Electronics for Analog Signal Processing - I
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Lecture - 4
Rectifier

We have had a discussion about the diode function generator. A popular application of this diode function generator, you can now see, as what is called rectifier.

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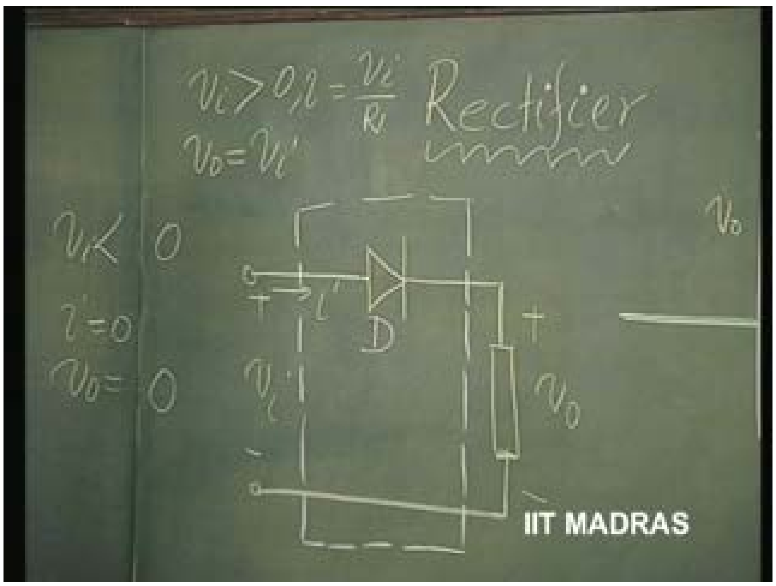

What is it? It is going to be having a specific input which is bidirectional and rectifier is something that converts it into unidirectional. The waveform can be anything, but it is a bidirectional input that is applied to a rectifier which it converts it into unidirectional.

You can see here the characteristics; v naught is going to be same as v i; that is, Delta v naught by Delta v i is going to be 1. This slope is going to be 45 degrees.

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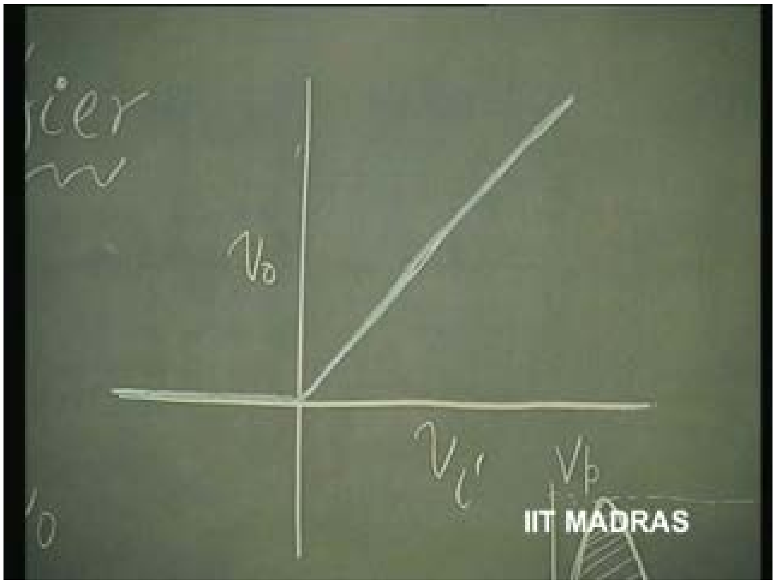

Delta v naught by Delta v i is going to be equal to 1 throughout the region where v i is greater than zero; and where v i is less than zero, v naught is going to be zero.

So, this is the mathematical function, non linear function for rectification, half wave rectification it is called, because one portion of the waveform only survives, the other portion of the waveform is removed.

So, in a periodic waveform, which is going to be something like this, let us say, this is a sine waveform. So, if this is a sine, input sine waveform, then, only this portion of the waveform is going to appear at the output, and this is going to be deleted, chopped off.

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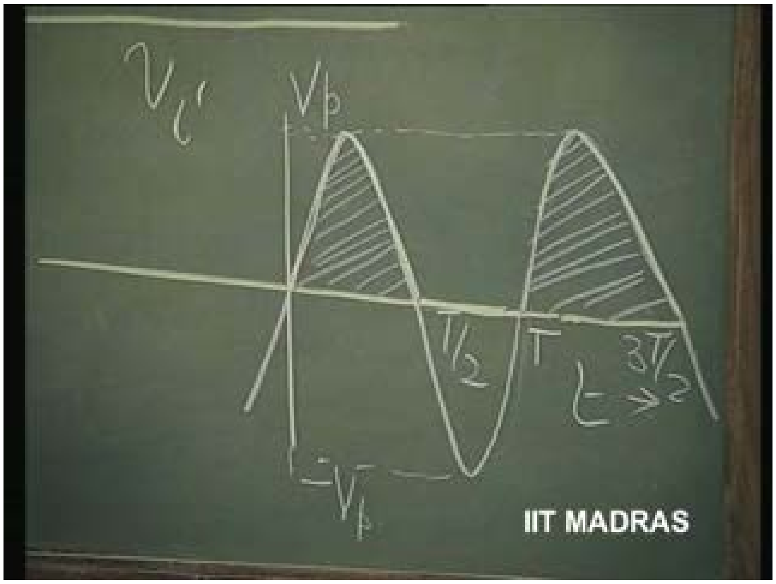

So, this portion goes off at the bottom and only this portion survives. Here, it is going to follow the input and here output is going to be zero; here it is again going to follow the input; again, output is going to be zero at this point. So, this is what is called half wave rectifier.

Let us see the circuit here; it needs only a single diode, a simple circuit. Let us say, this is the load resistance R L through which you want the half wave rectified waveform to appear. This is the block which is generating this transfer function, in such a manner, then, when v i is positive, i is going to flow so that, this diode short circuits the input point to the output point, so the transfer function is unity.

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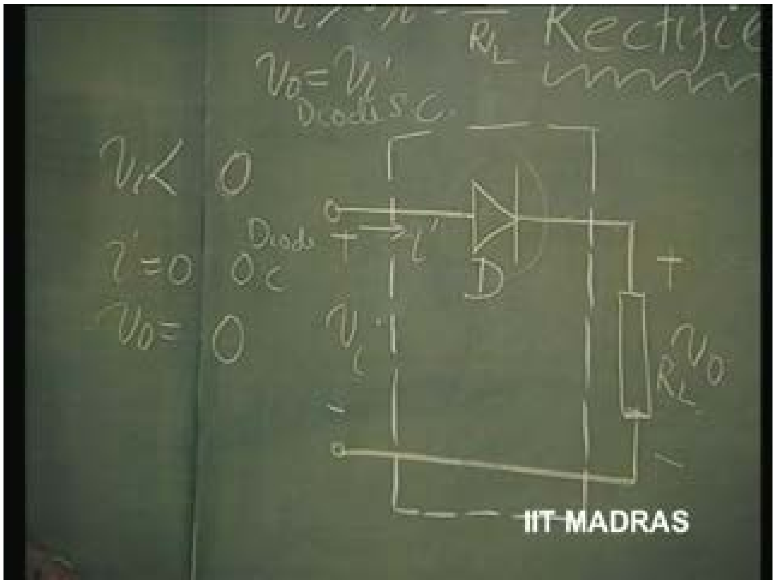

This is going to be replaced by short circuit. For v i greater than zero, i is equal to v i divided by R L; for v i greater than zero, i is going to be v i, because this is a short circuit, divided by R L. v naught is going to be equal to v i; therefore, because, this is a short circuit, v naught is going to be same as v i. So, we can replace it by means of a short circuit at this point; v naught is going to be same as v i.

