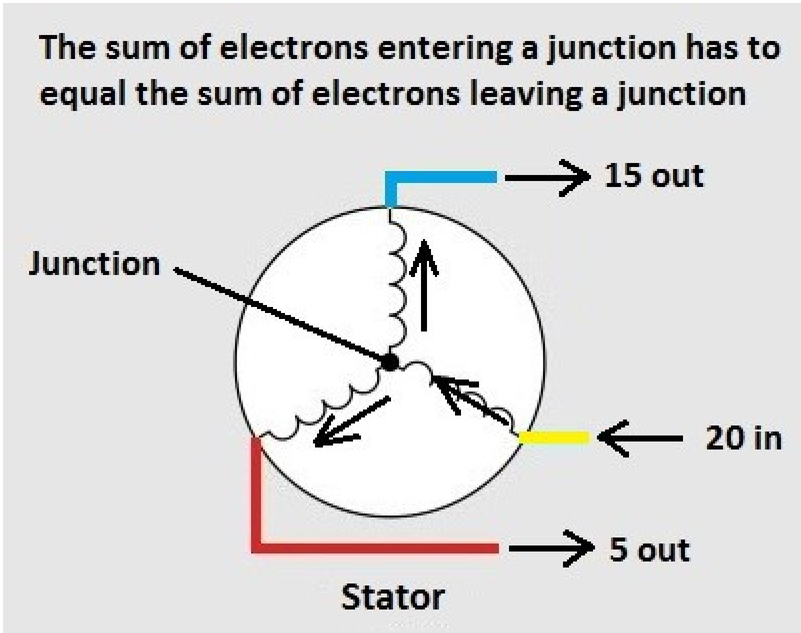
We need to understand something called "Kirchoff's Current Law at a Junction". Simply stated what this means is the sum of the current that arrives at a junction has to equal the sum of the current leaving the junction. Let's put it into easier terms.

You, and 19 of your biker buddies are traveling down a road. (you + 19 biker buddies = 20...that is the sum) You come to a fork (or junction) in the road. All 20 of you cannot go down both roads at the same time. You can either all go down one road or the other, or some can go left and some go right. Since 20 of you arrived at the junction, 20 of you will leave the junction. If 15 of you go right and 5 of you go left, the sum of you leaving is still 20. 20 in, 20 out.

It's the same with electrons. No matter how many arrive at a junction, they have to equal the amount leaving it.

(...and yes...I know if there's a strip joint at the junction nobody's leaving anytime soon.)

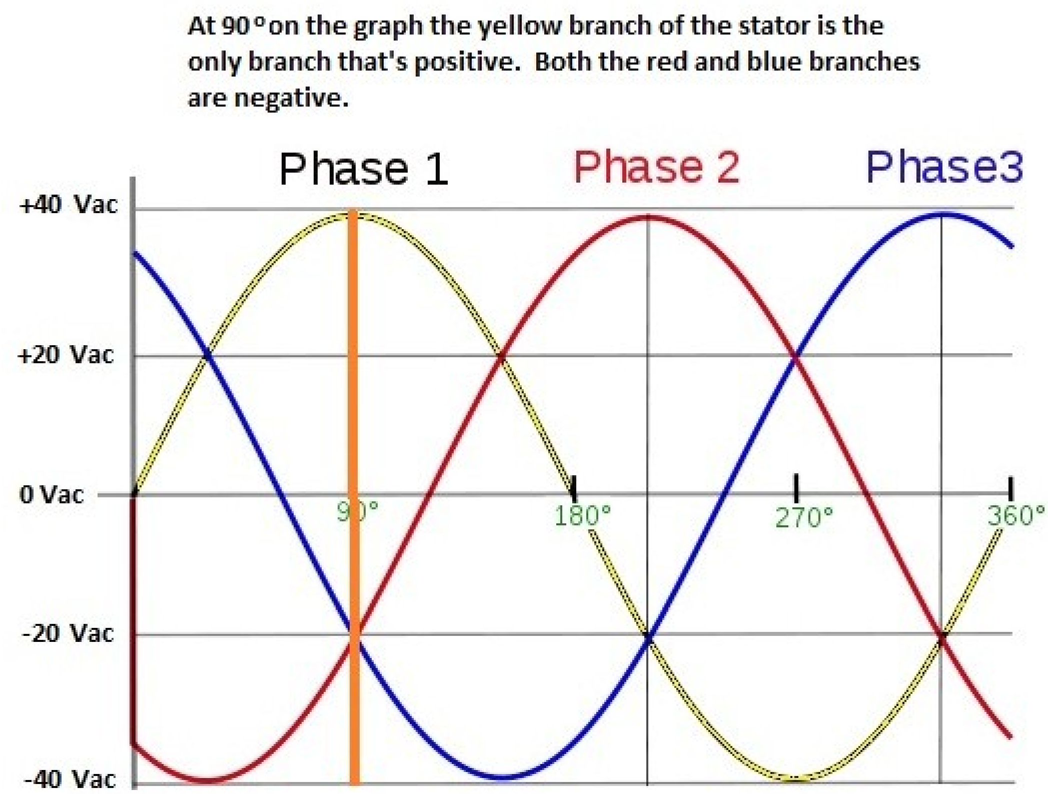
Let's take another look at the stator.



