Principles of Communication- Part I
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Module No 3
Lecture 12
Envelope Detection for Amplitude Modulated (AM) Signals and Time Constant for Capacitor in Envelope Detector

Hello welcome to another module in this massive open online course, so we are looking at an amplitude modulated signal and envelope detection of an amplitude modulated signal.

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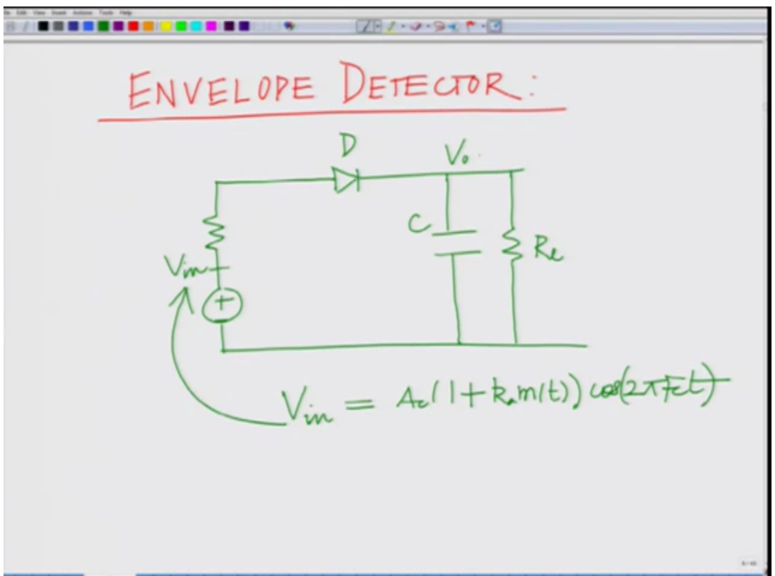

So let us continue our discussion on the envelope detector and we have seen that the envelope detector is a very simple circuit, correct? The amplitude modulated wave is fed as input it comprises of a diode, correct? And a capacitor a capacitor and a load resistance in parallel, so this is correct? This is output this is the input voltage and we have said that the input voltage is our AM wave that is Ac one plus ka m(t) times cosine two pi Fct this is our amplitude modulated signal, correct?

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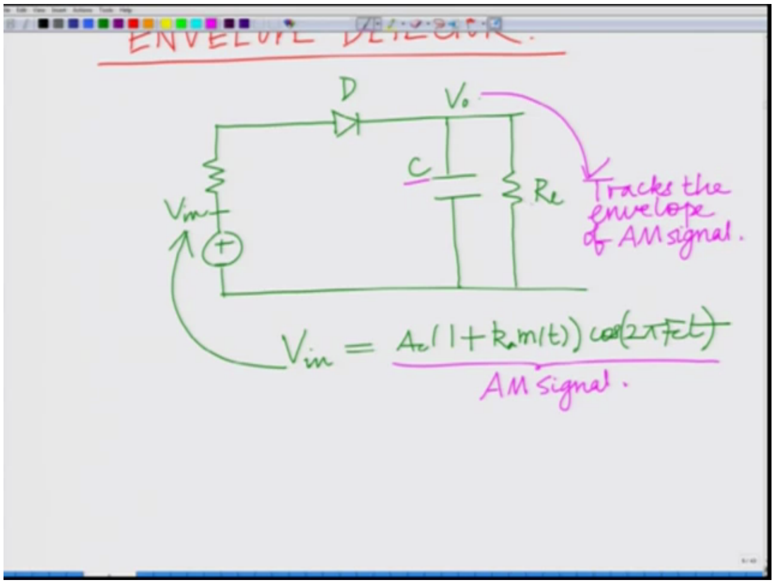

This is our input signal which is our Am signal is fed as input to this and we said this is the envelope detector and the V out, correct? Tracks the envelope tracks the envelope of the AM, this tracks the envelope of the AM signal and we have said that if I denote this RlC, correct? This time constant Tau equals RlC, correct? This is the time constant of the envelope detect, correct?