Then, when v i is less than zero, v i negative, i is going to be zero because the diode is going to be an open circuit, diode is an open circuit. Here, the diode was a short circuit. So, diode is an open circuit. So, this is an open. So, this is going to disconnect the input from the output and therefore, i is going to be zero, no current; and v naught is going to be zero, because it is disconnected from the input.

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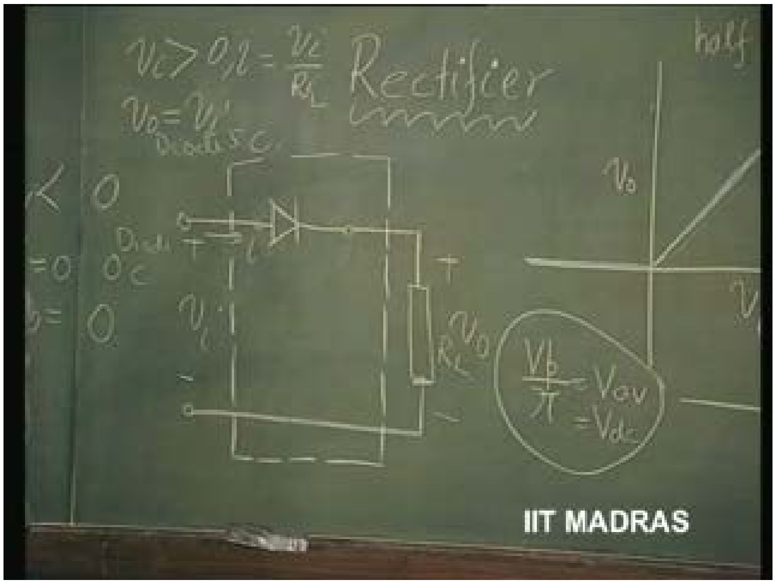

So, this is the function of this diode; a simple application, but one of the widest applications that we can think of. For simple unidirectional voltages, you will find that people use just a transformer and a half wave rectifier and you get simply this unidirectional output which has a DC component in it, average component in it.

So, this half wave rectified waveform has an average component in it. If you take the average of this, it will come out to be v p divided by pi, is the v average. This is the DC component.

So, if you put a DC meter in here, a DC voltmeter, it will show an indication which is v p divided by pi, which is nothing but the average of a half wave rectified waveform. This you have already done it in your network courses for how to find out average for a given periodic waveform. So, v p by pi, please remember, is the average of a half wave rectified waveform.

So, it can be used as a, in place of, a battery which gives an average voltage of v p by pi, v p being the peak voltage of this sinusoids, which can be represented as v p sine omega t, where omega is the frequency of the waveform.

So, the peak voltage divided by pi is the average. It has lot of ripple, voltage still is not constant. It is only unidirectional. It is not free from what is called as ripple. Ripple is this variation. This is enormous. And it is, if one is not happy with this kind of ripple, would like to get rid of this ripple. Let us see how to get rid of this ripple.

But presently, we would like to reduce the ripple by, instead of making this voltage here zero, we can convert this waveform which is going negative to positive. So, if we can make this get inverted here. How do we do it?

This is the common load. Let us come to this. This is the common load here, which is indicated here. This is the diode D 1, let us say, which is conducting, whenever this is positive and this is negative.

If I have another voltage, which when this is negative and this is positive, goes positive and negative in such a manner that I can pump in current into this in the same direction, then, I have achieved my purpose of introducing this waveform here. Again, what it means is, I have to have another diode. I have to have another diode here in such a manner that it is going to conduct, when this is going to be positive and this is going to be negative; such that, this diode pumps in current in the same direction as this diode but when the voltage is in the opposite direction, such that, on both the half cycles we have an output. That can be done by using, at this particular point, what is called as a transformer.

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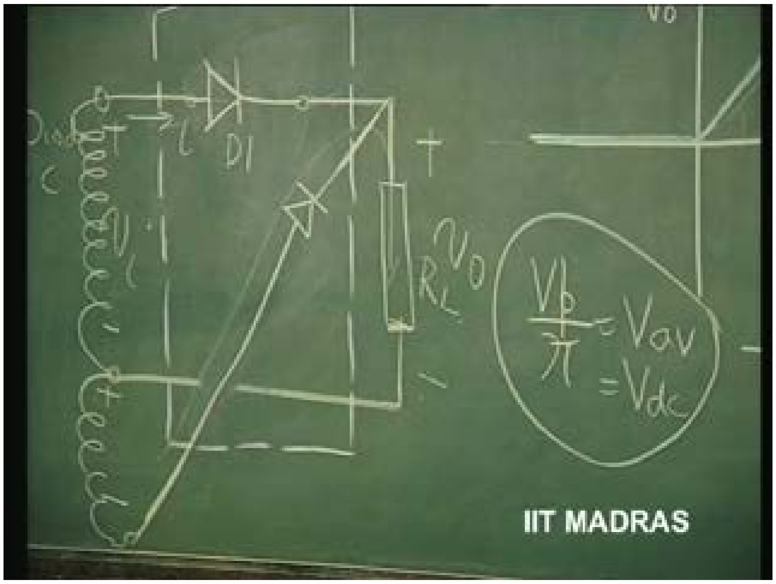

So, we have the same trans ratio at this point as this point, which is illustrated here in this curve. We have a main transformer, means, transformer which is connected to the power supply here, with a trans ratio n is to 1 and n is to 1 with a center tap such that, when this is v p sin omega t here, this is going to generate plus minus v p sine omega t here, plus minus v p sine omega t here Same voltage gets induced here, as well as here, because the number of terms here as well as here are the same.