When we used the simple charging circuit diagram to show you how the stator, diodes, and battery work together we only used the yellow branch of the stator. We only showed the electrons flowing in and out of the yellow stator branch. From the above diagram you can now see that in order for the electrons to flow into the yellow stator branch they must also be able to flow out of either the red branch, the blue branch, or both.

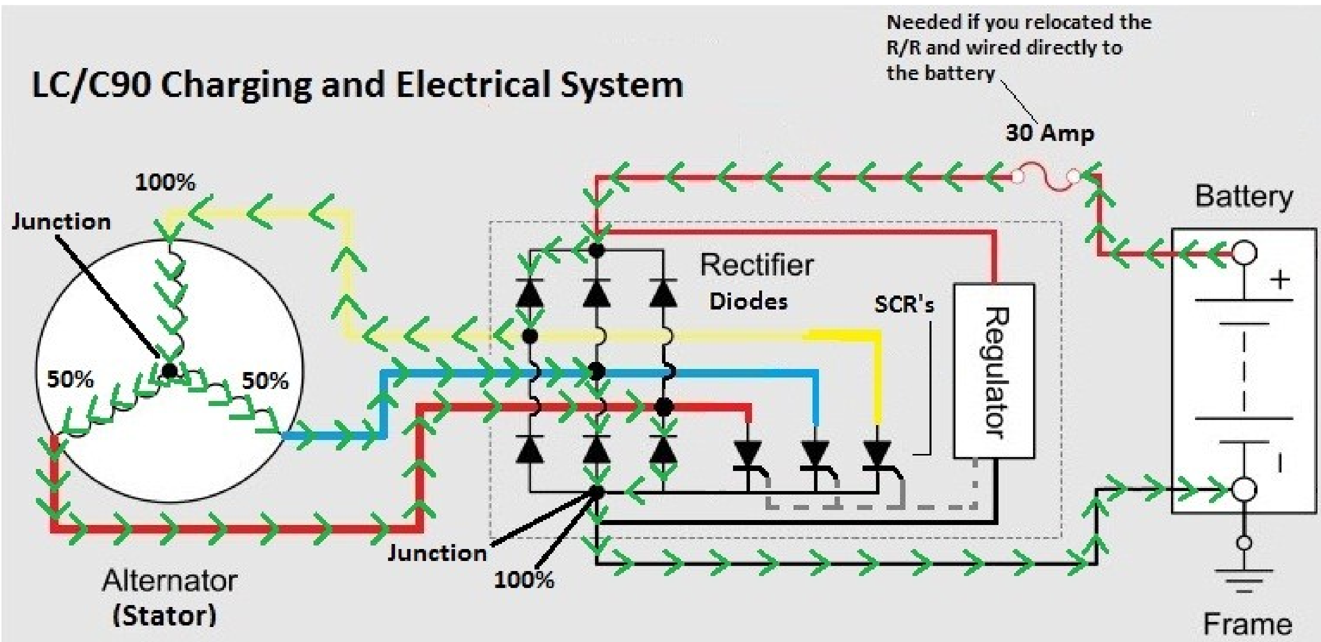
How the Three Phases Work Together

Previously we've seen the single AC wave graphs and the corresponding simple charging system diagrams showing how the electrons flow during the AC wave. Next we are going to pick a point on the AC three-phase graph and show how electrons flow in the charging system through all three phases.