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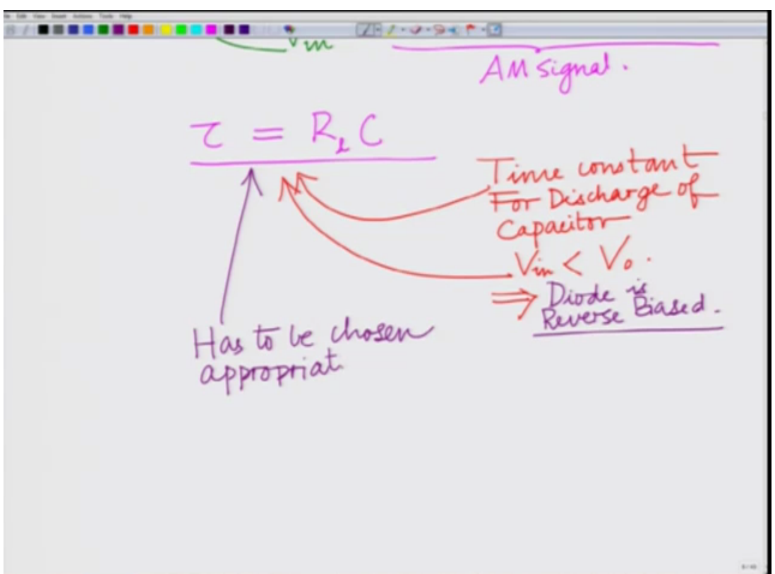

This is the time constant for discharge, correct? Once the diode of one's the diode is cut off that is when the output voltage of the capacitor is when the capacitor reaches the peak in the input voltage of the AM signal starts falling that is when the capacitor when the diode is reverse biased and the capacitor is cut off than the capacitor discharges through Rl therefore the time constant is Rl times C, okay.

This is the time constant for discharge of the capacitor when V in is less than V out, correct? When V in will be less than V out which implies the diode is cut off, okay. Diode is reverse biased is basically your the diode is reverse biased, okay. And this has to be chosen appropriately this time constant has to be chosen appropriately, okay. Appropriately correct? Because for instance that is it should not be too large or too small for instance let us considered if Tau is tool for instance if for instance let us take a simple example let us consider an amplitude modulated signal, correct?

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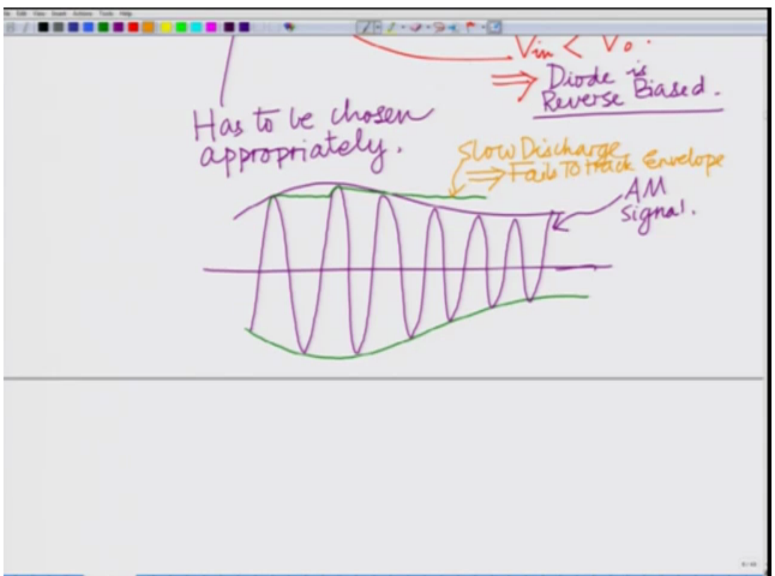

Let us consider an amplitude modulated signal, right? Correct? This is your AM signal which is fed as input to the peak detector, now we have when it is fed as input to the envelope detector the capacitor charges, correct? And it discharges now if the time constant is very large then the discharge is going to be very slow and what might happen is once it charges the discharge is so slow that it fails to track the variation of the message.

What happens at this point if you notice at this point because the discharge is very slow it is feeling if you can see let me just draw this again just to make it clear, so the capacitor is charging and discharges very slow, correct? It charges and discharges very slowly and at this point fails to, so if the discharge is slow this is basically showing a very slow discharge and this implies it fails to track the envelope, alright.

So if Tau is very large is the time constant Tao that is Tao equals to RlC is very large the discharges very slow, remember Tao determines the rate of discharge time constant is the time constant is very small implies it discharges faster if the time constant is very large, correct? The discharge is very slow if the discharge is very slow the envelope detector fails to track the envelope of the carrier as you can see over here it fails it fails to track envelope of the carrier and that you can see over here it fails.