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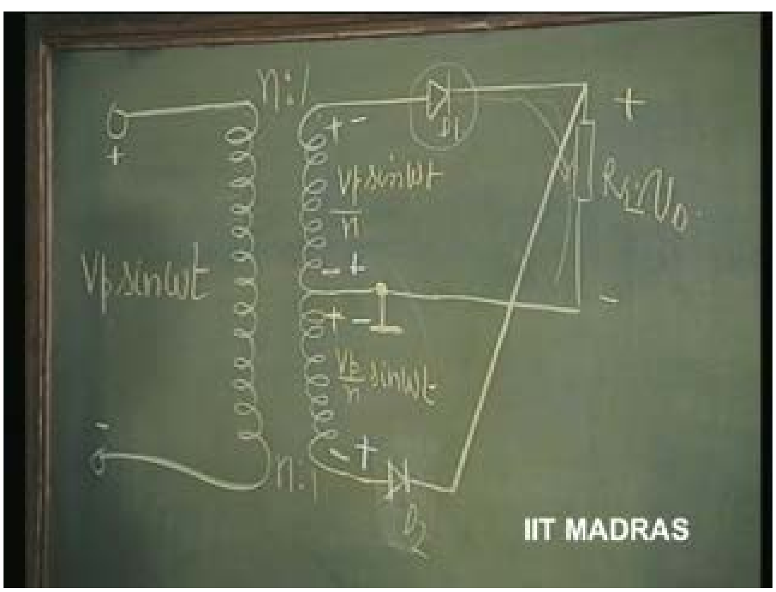

Now, what happens? Let us consider the original diode D 1 here and the new diode D 2 here. When D 1 is getting plus minus voltage, when this is going positive, then it is v p sine omega t divided by n here. This is going to conduct and pump a current in this direction. This is plus minus, so this diode is reverse biased; it is not going to conduct. So, this is open, this is a short. When, now, the voltage changes to minus plus, this becomes minus plus. This is reverse bias. So, this diode is an open circuit and this diode is a short circuit and this is going to conduct and pump in current in to this direction.

So, the space reverser can only be done with the help of what is called as a transformer. When this waveform is going to be this way, this is going to be, as far as this portion is concerned, it is going to conduct in this direction and pump in current in the same direction and add on.

Now, this is for the first half. The second half, instead of being zero, is going to be what is called as full wave rectification. So, this circuit is a full wave rectifier as against the half wave rectifier.

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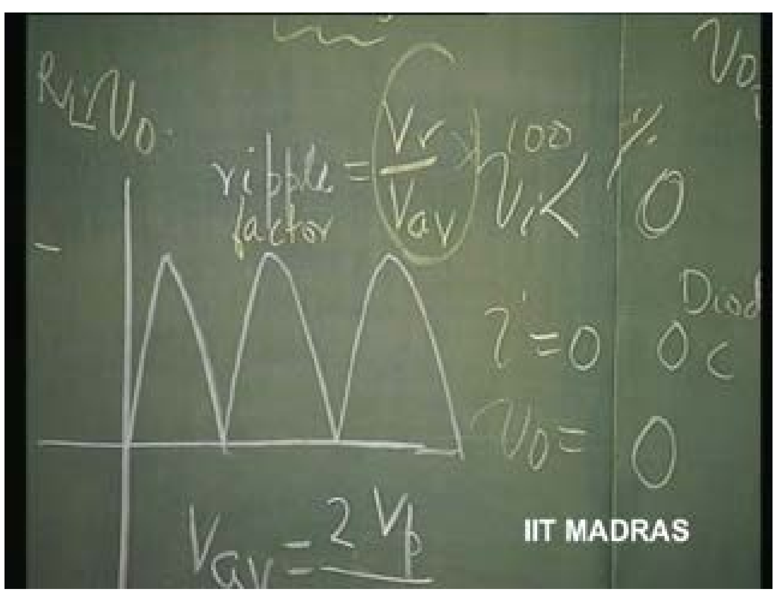

So, we have reduced the ripple. Earlier, this was zero; it was coming down to zero. Now, it is the same as the earlier half. So, we have reduced the ripple. The ripple frequency gets doubled. Earlier, the frequency was, let us say, 50 hertz. Now, the frequency becomes 100 hertz. 50 hertz ripple is not at all there in this.

So, that is the advantage here and the average is going to be equal to 2 v p divided by pi. This is the average. Earlier, it was v p by pi; now, it is 2 v p by pi, twice, because we have restored the other half also similar to this half. So, it is twice the average correspondingly. The DC is doubled, the ripple is reduced. So, this rectifier is quite useful for generation of DC from an AC.

So, AC to DC converter, this is called AC to DC converter. One may not be still happy here because this ripple is still there. Even though much reduced compared to the half wave rectifier, the ripple here is still existing.

So, let us define certain things for measuring the performance of this rectifier. We have to have what is called as, apart from average, it is something that converts bidirectional waveform into unidirectional with reduced ripple. So, we have to define what is called ripple factor. What is ripple factor? Ripple factor is nothing but percentage or it is expressed in terms of percentage or as a ratio; ratio of ripple voltage to average voltage, DC voltage. So, this is nothing but ratio of ripple voltage to average voltage, expressed as a ratio, or, into 100 percent, percentage.

So, what is the ripple factor quantitatively in the case of half wave, in the case of a full wave? That can be very well established, if we can find out the average from this.

Basically, the RMS value of the ripple voltage is nothing; but, if you remove the dc from this, the RMS value of this waveform is the same as RMS value of the original waveform. Nothing has been lost; we have restored everything.

So, whether we use a sine wave like this or a rectified waveform like this, the RMS value remains the same. RMS value is root mean square; the moment squaring is done the sine is lost. So, RMS value of a full rectified waveform is the same as RMS value of the sine waveform, in which case, we take the RMS value of the sine wave which is nothing but v p divided by root 2.

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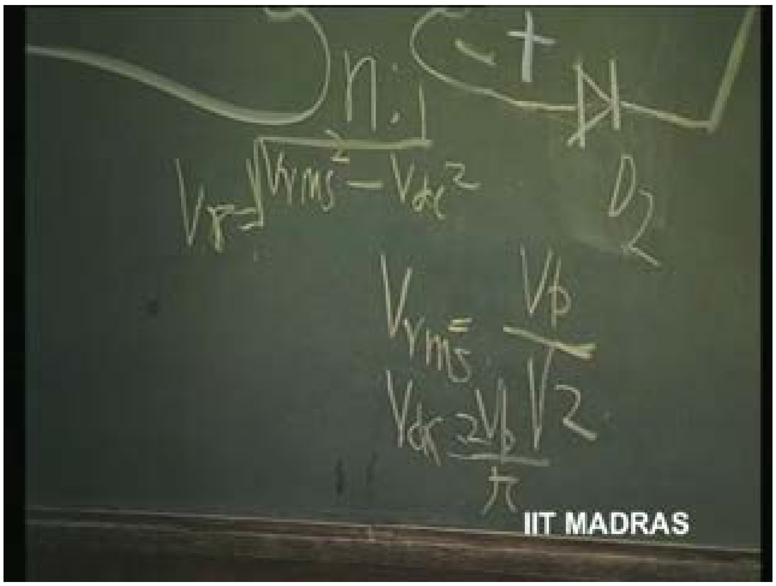

RMS value of a sine wave is nothing but peak value divided by root 2, this all of you know. So, if we have a sine wave which is v p sine omega t, RMS value is already known. The RMS value of the average is the average itself. So, the DC is known to us as v p, twice v p by pi; that is the DC. So, what is the ripple RMS value? By definition, the RMS value of the ripple is now nothing but V rms square minus V dc square under the root. So, V rms square minus V dc square under the root is the RMS value of the ripple.

So, the ripple factor, therefore, is going to be equal to V rms square minus V dc square divided by V dc. This can be obtained from this expression here. For the half wave rectified waveform, V rms is going to be v p divided by 2 and V average is going to be v p divided by pi. So, we will now rewrite all this things clearly so that we can understand the definitions involved in the rectifier.

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Ripple factor is defined as V rms ripple divided by V average. In the case of a full wave rectifier, V ripple is going to be square root of rms value of the ripple; that is, rms value of the sine wave square minus V dc square; this divided by V dc square.