Take a close look at the above graph. The vertical orange line at 90 degrees is the moment in time we will use as an example. You will notice that the yellow branch of the stator is the only positive branch, and that both the red, and blue branches, are both negative. Take note of the voltage numbers at the left of the graph. The yellow branch is at it's peak at +40 volts. The red and blue branches are each at -20 volts. If you add the two voltage numbers at the bottom you will notice they add up to -40 volts. This is important to note because ***whatever happens on the positive side of the graph is also equally and oppositely happening on the negative side of the graph.*** (engineers cringe again..I know three phase is about consistent *power* transfer, but we're trying to keep things simple and get the concept across) Remember the stator junction diagram? What enters the stator has to equal what leaves the stator. Equal and opposite.

Let's look at the corresponding electron flow at the orange line in the above graph.

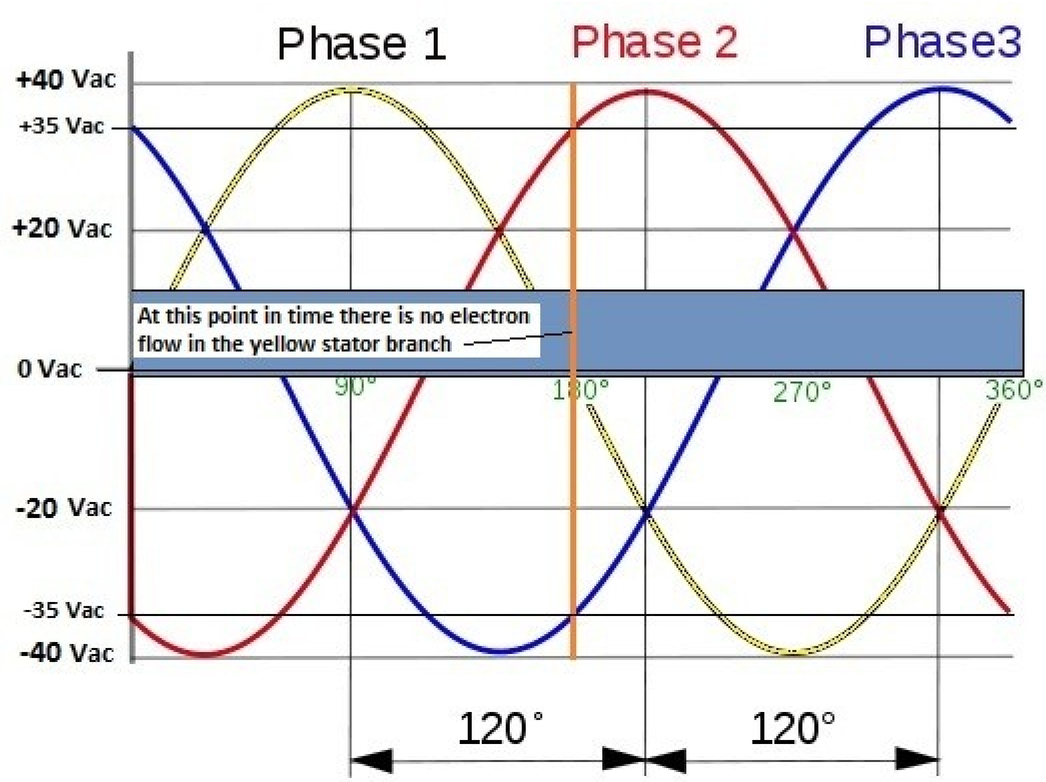


A few things to point out in the above diagram. We will use percentage of electrons as we traverse around the circuit. Also, notice there are two junctions marked. One is the junction in the stator. The other one is the junction at the bottom of the negative diodes.

