so before i start today's lecture let me recap what we did in the previous lecture the first thing was that when you have this pn junction then across the junction you have charge density you have electric field and you have potential variation

so this is how we model the charge density ah negative charge on p side a positive charge on n side and then for uniform doping we take this charge density to be constant in this region as well as in this region the electric field is then linear and the potential that changes in quadratic fashion and if you write the electron energy it is reverse of that potential because of the negative charge and therefore the conduction band energy the valence band energy they change on the p side the energy levels go up on the inside they go down and you have this kind of diagram and potential barrier is created for electrons if they want to go from this n side to this p side then this is the potential barrier and they have to cross this barrier if they want to go in this side and the majority carriers the more energetic majority carriers they are able to diffuse they are able to cross the barrier ah even though there is this barrier and that gives rise to this diffusion current from p sides to inside then you have minority carriers for minority carriers the potential difference helps in migration and that gives rise to the drift current the electric field drives this current this is the drift current and because of the concentration difference there is a current that is diffusion current they are in opposite directions and if you do not connect any battery then the magnitudes of diffusion current and drift current are equal and there is no current across the junction but what if you join a battery

so we discussed that if you join a battery in this fashion

so that positive of the battery is connected to the p side this is p side and the negative is connected to the inside known as a forward biasing

so this is known as forward biasing of this pn junction and if this forward biasing is done then the barrier height is decreased the depletion width is decreased both of them decrease and that increases diffusion current

so diffusion current increases and that increases non linearly but the drift current remains almost the same because the drift current is caused by the electric field and there is no barrier to these electrons or holes and therefore this drift current remains the same its guided by the concentration of the charge carriers

so that is this

so a net current goes from p side to n side across the junction in forward biasing and how does that look like if you plot it goes like this this is that biasing voltage

so up to some voltage of this external externally applied source there is almost no current it is all exponential and non-linear ah once that threshold is crossed then all of sudden lot of current goes and you have to put some devices

so that the current does not exceed a limit

so that your p n junction is not destroyed and

so on

so these things we talked in the previous lecture and now let us go ahead and

so if i plot if i plot this bias voltage v here this is the battery voltage the voltage that we apply applied voltage also known as bias voltage and positive side is for forward bias and here if i write i then as this v increases i will increase but this is not increasing linearly that also we discussed it does not increase linearly because it depends on how many electrons are at which energy level and that is not linear that is not uniform that is that goes exponential depends on temperature and all that

so you expect a non-linear thing

so when the potential is small then generally the current is very small and almost difficult to measure but then when the barrier height is considerably reduced suddenly lot of majority carriers will start diffusing and therefore it suddenly increases like this now at what point you see this visible increase in the current that depends on what kind of semiconductor it is and what kind of doping concentrations are but for silicon this voltage is roughly say 0.

6 0.

7 volts for germanium it will be less 0.

3.

35 volt

so that is the kind of voltage there

so if you have a pn junction we call it pn junction diode if you have this pn junction diode and you apply a external volt in forward bias condition initially for small voltages point two volt point three volt ah if you have silicon based semiconductor you do not see any current and after some point six point seven volts suddenly you see lot of current going in now for any p-n junction diode there is a limiting current which is say rating of that diode if the increase if you increase current beyond that you can damage this thing

so if you are using this in circuit you have to put proper resistances and the design should be such that after this voltage when the current suddenly rises the current should not become very large and whatever is the rated current allowed current the total current in the circuit should remain less than that otherwise you will have lot of heating and the whole characteristic of semiconductor may get damaged

so that is about the forward biasing and what about reverse biasing you may have already guessed if you know forward biasing the opposite of that is reverse biasing this is p side this is n side remember your p side extends up to junction and n side also extends up to junction and this is your depletion region this whole thing is depletion region now if i connect my battery

so that the negative of the battery is connected to the p side the positive of the battery is connected to the n side like this remember you have a metallic contact you have a metallic contact for connections very important and this is done at the time of fabrication itself this metallic contact

so this is known as reverse biasing where you have what you have done to the potential barrier you have increased the potential barrier originally if the barrier was like this now it is like this you increase the potential barrier and if you increase the potential barrier what will happen if you increase the potential barrier this this is v let us say this is x if you increase the potential barrier then i diffusion will decrease same reason if decreasing the potential barrier increases diffusion current then increasing potential barrier will decreases