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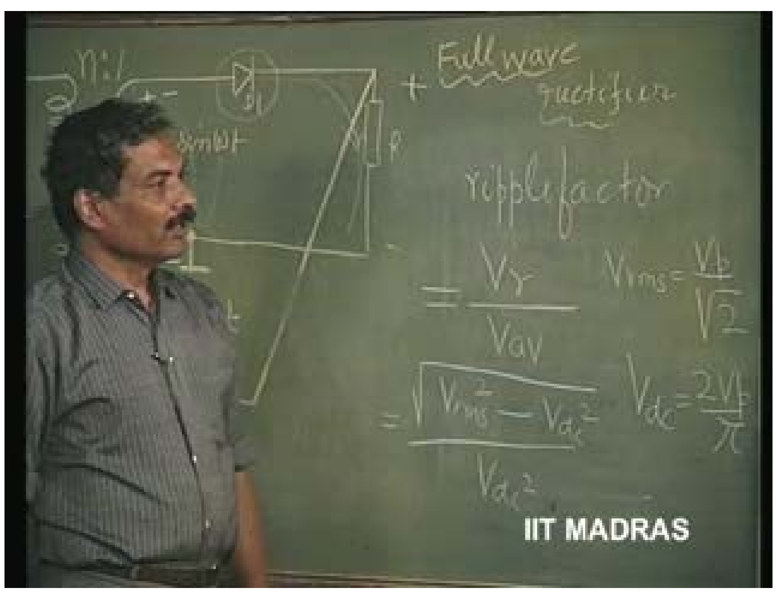

V rms is going to be v p divided by root 2. V dc is going to be twice v p divided by pi. Once again, this is for the full wave rectifier. For the half wave rectifier, let us put it down here.

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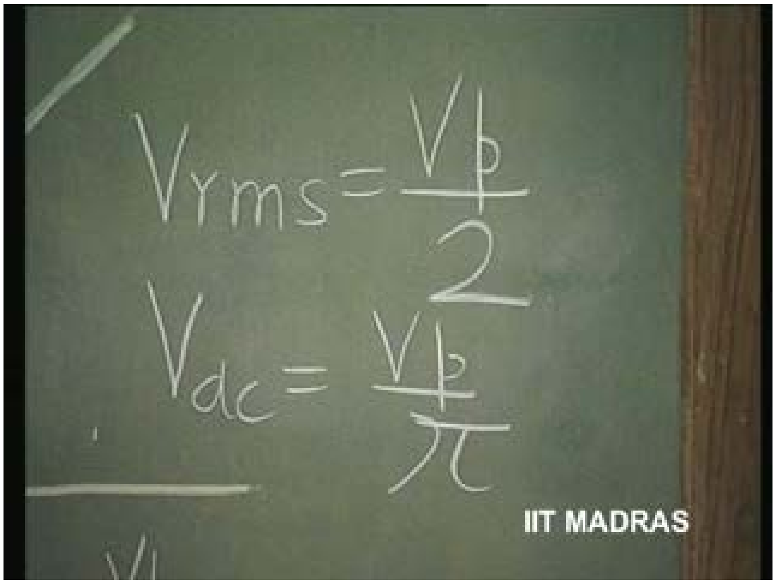

For the half wave rectifier, V rms is going to be v p divided by 2 and V dc is going to be v p divided by pi. Therefore, you can evaluate the ripple factor, both for half wave rectifier as well as full wave rectifier and see for yourself, that the ripple factor is going to be much smaller for the case of full wave rectifier as compared to the half wave rectifier.

So, this is a measure of how good your conversion from AC to DC is; the ripple factor. Now, we would like to further reduce this ripple voltage. How do we go about doing it in a very simple fashion? This is what we are going to discuss.

So, V dc, that is, square root of V dc, which is V dc, V dc square; so, V dc is going to be higher and the ripple is, voltage is, going to be lower for the case of full wave compared to half wave.

We would like to reduce this ripple voltage further in the case of both the rectifiers. Let us see how this can be done with the help of what is called a capacitor.

So, that will be the topic of discussion that we will start discussing from the next session onwards. We have just finished discussion about half wave rectifier and full wave rectifier.

Before we further try to reduce the ripple voltage, let us digress and go over to another application of the diode. Ultimately, we will come back to the technique of reducing ripple in the case of full wave rectifier as well as half wave rectifier.

This is another basic application called peak detector. This kind of peak detector exists in your radio receiver for detecting the audio signal after the IF stage.

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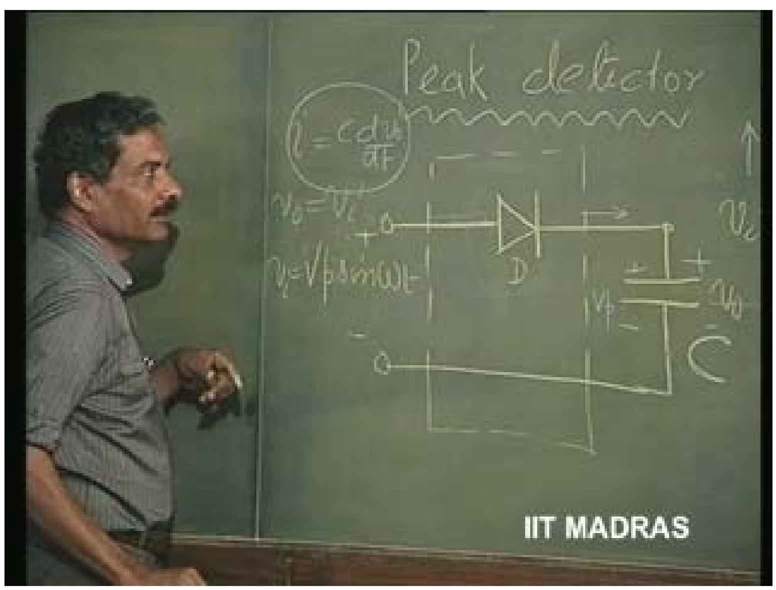

A very simple technique of detecting the audio contained in the carrier, which is, intermediate frequency, or rf, whatever it is. So, you can just simply put this peak detector and detect the peak of any time varying signal. Let us see how it does.

We have the diode. Instead of the resistor there as the load, we will put a capacitor. Capacitors, you know the property of the capacitor. Capacitor can be charged or discharged. You can store a charge through which is c into v, voltage across it or it can be discharged by connecting a resistance across it.

Therefore, v i is equal to v p sine omega t, let us say, is the sine wave that is applied to the diode. What happens in this case? We will change the waveform later to something else and see what happens.

Since we understand application of sine wave, a periodic waveform, better than any other waveform, I am now considering the sine waveform. When we apply v p sine omega t, let us assume that this waveform is specifically starting from zero in the following fashion. Before this, there was nothing applied; so it is starting in this fashion.