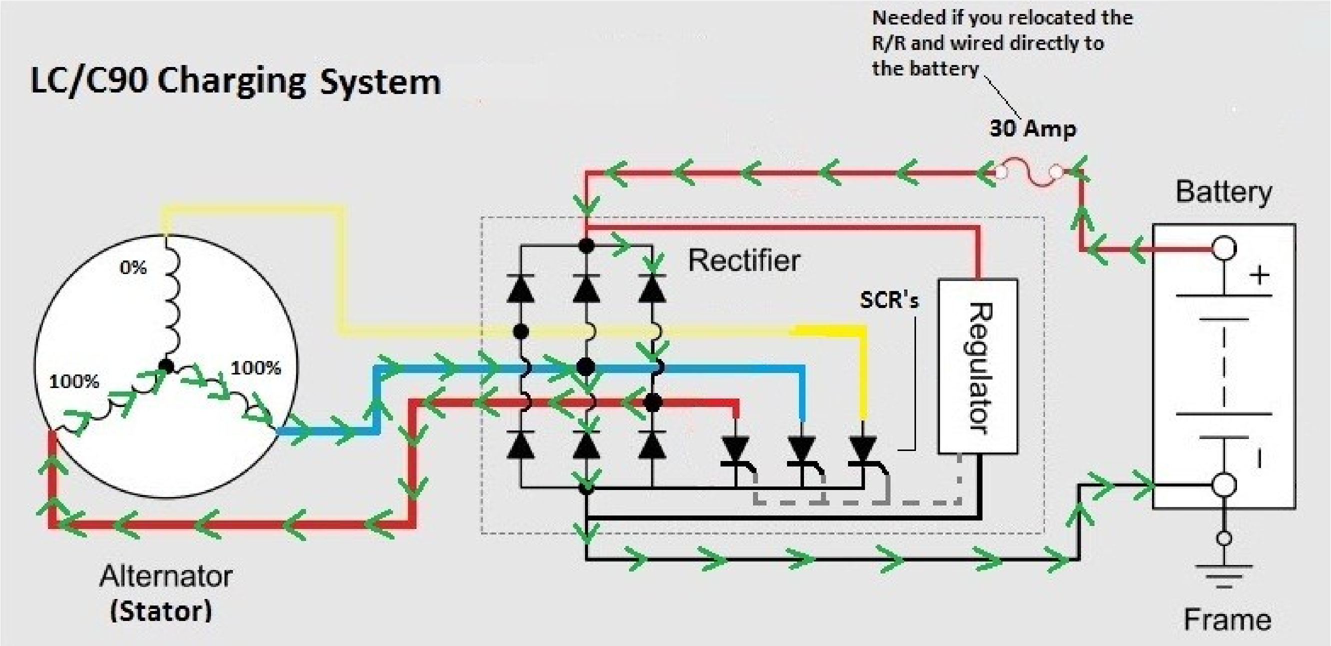
Let's start at the positive battery terminal and follow the electron flow. At this point 100% of the electrons flowing from the positive terminal are flowing through the yellow branch positive diode and into the stator. This is because the yellow stator branch is the only one that is positive at this point in time. It is at it's peak voltage of +40 Vac according to the orange line in the three phase graph. When they reach the junction in the stator they meet the red and blue branches. The red and blue branches are both at -20 volts each. This means the electrons will split evenly. 50% of the electrons entering the junction will leave via the red branch, and the other 50% will leave via the blue branch.

As they travel through the red and blue branches they will go through their respective negative diodes and again combine at the junction of the negative diodes anodes. From here it's on to the negative battery terminal.

Let's pick another moment in time and see what's happening. This time we'll use 180 degrees on the three-phase chart.



As you can see on the chart the yellow branch has no electron flow at all because it's passing through the region where neither of the diodes connected to it are turned on. All the electrons are entering the stator through the positive red branch diode and leaving the stator through the negative blue branch diode.



It should become apparent now why three-phase power is so efficient, and why a stator failure will not keep a battery charged. For example, if you took the yellow branch out of the equation (let's say you lost it due to a failure) then you will lose two out of the three paths for electrons to flow through. They could not flow red/yellow or blue/yellow. They can only flow red/blue. Electron flow would be cut by *more* than two-thirds because when either the blue or the red branches pass through the region where neither diode turns on then no electrons flow in or out of the stator/rectifier at all.