so this will decrease and therefore this current this forward current which already was very small remember with no biasing remember that with no biasing i diffusion is equal to i drift and that is typically in micro ampere region

so already i diffusion was very small in micro ampere region and it is further decreasing as you increase the potential difference and then the drift current is remains the same once again and therefore your net current in reverse direction will be i drift and minus i diffusion and i diffusion will go on decreasing starting from magnitude equal to i drift it is continuously decreasing if you are increasing the potential barrier more and more and at certain state diffusion current will become almost insignificant and your final i will be i drift

so if i plot that part also on this diagram this is known as vi diagram or vi

characteristic
 so if i plot this reverse bias thing also on this vi characteristic what do you expect on this side this drift current is i is equal to i drift
 so here zero voltage the net current is zero at zero applied voltage the net current is zero here i diffusion is equal to i drift and finally it will be equal to i equal to i drift in between it will go from zero to that i drift
 so that is the kind of thing but the i drift is of the order of micro amperes whereas this current here in the forward biased is in say milli amperes also several tens of milliamperes of 100 milliamperes like that depends on what rating you put that maximum allowed current but this drift current is going to be very very small as compared to the forward bias current once you have beyond that ah cut off voltage then this
 so on the same scale it is very difficult to plot
 so generally what people do is when they want to draw this v i characteristic they put two different scales if current and voltage this is remember this applied voltage and this is the net current this is net current
 so here they will put some scale like this and this scale will be calibrated or will be shown in say milliampere
 so suppose this is 10 milli ampere this is 20 milli ampere this 30 milliampere and
 so on
 so this is all in milliamperes this is all in milliampere
 so all these things are in milliamperes on the on this side
 so this is all in milliamperes whereas here again they will write as a 10 20 like that but then this is in micro amperes and then they will draw whatever diagram they want to draw
 so you have this cut off voltage and then you have sudden rise of that and this side it is like this
 so this is the kind of drawing one has to do now if i keep on increasing this reverse bias voltage will the current be constant all through there is still some kind of threshold you cannot go beyond that
 so suppose this is the threshold what does that mean that if you come to this point then the voltage if you increase the voltage further try to increase the voltage further then some other phenomena takes place because of it all of sudden this current reverse current keeps increasing very high
 so the current increases in that reverse direction and that becomes really high current
 so what is this phenomena this phenomena is known as breakdown and this voltage at which this happens this is known as breakdown voltage what happens here
 so you have this ah minority current which is giving you that drift
 so this side is p this side is n
 so suppose you have an electron here and this electron moves in this is this direction that is the drift current right that is the drift current the electron moves in this minority carriers move because of the electric field that is known as drift current
 so when it passes through this electric field region this is that depletion region and remember in this depletion region only you have this electric field this is the electric field and the electron is going in this electric field force is acting opposite to the electric field and therefore this electron is accelerated this electron is accelerated now if the voltage is high and the depletion region is wide then it can get large velocities and if the velocity is large then that can be sufficient to create new whole electron pairs the energy can be sufficient this electron highly energetic electron can collide with an atom and break the bond there and therefore it can create a new carrier and that

is how the this current can increase very high and that is known as breakdown and if the current is under limit this is reversible when you de you remove the voltage and everything is all right but if the current is more than the rated current for that particular p-n junction diode then it may get damaged also
 so the complete iv characteristic will have a forward biasing part a reverse biasing part and then this is the breakdown
 so now let us do some modelling
 so our this p n junction in forward bias shows this characteristic and this is somewhere something like 0.
6 volt 0.
7 volt for silicon for germanium it will be less for other semiconductors it will be different you have many more semiconductors other than silicon and germanium
 so let us say that the resistance if i talk of resistance can i talk of resistance what is the resistance how do you define that you define it as v by i in general you define resistance as v by i but here if v by i is not constant in this non-linear curve if you see what is v by i it is not constant
 so that may not be very meaningful definition
 so what we do is that at what voltage we are talking of at what voltage we are talking of suppose i am talking of this voltage at this voltage
 so at this voltage what is the current at this voltage the current is this the current is this whatever is the value some value this is the current then if i increase the voltage little bit from here to here then what happens the current increases how much is that increase
 so that increase one can find how much of that increase
 so suppose the current reaches here
 so you have a delta i and you have a delta v this is the delta i the increase in current and here is the increase in voltage
 so if my circuit is around this point if my circuit is around this point then i am concerned with this portion only and then we define what is called as dynamic resistance and that dynamic resistance is delta v over delta i delta v over delta i
 so from the graph you can see that this delta v by delta i if you write its very small because you increase the voltage by a small amount and the current increases to a high value
 so in forward biased the resistance of the p n junction is very low its small whereas if you look at the reverse bias condition in these areas what is happening you are changing the voltage you are increasing the voltage of course in negative direction and the current hardly increases current current remains the same
 so delta i is very small
 so if you are in reverse bias delta i is very small negligible almost 0 whereas delta v can be considerable few volts for example and your current is not even the change in current is not even a micro ampere
 so in that case if you define r which is delta v by delta i this will be very large
 so in forward bias the pn junction offers a low resistance in reverse bias it offers a large resistance in forward bias also if you are above that knee voltage after which it increases rapidly then you have low resistance but if you are in a in that region below that the resistance is still high
 so to understand the function what we will do is we will do a kind of an approximation approximate model and we will assume that in forward bias resistance is 0 and in reverse bias resistance is infinity ok
 so in that case what we are assuming is my iv characteristics is of this kind