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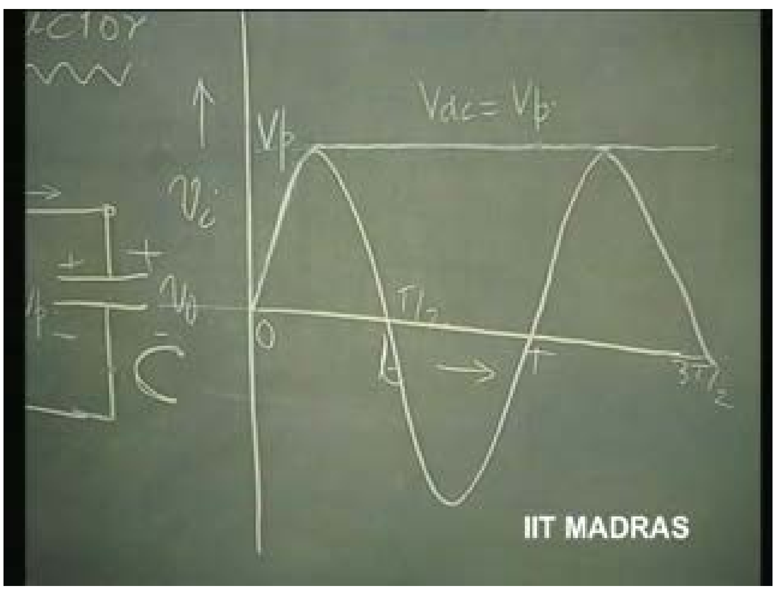

If this is the assumption, and the assumption is that the capacitor is initially not charged; then, there is nothing across the capacitor - no voltage, voltage is zero; so the voltage v naught is zero and v i is parting from zero, let us say, and, it is going more positive. This voltage here is zero; this is starting from zero and therefore, since there is a slope here, c d v by d t is the current in the capacitor.

All of you know, i is equal to c d v naught by d t. This is the current in the capacitor; the basic relationship between current through the capacitor and the voltage across the capacitor v naught. In this case, voltage across the capacitor is v naught.

i is equal to c d v naught by d t. d v naught by d t is finite here. This is a sine wave and therefore, there will be a current in this corresponding to theirs.

So, the capacitor is going to get charged by that; and this current of charging is going on decreasing. As soon as it reaches the peak, it becomes equal to zero. So, it stops charging there; but, the voltage here has become equal to v p. So, it is following this mainly because initially the voltage across this is zero, this is becoming more positive, the diode is conducting because this is becoming more positive than this, and the capacitor keeps on getting charged. So, at this point of time, there, the output voltage will follow the input voltage because capacitor is getting on, getting charged by currents which are of varying magnitude depending upon the slope.

Thereafter, the voltage here is less than this voltage. This has already got charged up to the peak value of voltage here; v p, let us say, v p, and it has got charged to v p. Here, this voltage now has started falling, reducing. So, this voltage is higher than this voltage. So, effectively, this is reverse biased. So, the current cannot flow in the opposite direction; it is blocked. So, this is an open circuit here.

Once again, let us say, this voltage initially was higher than this voltage because the capacitor was not charged. So, the current is permitted to flow here and the current is obtained from this - c d v naught by d t. So, it will keep on, since v naught is equal to v i at that point. v naught is equal to vi. i is equal to c d v naught by d t, is equal to c d v i by d t. So, it will keep on getting charged and reach the input voltage every time the diode gets connected, and up to this point it will go.

Thereafter, this voltage cannot be coming down because it doesn't have any path of this charge. The only way the current can flow into the capacitor is in this direction to charge. So, this voltage, the moment it reduces, the voltage across the capacitor remains the same. So, it will remain like that forever. So, we see that, this is the easiest technique of obtaining a DC.

So, we have now, only during this portion of time it is following the input. After it reaches the peak, it has remained at the peak forever. So, we have obtained a DC equal to the peak. V d c is equal to v p. Here, it is a DC voltage. The capacitor remains charged at the peak voltage v p forever until and unless I discharge it by connecting a load.

So, the thing is, the moment I connect the load, it is likely to discharge. As long as I do not connect a load here, it is going to remain charged at v p. So, this is what is called a peak detector.

What happens therefore, if I, for example, apply a waveform which is not really sine wave? Let us assume that the waveform is quite arbitrary. This is the waveform applied.

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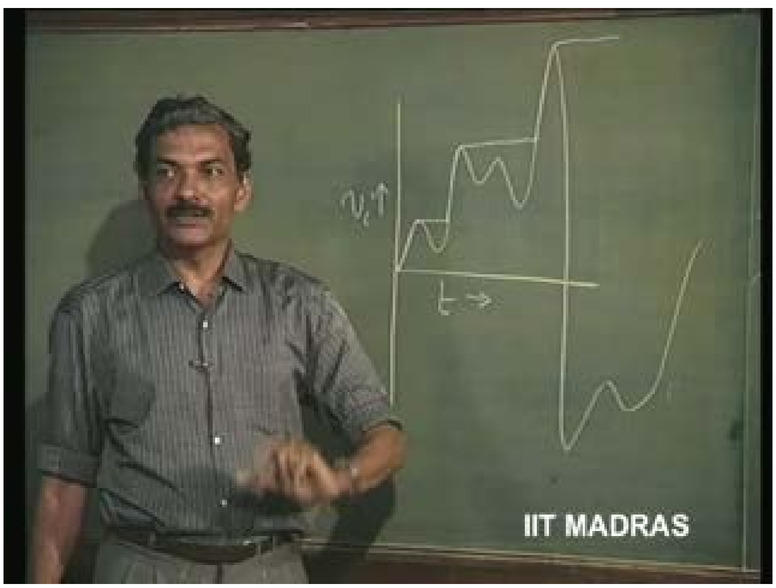

Let us investigate - if this is the waveform that is applied, which is an arbitrary waveform, what happens to that circuit of ours? Again, it is starting from zero; capacitor is not charged. So, let us say, this is v I, this is t. So, the moment our circuit reaches this value, the voltage here has gone down and therefore my capacitor is incapable of discharging. So, it will remain at this level until the next input voltage is reached, at which point of time, it will follow this and it will remain like that until the next increase in voltage above the peak is reached.

So, you should remember that if an arbitrary waveform is applied, this peak detector of ours is going to find out the peak of the peaks. Therefore, it will go get charged to the highest peak that is ever reached in the time varying waveform. Thereafter, it will not come down at all.

So, this is a very important industrial application of a peak detector. They, let us say, a temperature of a particular furnace is to be monitored. I am not interested in the intermediate values. I would like to know what is the maximum ever value reached by the furnace; under what circumstances, at what time, I would like to know. So, if you just put the peak detector like this, it will keep on monitoring the temperature; the waveform will be keeping on fluctuating; but, the peak detector will always indicate the highest temperature ever recorded in the time interval.

Similarly, if you want the lowest ever recorded, what should we do? You have to merely change the direction of the diode from this to the opposite direction. If I change the direction of the diode to the opposite direction, then it will record the negative peak instead of the positive peak.

So, you can see that, this is a very useful industrial application wherein I can always make this peak detector keep the information about the highest temperature or the lowest temperature, highest pressure or the lowest pressure, ever recorded in a time interval, irrespective of the intermediate values of the time varying pressure or temperature.

Apart from its application in radio receiver, this is another application of the peak detector. Now, obviously, let us see what is the use of this kind of voltage.