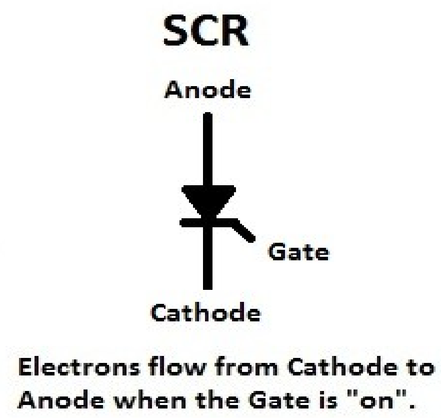
There is an animation that shows current/electron flow in a three phase generator (same flow as in the stator) on this Wikipedia page

http://en.wikipedia.org/wiki/Three_phase_power

The Regulator

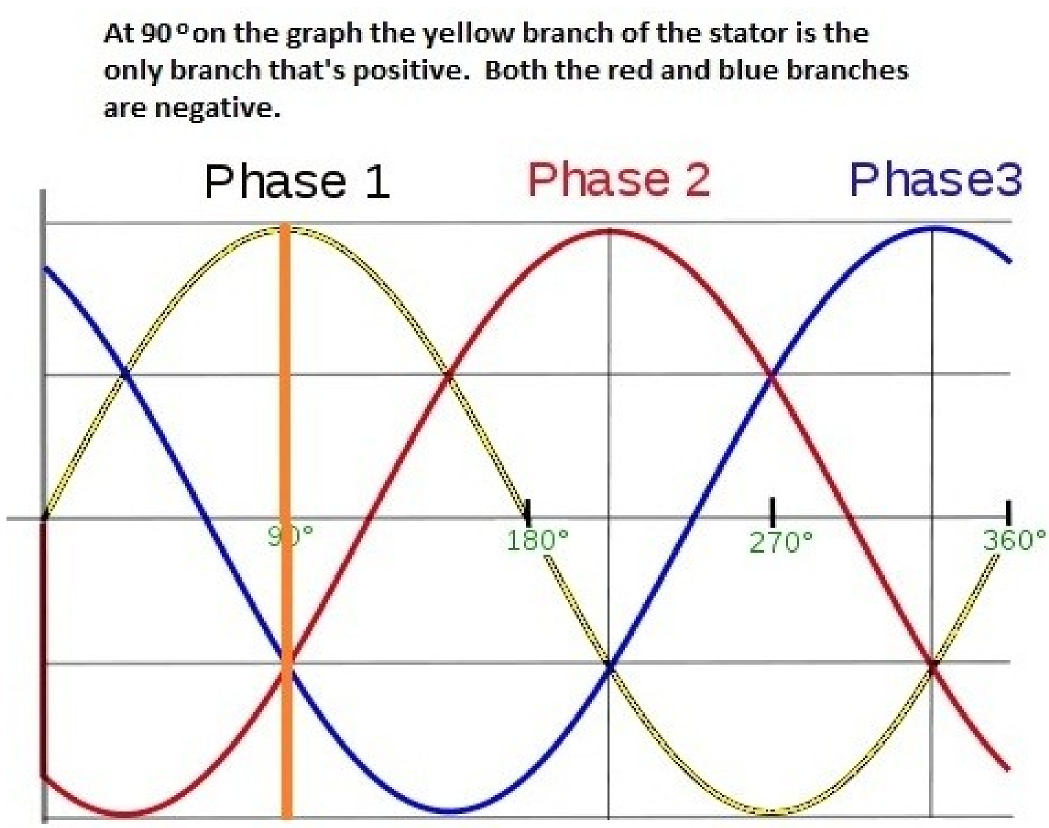
The regulator is made up of circuitry with a preset voltage reference. It keeps the voltage steady by controlling the amount of electron output. It does this by turning the SCR's on many times a second so that only the necessary amount of electrons can make it to the negative battery terminal.