the resistance is infinite

so no change in current and here's all of sudden resistance is zero

so you have large current

so anything beyond this you have zero resistance anything below this you have infinite resistance ok now let me talk of applications

so suppose you have ac source suppose you have an ac source which gives you power voltage which changes with the time sum v equal to v naught cos omega t type the kind of power we get in our household what we need is a dc voltage for example to charge my battery of mobile or charge my battery of laptop or some other application where dc is required direct current voltage is required

so conversion from ac to dc right conversion from ac to dc is known as rectification and the unit that does this is called rectifier and this p n junction diode we call it diode can be a good or a basic unit for rectification a good rectifier lets see how suppose you have a circuit suppose you have this voltage source ac voltage source and then you have these connecting wires and what we do is we connect a diode here what is this

so what is this triangle that i am drawing what is this triangle and this is straight line that i have drawn this is a symbol for diode ok we draw a triangle a horizontal triangle like this and put a line here and then a line here and then a line here and this represents p n junction diode and what are the things this straight line represents p side of the junction and this line represents n side of the junction ok and these are of course the metallic contacts these are of course the metallic contacts where you do this this is a representation of the p n junction that we had talked in detail

so here this is p side and this is n side and then if i connect it to some resistance or something what will happen what will happen if i take the voltage here what will happen

so let us try let us understand what will happen

so let us draw a graph let us draw a graph where i am plotting time here and this voltage here this is my voltage v this voltage v here since it is an ac what you have is a wave form which will look like this will look like this it will continue

so the power source the power source the source here this source here that is providing me this kind of voltage but when this side is positive because now it is changing signs your v is positive here your v is positive here v positive this is positive and this side is negative

so half the time it is positive half the time is negative when it is positive then this side is positive this side is negative and this p n junction is forward biased why it is forward biased this is forward biased because your p is connected to higher voltage n is connected to lower voltage and that is the forward biased and in forward bias under our approximation the p n junction offers no resistance and the entire current will flow

so what you will have is on the other side you will have a current i in this and if i again plot this voltage which voltage now i am plotting and which voltage this was this was our source voltage and now this is the voltage as received by the resistance okay

so in the positive cycle when v is positive then this offers no resistance and what you have is a ah voltage which is just the previous one this one what happens when you have negative cycle what happens when your time is here the voltage it becomes negative

so this plus becomes minus

so this plus becomes minus here and this minus becomes plus here

so now the p side of the junction is connected to the negative of the voltage source inside is connected to the positive of the voltage source and now this is

reverse biased and in reverse bias the p n junction offers large resistance and therefore the current is blocked very small essentially zero
 so here there is no current in this resistance and therefore you do not have any voltage on this and
 so the voltage becomes zero and after that again after that again the voltage becomes a positive again that new cycle starts and
 so on and therefore here again a new cycle half cycle will start and the voltage will be like this and this is how it will continue ok
 so this is how it continues
 so what has happened in this resistance the current is either in in this direction or it is zero
 so at least the direction part has been taken care of it is not a very good dc a very good dc means you should have a constant voltage like a battery
 so this is certainly a very bad dc but it is dc in the sense that the current is not reversing direction either it is going in one direction or it becomes 0.