We have here, v p which is going to remain in this case. When I apply a sine wave, this will get charged to be p and remain like that. If it is going to remain like that, you have here v p sine omega t and v p here. The diode is not going to conduct after the first half cycle or quarter of a cycle, let us say. It depends upon how the waveform gets started. If the waveform gets started at time t equal to zero with maximum negative, it will keep conducting up to half cycle and thereafter it will get locked to v p. If it starts with zero for one quarter of a cycle, it will conduct and then remain at v p.

If such is the case, this is v p sine omega t at all times; this has remained at v p after this time, so what is the voltage across the diode? Let us investigate that. The voltage across the diode is this voltage which is constant - v p plus minus, plus this voltage which is v p sine omega t.

So, if you really find out the voltage across this, you will find that, that voltage is nothing but this DC voltage, which is v p, and, plus v p sine omega t.

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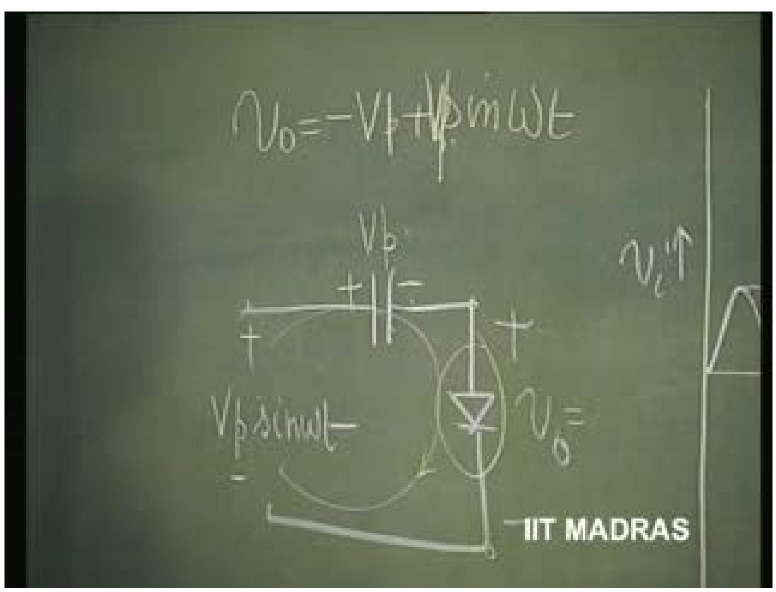

So, if, let us put this circuit in a different manner. Capacitor is brought here and the diode is put here; same circuit, nothing has changed. I have put the capacitor on this side and diode on this side and this is v p sine omega t.

So let us see what v naught is. Please remember, this is the same peak detector circuit which has been changed only in this aspect; I am finding out the voltage across the diode instead of voltage across the capacitor.

If this is a peak detector, what is this going to be? This is another application of the diode. What will this be? We will know that once we connect this capacitor and the diode in a loop. Please remember, once the capacitor and the diode is connected in a loop, the capacitor will always get charged to the highest voltage of this particular circuit arrangement.

In this case, it is v p. So, this is going to get charged in this direction because this is the only direction in which current can flow and the highest voltage possible here is going to be v p. So, it is going to be charged in this direction plus minus and this is v p. So, thereafter, the diode is never going to conduct; that is what we concluded there. In which case, what will be the voltage between this and this? Minus, plus, minus vp plus vp sine omega t.

So, the voltage v naught is minus v p plus sine omega t. If you plot this, let us try to plot this voltage; this is minus v p and this is plus sine omega t. So, v p sine omega t.

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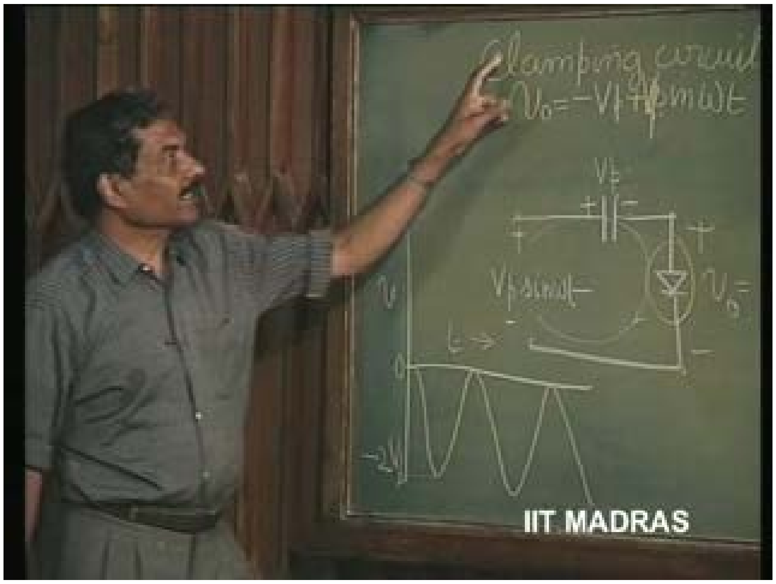

So, let us plot this waveform. It is always going to remain below zero; you cannot, because, this is going to change between plus v p and minus v p. So, when it is plus v p, this voltage is zero; so waveform is going to look like.

What will be the value of this? Please note that this was v p, plus v p or minus v p, and therefore, it will be zero or 2 v p, minus 2 v p, so minus 2 v p. So, this is what is called clamping circuit.

Now, I have pointed out two applications of the diode in combination with capacitor - a diode in series with the capacitor will give you two applications. First is the peak detector. If you take the voltage across the capacitor, you will find that the voltage across the capacitor is going to remain constant at v p. Here, it is a clamping circuit, irrespective of what this voltage is.

We have not said what this voltage is going to be; it might be 100 sine omega t. If it is 100 sine omega t, this capacitor will get charged to 100 volts. Thereafter, the voltage is always going to change from zero to minus 200; so it is always clamped to zero. That is because, the diode will never permit it to go above zero; because, diode is conducting in this direction. So, this diode will never allow it to go above zero. That is why, this is what is called as a clamping circuit.

This also is very important in a variety of applications. Let us say, in the case of a sort of standard value of voltage for black, blacker than black, in television application, etcetera. You would like a particular value of voltage to be maintained and all the voltages, let us say, video signal to go below that or above that. So, in such a situation, we introduce what is called as a clamping circuit.

We can clamp it to any value of voltage. That value of voltage to which we have to clamp, should come in series with the diode. That is all. We can clamp it to positive voltage or negative voltage, depending upon what you want.

We can put the corresponding voltage in series with the diode; it will get clamped to that particular voltage, below that voltage, or, above that voltage. In this particular case, if you want to clamp it down to some value of voltage like this; so, if I put a positive voltage here, it means, this voltage peak is going to get clamped to that value v and it will always be below that because, this diode will never allow it to go above that.