The SCR's

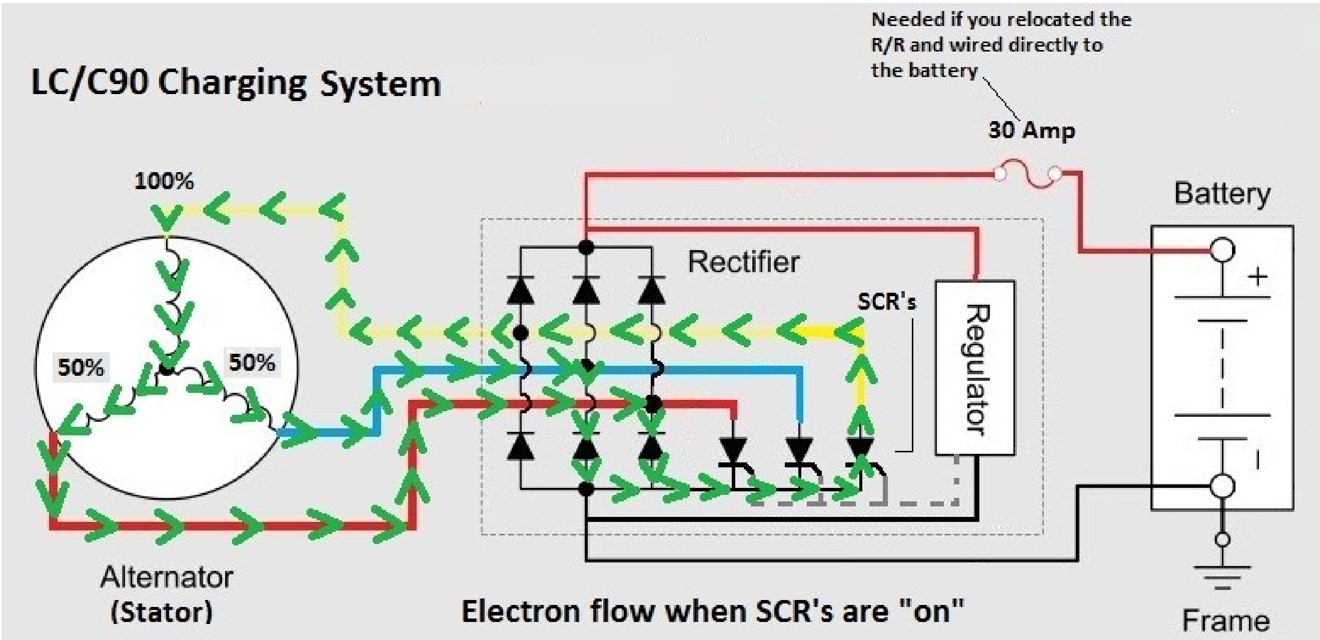


The regulator controls the voltage and electron output from the charging system. It does this by turning the SCR's on as needed to avoid overcharging the battery. This happens many times a second. The SCR's are like the rectifier diodes we looked at earlier in that the electrons will only flow through them in one direction. The difference here is that the SCR gets turned on by the regulator via the Gate. Basically it turns off when the positive part of the AC wave at the anode of the SCR hits the zero volts line.

Let's look at the electron flow in the charging system when the SCR's are "on". We'll use the three-phase graph we used earlier at the 90 degree point.



Below is the electron flow for the above graph with the SCR's turned on.



There are a few things to point out in the diagram. Notice that no electrons are entering the yellow branch positive diode, even though the stator voltage in that branch is at its positive peak. This is because with the stators branches “shorted” (or connected together through the SCR's) there is almost no resistance to the flow of current. This loads down the stator voltage tremendously. During this time the peak positive stator voltage in the yellow branch would be below the +12.7 volts it would take to turn on the positive diode(s). The red and blue branches negative diodes *do* allow electrons to flow as they normally would. This is because it takes less than -1 volt to turn on the negative diodes. Once the electrons pass through the negative diodes they are not attracted by the zero volts at the negative battery terminal. With the SCR's on the electrons are attracted to the more positive stator voltage. They flow back to the stator through the yellow branch SCR because the anode of that SCR is more positive than the cathode at this point in time.