 so that is how the basic unit of rectification going from both directions to a single directions going from changing direction of the current to a same direction n current can be taken care of just by one p n junction put in the circuit
 so that is the kind of now this is known as half wave rectification
 so this is known as half wave rectification why why half wave because half the time it is zero is doing nothing half wave rectification now before going ah further let me do some experiment and show some of these things qualitatively how this reverse bias or this forward bias or this rectification takes place in a real circuit
 so let us do some experiment here i have a setup in which this is a heater coil which i will be using as an extended resistance and on this heater coil i will be putting this nine volt of battery
 so one end is connected here one end of the battery is connected here and the other end of the battery i will be connecting here
 so if i join this this whole nine volt is now dropped on this coil
 so if i take a smaller length i will get a smaller potential difference if i take a larger length i will get a larger potential difference
 so now i have a variable source of variable voltage that can i can apply
 so the first let me show you what happens if i connect some kind of a meter a galvanometer to this voltage and see how it works
 so i have this galvanometer this galvanometer and these are the two ends one end let me fix at one end
 so i am putting it here and it is fixed the other end now if i want a very small voltage to be given remember this is galvanometer very sensitive instrument
 so if i just touch it here see what happens ok
 so it deflects
 so in this small length of heater coil there is some voltage which is able to deflect this needle ok if i take a larger length here the deflection is much more smaller length deflection is small
 so it shows that as you take larger and larger length you have more and more potential drop here now let me put a diode in the circuit
 so let me put a diode here in this path and where is my diode this is the diode ok
 so let me put it here this is the diode we had made diagrams varieties of diagrams we had drawn rectangles and then we had shown some lines depletion region this that but if you go in the market and ask for a diode what they will

give will look like this this is the kind of thing you have this black thing here then these are two connecting wires which are there you can see a silver line here a ring type line
 so that shows which side is p and which side is n
 so this diode i will be connecting in this circuit
 so let me do that
 so now i am connecting the diode to the galvanometer one end and the other end of the diode let me put it here
 so i have connected diode and this end of the diode i am connecting to my say zero of the voltage source and this is the other end
 so let me try to apply some voltage here
 so see what happens i am touching it here i am touching it here did the needle deflect did the needle deflect this needle no i am increasing this length i am touching it here
 so i have applied larger potential difference did this needle deflect no does not seem to be let me go ahead no here here you can see a slight deflection here you can see a slight deflection and if i go for larger voltage see what happens see what happens
 so you remember our vi characteristic in the forward bias if i apply a small voltage very negligible current goes and once that knee voltage is achieved after that it goes rapidly
 so that you are seeing here if i connect this across a small length i am applying a small voltage remember this is in forward bias and if i increase the voltage not nothing changes almost nothing changes i increase it further i increase it further and somewhere it starts deflection this is that point for silicon i told point six to point seven volt
 so that is this point of course this is not silicon
 so and after that if you increase the voltage see i am increasing this distance
 so i am increasing the voltage and this current is increasing
 so this is one part of the experiment that i wanted to show
 so this was forward bias now let me go for reverse bias
 so if i change the polarity of this p n junction that will do
 so i will be just opening it here and reverse the polarity
 so i have opened it i have opened it i have inverted it and again i am connecting it
 so this goes in reverse bias now in this reverse bias i will be applying voltage i apply a voltage here look at this needle is there any deflection in the needle no i am increasing the voltage i am increasing this voltage nothing happens to this needle i have increased it this much nothing happens to this this much nothing happens to this and
 so on
 so in the reverse bias if you apply even large voltages you should not apply voltage more than the breakdown but you have seen that i have applied reasonably large voltage here and there was almost no current at least not visible in this instrument
 so reverse bias almost zero and forward bias after that knee voltage it goes up
 so now in this setup you can see several things here essentially this is an ac power supply and i can change the frequency of this ac by this knob this knob can be rotated and that will change the frequency i can change the amplitude of the voltage for that you have this knob here you can see a line here blackish line
 so if i rotate this knob then the voltage the amplitude of that voltage will change and the voltage is actually obtained at this point here
 so you have two wires in fact in this cable which are connected to some circuit

and here you are getting that final ac voltage here at these two points

so you are getting your ac supply here to see that let me put this galvanometer bring this galvanometer once again and i connect this galvanometer to this power supply to this ac source and put this on and you can see the ac you can see this needle can you see this needle is going towards left it is going towards right and with a very small frequency very very small frequency i can increase the frequency using this knob i am increasing it and see now it is going with somewhat larger frequency