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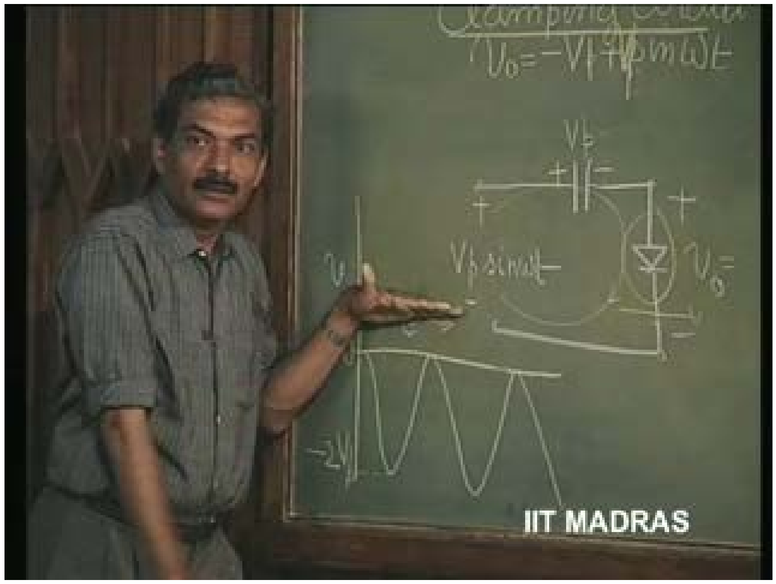

So, if I have a voltage v here, then, this voltage, instead of being zero, will be at v whether it is positive or negative; so this is the technique of clamping.

If I want to clamp it above a voltage, then immediately, the diode has to be changed in its direction. We will change the direction of the diode and you will have then have this kind of arrangement.

So, again, you can have voltage v positive or negative. This arrangement will see that the voltage will always go above that value of voltage that we have put here as the battery in series.

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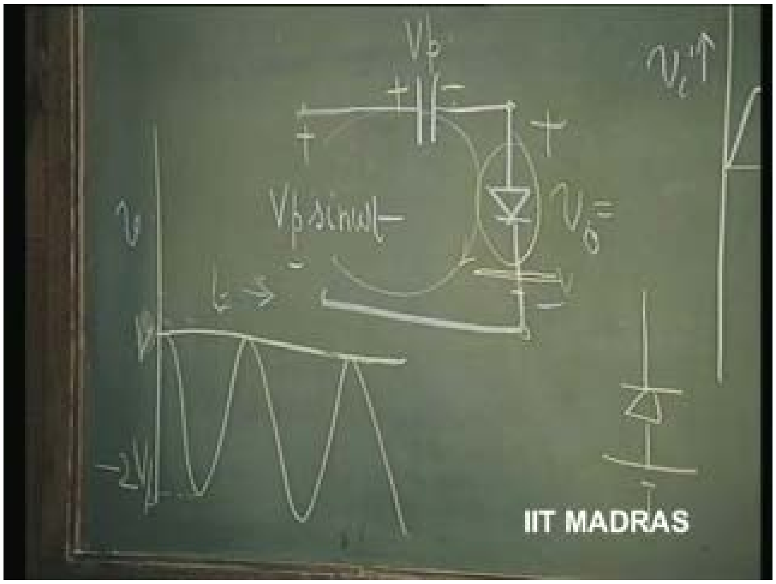

So, these are the general clamping circuits that are available to you and these clamping circuits also become very important; it is independent of the shape of the waveform. It is not necessary that the waveform should be a sine wave. It can be a square wave. It can be a composite waveform comprising sine wave with a square wave or a triangular wave; it does not matter. It will always clamp it down below a certain value of voltage or above a certain value of voltage.

So, this part of the discussion now tells you that this arrangement where in a diode comes in series with the capacitor will either act as a clamping circuit or act as a peak detector depending upon whether you are taking the output across the diode or across the capacitor.

So, we will further discuss about this as to how, when a load resistance R L is coming, brought into picture, this situation changes slightly, in the next section.

We had just seen how a capacitor coming in series with the diode can result in a clamping circuit or peak detector. Now, let us see, how a combination of these things can work.

First, let us consider a clamping circuit. So, we have a capacitor in series with the diode D, capacitor C 1. So, the voltage across this diode, now, if you take, we just saw, that is going to be nothing but minus v p plus v p sine omega t, because the capacitor is going to be charged plus here minus here as v p.

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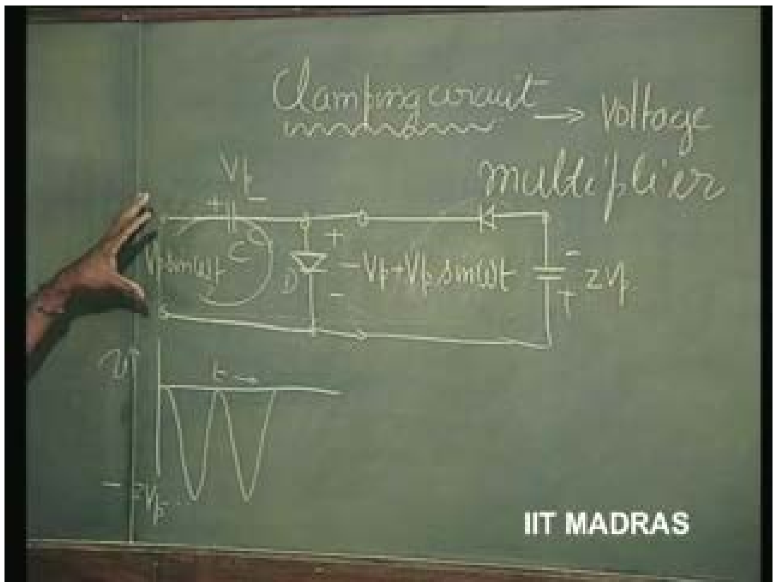

This is what we saw in the last class. So, the voltage here, we have depicted earlier, is going to be looking like this. It is going to be clamped down to zero and it will vary from zero to minus 2 v p.

Now, let us imagine that this is the waveform and we are going to put again a capacitor and a diode, but we will be using it as a peak detector to detect the negative peak. If we have to detect a negative peak, we have to put a diode in this direction and therefore the capacitor is going to be getting charged here, plus minus, this way.

So, the voltage is going to be now the peak of this, which is nothing but zero to 2 v p it is going; so minus 2 v p. So, it is going to be 2 v p in this direction that is negative.

So this waveform has a maximum negative voltage of 2 v p and it is going to get charged to that. So, we started with capacitor getting charged to v p. Now, by coupling on, this is a clamping circuit, with a peak detector, I am going to get a voltage which is 2 v p.

So, voltage has been doubled. If v p is, let us say, the ordinary 100 volts, let us say, this will become 200 volts DC. So 200 volts DC now is going to be added to this voltage and therefore, we can take now, for example, this voltage in combination with this.

Earlier, we took this voltage in combination with this and applied; so, we can now take this voltage in combination with 2 v p. So, it is going to be 2 v p and v p sine omega t plus v p sine omega t; and that will have again, a peak of minus 3 v p. So, we can keep on multiplying this voltage.

This is called a voltage doubler. This is nothing but a voltage doubler. If you keep on adding similar circuits and make a ladder like structure here, it will become voltage multiplier.

So, from a power line frequency, for example, your 220 root 2 sine omega t, you can get very high voltages generated, DC voltages, using this circuit. If the capacitors are good quality capacitors, which have very low leakage, this is one of the simplest ways of generating high voltage DC without using any extra circuitry. This does not use a transformer. This simply uses only capacitors and good diodes which have good reverse bias voltage. They should not break down when such large voltages come across it.