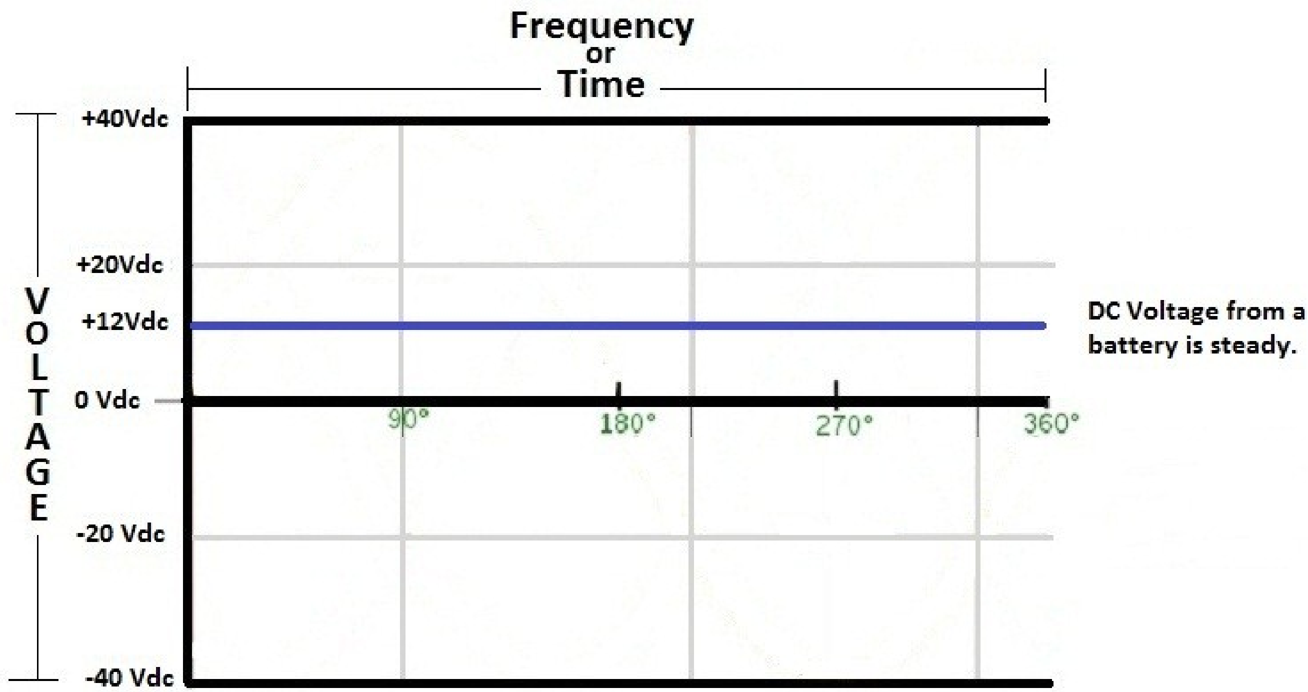
The red and blue branches SCR's have the same signal going to the gate from the regulator as the yellow branch does telling them to turn “on”, but since the voltage at the anodes of those SCR's basically equal the negative cathode voltage at this point no electrons flow through them. They are at the same potential. The anodes have to be positive in order for electrons to flow through them.

As long as the regulator keeps the gates of the SCR's “on” electrons will flow from their cathodes through any SCR whose anode is positive and return to the stator. Electron flow will remain within this “stator short circuit” until the regulator turns the gates of the SCR's off.

The Battery and the Load(s)

We need to talk a little about how the battery powers the load. First, most folks think of the electrical system as being made up of many loads...and it is. Each device that uses electricity, is itself, a load. However, they all combine to become one load. A load is also a resistance. All these resistances combine to make up one equivalent resistance, and that's what the battery sees. One big load.

The battery is a constant, steady source of DC electricity. It does not change polarity like AC voltage does. This is how it looks on the chart we were using for the AC wave.



Now let's think about what's happening here. The battery puts out a *steady* DC voltage and supplies a *steady* stream of electrons. The charging system does not. It turns on and off, or "pulses." When the SCR's are "on" the charging system isn't supplying anything to the battery/load. That means during that moment the battery is the sole source of electricity for the bike. When the SCR's are "off" the charging system supplies enough electrons to power the load *and* recharge the battery for the brief period it was powering the bike alone. The battery alternates between being a load on the charging system and powering the bike by itself. Of course this is all happening many, many times a second. This means the electrical system sees a pretty clean steady supply of DC electricity.

So, how does turning the SCR's on and off control the amount of electrons that make it to the battery? Think of a garden hose with one of those trigger valves we use to squirt people with as the charging system. Think of the battery as a 55 gallon drum full of water. You have three people, each with a 2 gallon bucket. Those people take turns filling their buckets from the 55 gallon drum and walk off to use the water someplace else. (They are the electrical system on the bike.)