so this is our ac source at these two points the voltage is changing its sign positive negative positive negative

so let me disconnect it here and put a diode in between remember you had a ac voltage source and then if you put a diode and then connect it the diode will pass the current only when it is forward biased and it will stop the current when it is reverse bias and if the voltage is continuously changing its sign half the time it will give a positive voltage half the time it will give a negative voltage and then you have half the time diode will pass the current in one direction and other half of the cycle it will just stop the current

so you have current in one direction only but intermittent

so let me do that

so once again the same diode which i had used and this diode i am connecting i am connecting in the circuit

so this diode i have connected in this circuit in between right and see what happens when i give the amplitude it only goes in the right direction and then stops here it goes in the right direction and stops it does its not going in left direction half the time there is a current half the time current is zero but the current is only in one direction

so that is that rectifier action that we had discussed right now let me reverse the polarity of the diode what do you expect since this is ac it will still work but what was positive cycle will become negative cycle and vice versa for this diode that in the half way when it was forward biased now it will be reverse bias

so let me do that

so i have opened this diode i have inverted and connected it again

so now see when i give the voltage what happens it goes in the left direction your needle goes in the left direction unidirectional but the direction has changed because i have changed that polarity of this diode and therefore what was forward biased earlier has become reversed bias and vice versa

so what we did on the table we made a half wave rectifier and what was that we had this we had the circuit we had this voltage source ac voltage source we had this diode and then in place of this resistance we had the galvanometer

so let me draw it again we have this voltage source ac voltage source i put a diode here and then if i put some resistance or some meter anything here then i get a a voltage here which is of this type which is of this type this is half wave rectification what we are plotting here we are plotting here voltage and time which voltage i am plotting this voltage which appears here between this these two points which are i had put a galvanometer in place of this resistance but then that voltage drove that galvanometer and we saw the deflection

so this is this voltage that we are plotting this is our half wave rectification current goes only in one direction now what happens if i put a capacitor here suppose i put a capacitor here what will happen suppose i put a capacitor here and let us say this is point a here and this is point b now this picture will change

so let me remove this picture because of this capacitor first let me draw the potential which is at point a

so at point a v at point a what is this potential i am taking this as the 0 potential
so this 0 is right from here to here this this is all 0 this is all 0
so this is 0 and this at a point i have v a this is just output of this ac source and
so it will be like this
so it will be like this and now next i plot the potential at point b v b as a function of time what will happen when this voltage increases this voltage increases as a function of time this voltage increases the diode is forward biased and therefore it allows current to go and that current goes in this capacitor as well as in this resistance and hence the capacitor will get charged and once the capacitor gets charged it will charge up to this maximum
so up to this time let me draw a a line to show the time to some extent
so up to this time this voltage is increasing r into i is also increasing the capacitor voltage is also increasing is same and it goes like this now the voltage is decreasing va is decreasing
so this potential has decreased you do have a charge on this capacitor and therefore that voltage is there that voltage is here and this is larger and this is smaller
so it gets reversed bias here itself
so in this positive cycle itself the remaining part of the positive cycle this part in this part in this part is already reversed bias and therefore this diode stops conducting current then what happens then you have this r c circuit
so you have this charged capacitor and then
so this charged capacitor will get discharged through the circuit through this rc circuit i hope you remember this rc circuit if you have a capacitor charged capacitor and then a resistance is connected across the charge will decrease on the capacitor the voltage will decrease on the capacitor and that decrease will be governed by the time constant you remember what is time constant now i am talking of a circuit where you have a capacitor and you have charges here some charges q minus q and you connect this to a resistance then as a function of time the voltage or the this q that will decrease exponentially it decreases exponentially this is time and this is let us say voltage across the capacitor and then the time constant is given by r times c
so the voltage decreases like this
so here also the voltage will now decrease and it will decrease exponentially
so it decreases exponentially
so the voltage decreases decreases fine your va also decreases becomes negative all right and at some point of time again it starts increasing the voltage starts increasing here here the voltage starts increasing and this side it is decreasing this side it is exponentially decreasing
so maybe at some point of time this voltage at say this time let us say at this time let us say at this time this voltage here and this voltage here suppose they become equal suppose they become equal in this drawing it it is not like that but suppose it is equal i can draw another curve
so the capacitor voltage was decreasing at this time they have become equal and after that the voltage on a side voltage here is now increased further the diode becomes forward biased i am talking of this part in this part what is happening in this part the capacitor voltage was decreasing but then the voltage which is at point a at this point on the p side of the of this p n junction has increased it has increased here here and therefore it becomes forward biased and therefore once again the same story forward bias
so the current will flow and the capacitor will get charged it will get charged up to the maximum up to here let us say up to this time up to this time the