So, if you use such capacitors, good quality capacitors, they can sustain a large voltage as the DC voltage. These are used in very useful things called negative ion generators or ionizers. These are available in the market.

It is a well-known fact that the negative ion, if it is present in a large quantity in a given room or place, that will make your mood become very good. So, it also collects dust and therefore it will get rid of dust etcetera, which cause lot of problem in terms of breathing etcetera; so in order to purify the air, in order to make the atmosphere conducive.

If you go to the beach, you will find that beach air is doing good to you. How does it happen? Because of the waves coming and splashing on the banks, because of friction, negative ions get generated.

If you go to the waterfalls again, when water falls, it generates copious amount of negative ions. That is why, when you go to that place, you feel elated. Therefore, this negative ion effect is very good. This is put in air conditioned cars and things like that in order to sort of get rid of the effect of pollution.

So, this gadget is nothing but just a diode in combination with capacitor. Ultimately, when you get, let us say, 1000 volts or 2000 volts, from just a power line frequency, you can just connect it to a very sharp metal, there it will ionize the whole atmosphere and produce large amount of negative ions. This is a very simple application of this voltage multiplier.

Now, we will come back to the clamp, that is, peak detector. Let us see what happens when a resistance is connected across this.

This is what happens in fact. In fact, the capacitor is never ideal like the one which we have assumed. If you connect a resistance here, this is bound to discharge the capacitor.

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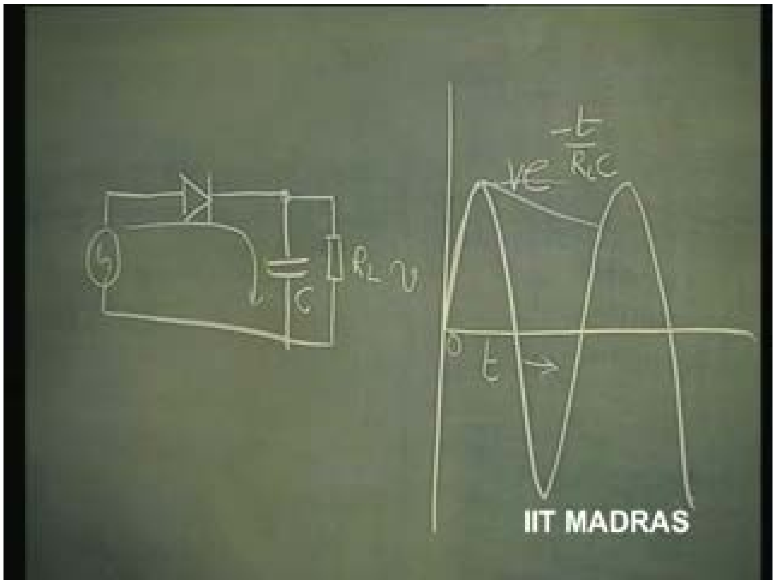

Let us now see the same waveform. Let us assume that the sine waveform is applied; but under the new situation now, like this, where it is going to get charged up to the peak, the moment I connect this at t equal to zero, voltage is zero, let us us say, the capacitor is not charged. It will keep on getting charged up to this input. Earlier, it would have remained constant; but now, what happens? Because the resistance is there, it will start discharging. So now, it will get charged, then, it will start discharging.

How will it discharge? We know that it will discharge with the time constant R L into C. So, the discharge is going to be following this kind of, say, v is the peak voltage up to which it is charged, and v into e to power minus t RL into C. This is the way it is going to discharge. This, you have studied in your networks.

So, if there is a resistance and a capacitance connected in parallel, the voltage discharge will follow this kind of exponential waveform. It will discharge and come up to this value and at this point the input voltage is this is nothing but the input voltage higher than the output voltage so again the diode d will conduct and therefore it is going to follow the input again it will start discharging.

Now, if R L is made very low, discharge is going to be very fast. So, if R L is made very low, discharge is going to be very fast. If R L is high, discharge is going to be very slow. Where exactly it is going to start getting discharged, this is the point, because, the moment it reaches peak, the input voltage is going to be less than the output voltage, the discharge will start.

If the rate of discharge, which is nothing but v divided by R L into C, the rate of discharge is slower than the rate at which input voltage is falling, then it will start falling straight according to this, v p e to power minus t by R L.

If the rate of discharge is faster than the rate at which input is falling; in fact, input rate is zero here, and it is slowly increasing; input rate is zero at this peak and it is slowly increasing. So, if the rate of discharge is faster than the input, it will keep following the input. The diode will keep conducting. So, when the slope actually becomes equal, the rate of discharge due to this time constant is the same as rate of discharge of the input, that is the point at which it will leave this waveform, so that, may be in normal occurring, if the time constant is very large at very nearly the peak itself.

So, you can for all practical purposes, consider that it is starting to discharge at the peak itself, if this R L into C is very large. How do you compare this? What do you mean by R L into C is very large?

Now, that is to be compared with only the time period T of the given waveform. If the time period T, R L into C is much greater than time period t, then the rate of discharge is going to be very slow. What it is going to loose is going to be very small amount. So, if R L into C is much greater than the time period T, the voltage is going to remain very nearly constant at v p, we can assume.

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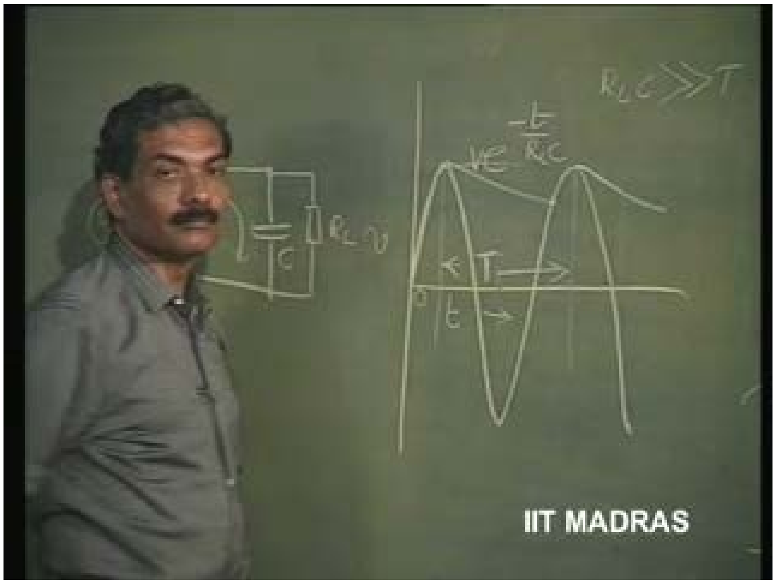

The ripple is going to be very small. So, in practice, therefore, if we are going to use it as a rectifier in order to generate a DC, we can put a capacitor across the load such that R L into C is much greater than T so that this discharge is minimized.

So, it is still remaining like the peak detector and the DC will be the same as the peak. This is the effect of putting a capacitor across R L in the case of a half wave rectifier; same thing can be done in the full wave rectifier.

We will discuss this in detail in the next class as to how much is the quantitative value of the ripple etcetera, in the next class.