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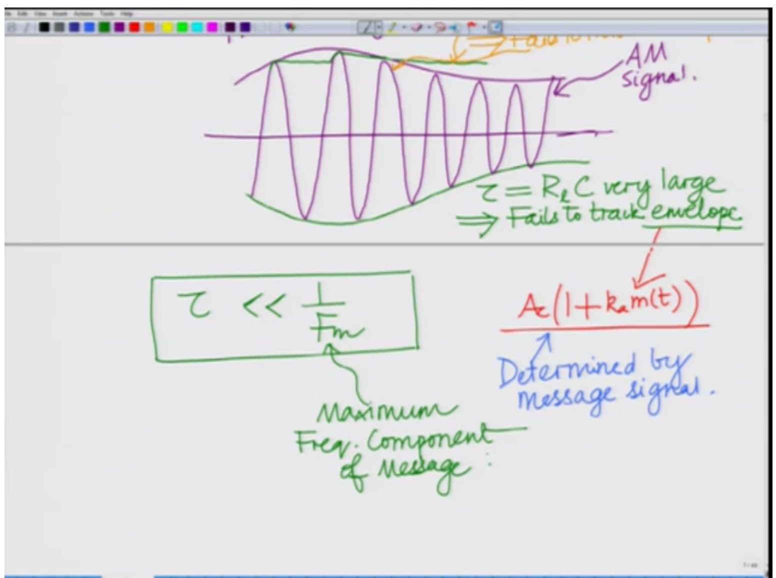

So Tao very large, so Tao equals RlC, correct? Tao equals RlC very large implies fails to track the envelope, correct? And in particular remember the envelope is determined by the message signal the envelope is basically one plus ka into m(t) envelope that is the rate at which the envelope is changing the envelope the rate at which this envelope is changing is determined by the message signal. So this is determined by your message signal, correct?

So if the message is varying faster the envelope is changing faster if the message is varying slower the envelope is changing slower, correct? So therefore the capacitor the rate of discharge the discharge the time constant of the capacitor should be such that it is discharging at a rate that is much faster than the rate at which the message is varying, in other words, correct?

If the maximum frequency of the message signal is Fm, correct? The time constant of discharge of the (capa) of the capacitor should be much smaller than the time period of the maximum frequency component of the message, correct? Because of the maximum frequency component of the message as frequency Fm it has a corresponding time period one over Fm, alright. Which means that is where in the time period is one over Fm which means it is approximately changing at within the time period one over Fm, correct?

Or if the order of or time period which is of the order of one over Fm therefore the time period of discharge of the capacitor of the envelope detector should be much smaller than that, alright. So (())(9:14) for the envelope detector to track the variation of the message signal, so we have to have Tao much less than one over Fm, correct? Where Fm is the maximum frequency component of the message signal.

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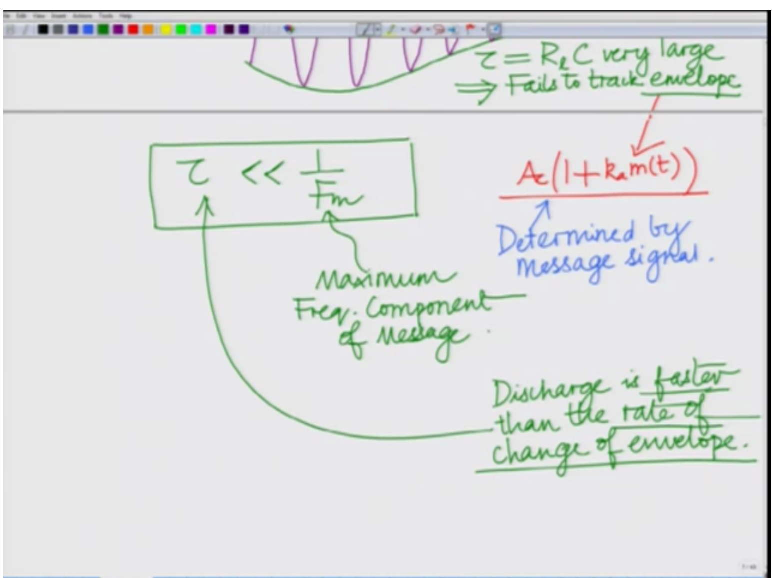

So that means basically time period, so discharge is faster so this implies discharge if time period discharge is faster than rate of discharge is faster than the rate of change of the envelope the rate of change of because the envelope remember is proportional to the message signal which is changing, alright. Which is changing at the rate uhh that is the rate Uhh that is basically it is changing at the maximum frequency component of the message Fm, alright? The rate of change uhh is basically proportional to Fm, alright. So the time period of the discharge of the capacitor must be much smaller than one over Fm.