Your job as the charging system is to keep the 55 gallon drum full of water, but you do not want to overfill it and overflow. If you keep the trigger pulled so that water flows from the hose into the drum constantly you will overflow. The guys hauling the water aren't filling their buckets fast enough to keep up. If you repeatedly squeeze the trigger on and off then water only flows part of the time. By controlling the on and off action of the trigger valve you can control how much water flows into the 55 gallon drum, so it keeps up with the guys with the buckets, but doesn't overflow. That's what the charging system is doing with electrons when the SCR's turn on and off.

Congratulations! You now (hopefully) know how the charging system works.

A Few *Technical* Notes...

Now that you know how *electron flow* moves through the circuits, you can just reverse direction to know how *current* flows through it all. Sometimes it's easier to picture tiny electrons flowing when thinking about electricity. With current you have to picture *holes* flowing. It's a bit more abstract for a lot of people.

Most people think when the bike is idling that the battery isn't being charged. This isn't true. At idle, the stator is still generating a higher voltage than the *loaded* battery voltage would be in short order without the charging system connected and operating. Stator current is also not at its maximum either. The RPM's have to be above a certain point in order to generate maximum current. (That point isn't *far* above idle, but it *is* higher than idle.) The charge it does receive isn't tremendous because the voltage difference between the stator and battery isn't very much. The electrical system still benefits from the generated current. Don't believe me? Without generated current from the charging system if you let the bike idle it would eventually drain the battery and stall. (It would take a while, but it would happen.) As long as the charging system is connected the battery will maintain a certain minimum voltage and the bike would continue to idle. (It would also eventually overheat. I don't suggest trying that experiment.) Of course, idling isn't going put the maximum charge on your battery. Enough power to run is one thing, enough to start the bike is something else entirely. The higher the charging voltage, the more electrons can be deposited in the negative side of the battery.

The stator is always generating current. It doesn't matter if the bike has a light load, or if you add some accessories to it. The generated current is either going out to the load or being sent back to the stator itself. (We are assuming an OEM Shunt Regulator.) As long as you stay within the capability of the electrical system you are not harming, or helping the stator by increasing, or decreasing the load. It's always doing the same amount of work regardless.

As you've seen by the design of the charging system, during use the stator gets shorted out to itself. This means if you find the plug for your stator-R/R has melted and shorted the stator wires together it will do no harm to the stator. It just means while it's shorted out it obviously cannot charge the battery. Remove the plug, hardwire it all, and be on your way.

The OEM R/R's are extremely reliable devices. If your stator goes bad and you decide to do the diode check on your R/R and it checks out good leave it in the bike. If the stator dies it in no way can do any damage to the R/R. Remember, when the charging system is working correctly the R/R is working *harder* than it would be if the stator dies. I can see no logical reason to replace the R/R as a “preventative measure.” As always, if it makes you feel better go ahead...but you're wasting your money. Money that could be used for chrome.

One other thing worth mentioning about the OEM R/R is that those of you who have voltmeters, or have used voltmeters to check the charging system output may have noticed that as engine RPM increases, the voltage output of the charging system decreases slightly. **THIS IS NORMAL**. This is most likely due to the increased reactance in the stator coils, due to the increased AC frequency, due to the increased engine RPM. (*that's* a mouthful) It isn't a defect in any way.

Our analysis of AC produced by the stator was ***EXTREMELY*** simplified. The basic premise of "what happens above the zero volts line is equally and oppositely happening below the zero volts line" in the three-phase system is true. How this happens in reality is ***very complicated***. The stator is an inductive circuit and voltage leads current. The instantaneous power at any point is the product of instantaneous voltage times instantaneous current. Since voltage and current aren't linear there are times the current can be positive while the voltage is negative, yada yada yada...and there are three phases to figure it all for. See why I tried to keep it simple?

A Few Things *I* Learned...

I learned that I never want to think about the charging system on this bike ever again. This was waaaay more work, and waaaay more time consuming than I ever imagined it would be. After all, it was going to be "simple." I lost track of the hours as I edited, revised, edited again, etc.

It was a lot more time consuming creating the pictures than I thought it would be also.

The "Paint" program is pretty cool once you get the hang of it. I could now go back and improve every picture I made....and I'm not going to.

I learned I am not a technical writer. Kudos to those who are truly good at it. It's an art.

I hope you were able to follow this and that it gave you a better understanding of how the charging system works.

Ride On!