capacitor will get charged again the voltage on this will increase and it will increase to the maximum value once it increases and reaches this maximum value here after that the voltage on the p side decreases this v a remember this is v a

 so here the p side voltage decreases the diode becomes reverse biased once again discharging starts and this whole cycle will continue

 so it will discharge again like this once again it will become equal somewhere here and after that again it will be charging and then discharging and

 so on

 so it will charge and then again it will discharge and

 so on

 so compare this with the case when we did not have any capacitor in that time the voltage diagram at b was of this type this was v b as a function of time and now it is this and you can see that it is a better dc this was a very poor dc very bad dc it was unidirectional but if you look at the voltage far from that ideal constant voltage situation you have this voltage which is going up coming down becoming 0 for lot of time again going up coming down 0 compared to this see this voltage here see this voltage here compared to that it is a much better dc

 so putting this capacitor here it is a kind of filter it is a kind of filter it makes your dc a better dc in the sense that fluctuation about that average dc is reduced

 so this is this kind of there are more circuits better circuits more refined circuits which can make it even smoother when you are using your chargers for mobile and laptops you cannot afford to have this kind of bad dc

 so the circuit there does this filter business and makes it much much smoother

 so far we had been talking of half wave rectific rectification in half wave rectification what we have is that the diode which we are using p n junction diode which is using is active only half the time and therefore your final output is like this of course you can do filter and all those things now it is possible to have a full wave rectification full wave rectification that means in your resistance the current is going all the time in the same direction

 so that is full wave rectification and the procedure is a simple we will be showing it using a transformer this is the symbol for transformer this side is your input and this side is your output and if you have a point at the center you have three leads one coming from top one coming from center and one coming from this bottom two edges of the coil this kind of transformer is known as center tapped transformer and if you take this as 0 if you take this middle one as always say v equal to 0 i will take here then this will be positive this will be negative after half cycle then after half cycle you will have this as positive this has negative and

 so on it will keep on oscillating now consider this circuit you have a put a diode here put a diode here then put a diode here and connect them together and then you connect your resistance here and think what happens when you have this kind of voltage at this end between these two points your voltage is like this

 so at this end let us say this is 0 and this is this is a positive at certain instant let us say this is positive and this is negative

 so what will happen this diode upper diode is forward biased this diode is forward biased and therefore then it will allow the current this lower diode is reversed bias it will not allow the current

 so the current will go like this and then no current in the lower diode

 so this current will return like this and then you this is the circuit this is the circuit which will be operating what happens in the next cycle when the upper point becomes negative and the lower point becomes positive then what

happens
 so suppose now this becomes positive and this becomes negative
 so if this is positive this is v equal to zero at the center and this is positive here
 so this diode is now forward biased this is forward biased and this is reverse bias this is negative remember this is negative here
 so this is reversed bias and therefore the lower diode will conduct in this figure current will go like this no current through that upper upper diode
 so what will happen the current will go through this lower diode and then it will return through this resistance and once again in the resistance the direction of current is same
 so as far as this resistance is concerned you have current always ah in the in the positive cycle also and in the negative cycle also positive cycle also negative cycle also all the time you have current in this resistance and in the same direction
 so you will get this kind of output this is known as full wave rectification this is known as full wave rectification ok
 so this is how the central tap transformer will look like this is the input side where you have two wires and then this goes in the main power ac and on the output side you have three wires you can see here there is a yellow wire in the middle and then you have blue wires at the ends
 so this yellow one is coming from the center of that coil and that is ah connected here internally
 so this is that center tap point and then on the sides you have two points one connected to this end one connected to that end
 so this is the that center tapped transformer
 so if you want to connect things connect it here this is your zero this is your v equal to 0 this one is v equal to 0 then you can put more connectors you can put the connector here you can put the connector here and then you can make your circuit you can connect a diode here you can connect another diode here and these two diodes can be connected among themselves and then the junction of that diode and the center tap you can put a resistance you can put a resistance here
 so i can join it here together with this and your full wave rectifier is done you