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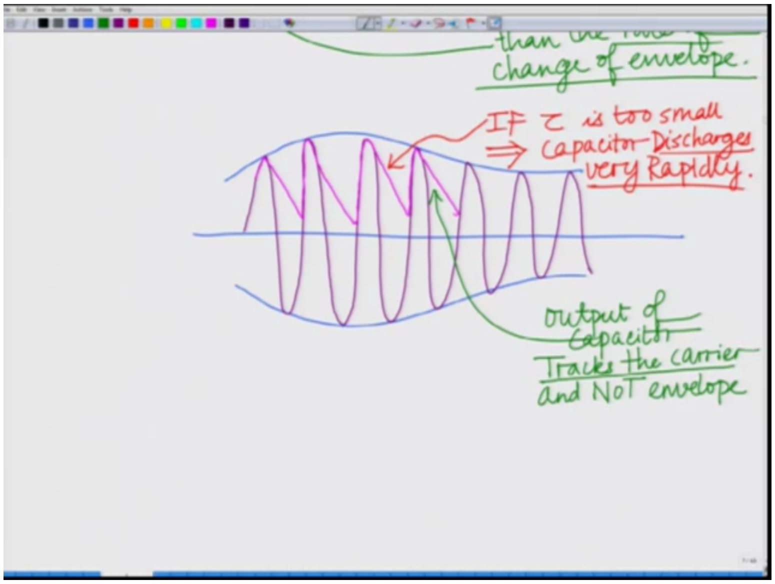

On the other hand now if you look at the other if you look at the other extreme if the time constant is very large let us consider now seen our let us now again go back to our amplitude modulated signal, correct? The time period let us consider what happens if the time period is very small, correct? If the time period is very small than the capacitor discharges too quickly, so the capacitor you can see here the capacitor discharges very rapidly, correct?

If Tau or the time constant is too small this implies capacitor discharges very rapidly this implies that it tracks the carrier you can see now see what is happening it is tracking the carrier rather than the envelope therefore output of the capacitor tracks the carrier and not the envelope tracks the carrier and we do not want that. So what is happening capacitor is discharging very fast, alright which means it is rising with the carrier rising to the peak and it is not holding at the peak it is again discharging very rapidly with the carrier because the time constant is very small.

So it is tracking the carrier rather than tracking the envelope and we do not want that we want the output of the capacitor that is output of the envelope detector to track the carrier therefore the time constant cannot be too small and when does this happen, this happens if the Times (con) constant is so small that it is smaller than the time period of the carrier frame. That is the time period Associated with the carrier signal and then it basically rises with the carrier and again falls with the carrier so we have to have the time period that is the time constant of capacitor discharge must be much larger than the time period of the carrier so that it does not discharge rapidly with the carrier it does not track the carrier signal.

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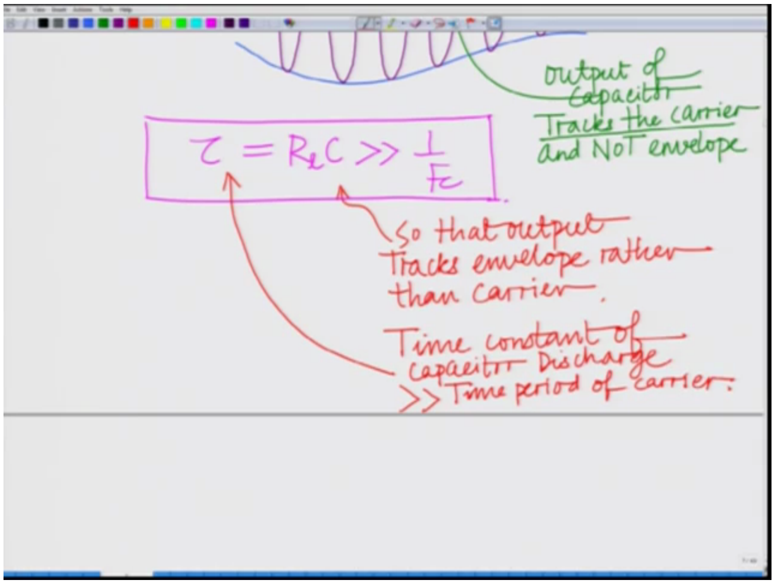

So, on the other hand we have to have the time period Tao must be Tao equals RlC must be much greater than one over Fc so that it does not track the so that output tracks envelope rather than the carrier. This implies basically (Tim) time (())(14:49) time constant of discharge of capacitor time constant of capacitor discharge must be much greater than the time period and therefore now we have seen the time constant has to be chosen as appropriately, if the time constant is too large then it discharges very slowly fails to track the message, the time constant is too small than it discharges very rapidly and it fails and it tracks the carrier rather than the envelope.

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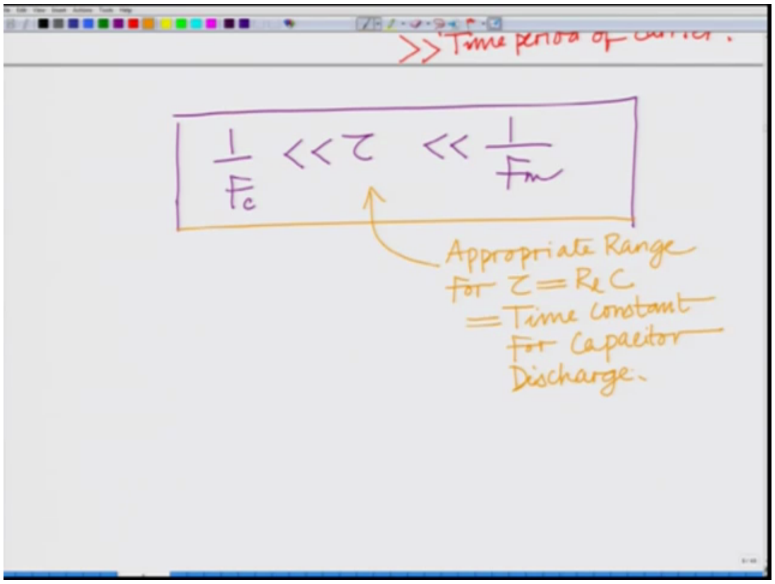

And now combining these two conditions we have Tao must be less than one over Fm and it must be greater than one over Fc, correct? So this is basically this is the gives the appropriate, this basically gives the this basically gives the appropriate range for Tao this is basically gives us the appropriate range for (ti) Tao equals to RlC which is basically your time constant which is the time constant for capacitor discharge.

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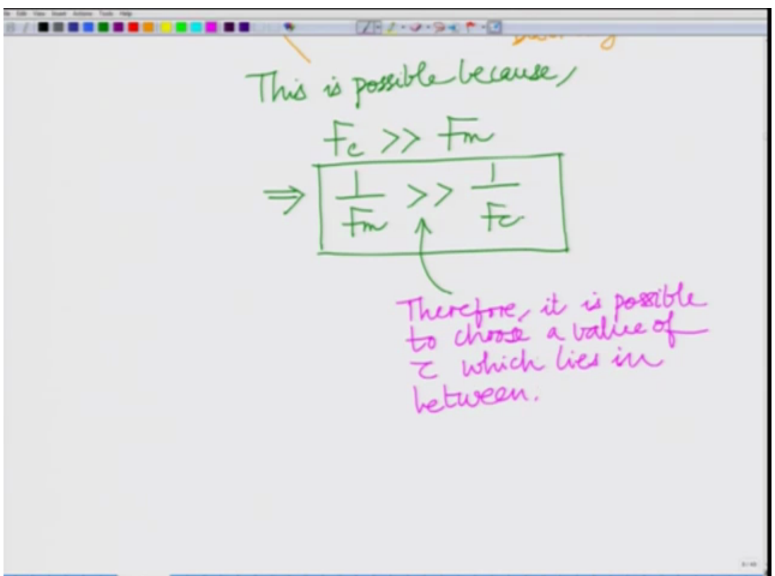

And finally also note that this is possible because note that the interesting point to note here that this is possible only because the carrier frequency Fc is much greater than the maximum message frequency Fm which implies one over Fm is much greater than one over which implies that one over Fm is much greater than one over Fc and therefore it is possible to choose a value of Tao which lies in between.

This is only possible we need Tao which is much greater than one over F tao to be that is one over Fc to be uhh we need one over Fc that this time period to be much smaller than Tao which is much smaller than one over Fm and this is only possible because Fc the carrier frequency is much larger than the message (freq) maximum frequency of the message signal FM which means one over Fc is much smaller than one over FM therefore Tao has to choose to lie appropriately between these two bots that is must be greater than one over Fc and smaller than one over Fm.

Alright so that basically (com) complete our analyses of the envelope detector that is how the working of the envelope detector how it tracks the envelope of the incoming AM signal and produces a close approximation of the envelope of the AM signal which is basically proportional to the message m(t), alright. When there is no (enve) envelope distortion it is also important to keep in (min) keep that in mind and also how to choose the time constant Tao that is RlC of this envelope detector appropriately.

So that it basically of the one-side it should not fail to track the message signal or the envelope and other side it should not track the carrier rather than tracking the envelope, alright. So basically that completing our analysis and we will continue with other aspects in the subsequent modules, thank you.