

Course name: EMI /EMC and Signal Integrity: Principles, Techniques and Applications.
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Week :04
Lecture 17: Detector of Spectrum Analyser

Welcome to the 17th lecture of the course on EMIMC and Signal Integrity Principles, Techniques and Applications. In previous lecture, we have discussed about the resolution bandwidth that used to be set for the spectrum analyzer for EMC measurements. Today, we will discuss that what detector we should take for spectrum analyzer. Now, you are measuring basically amplitude of a signal. So suppose your if the suppose this is your V_{in} . So if you want to take the signal level, you should take actually you see that instead of a clock I have taken a sinusoidal signal because we are measuring spectrum. So spectrum means actually that clock may be having an infinite number of spectral harmonics and each one is a sinusoidal signal. So that is why I am discussing about making the spectral amplitude measurement. So I have taken a sinusoidal signal. Now there you see I will have to detect the peak of the signal because that is given that what is the sinusoidal signal everything. So that means a detector which gives an output of this form that will do that it will charge and then be at a certain value. And then after this it will detect actually here you see when it is falling down, then it will start falling etcetera. But this is called a peak detector. So what is its circuit? Its circuit is simple you have a just put an envelope detector that means a diode and then you put a resistance and then a capacitance R_c , low pass filter and then this is your V_{in} , this is your V_{out} R_c . So this is called peak detector, basically an envelope detector.

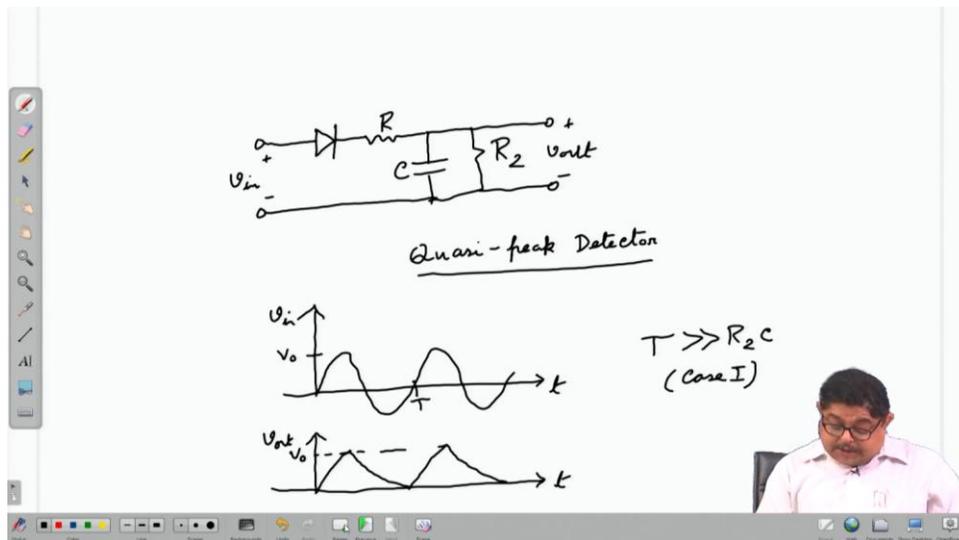
But regulatory agency said that no you cannot use this detector. You will have to use a either a quasi peak detector or an average detector.

LECTURE 17 : DETECTOR OF SPECTRUM ANALYSER

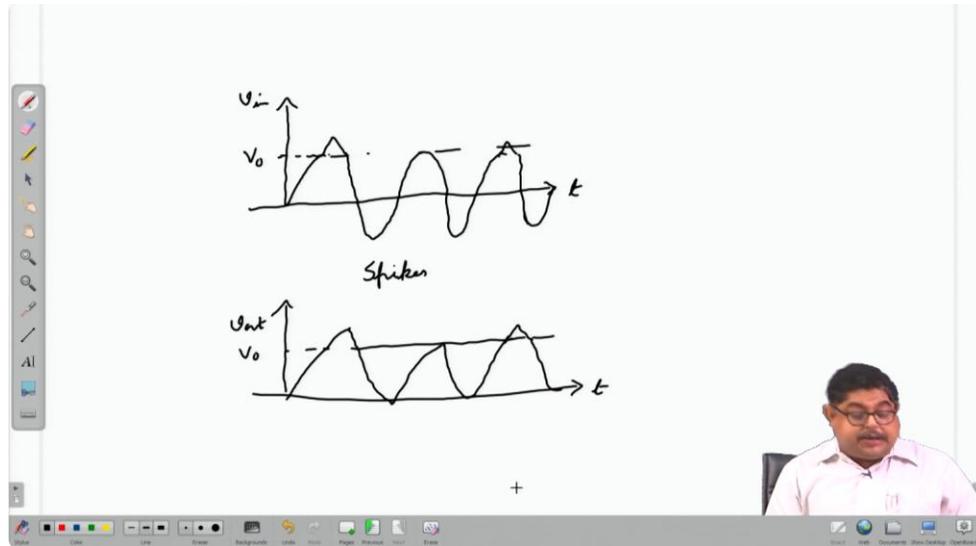
The whiteboard content includes:

- A graph of input voltage V_{in} vs time t showing a sinusoidal wave.
- A graph of output voltage V_{out} vs time t showing a signal that follows the envelope of the input and then decays.
- A circuit diagram of a peak detector consisting of a diode, a resistor R , and a capacitor C in parallel, connected to an input V_{in} and output V_{out} .
- The text "Peak Detector" written below the circuit diagram.
- A large "X" drawn over the circuit diagram.

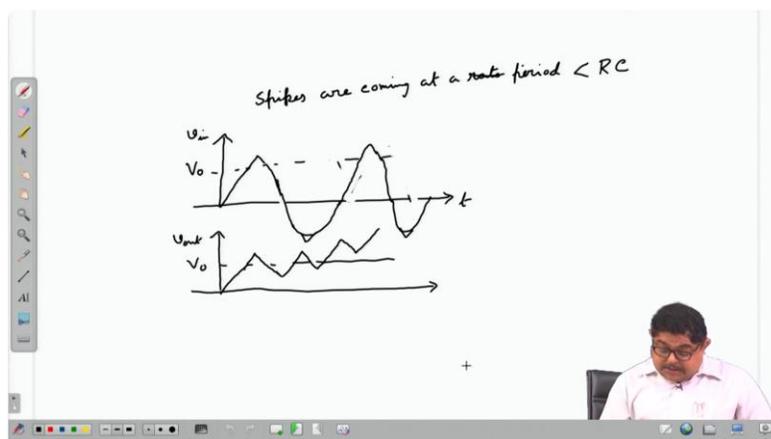
So what is a quasi peak detector? A quasi peak detector is that you have the same type of circuit, but you this is your R , this is your C , but you also have another resistance in parallel with the capacitor of the output. So this is your V_{out} , this is your V_{in} . So that means in peak detector you have the charging path in this is called quasi peak detector. Quasi means almost similar quasi peak detector. So you have a discharge path also. So that means your input signal is $V_{in} t$. Now let us call this is your V_0 . So this is your input. Now what the output will be? Let me try to accommodate it here. So you will have a charging, then so you see you have a discharge which was not there in peak. Now here I have assumed one thing that the T of the input signal is greater than R_2C . That means the circuit is fully discharging before the next one is coming. T is greater than RC time constant of the discharge side. Now that means we are using the case 1. If you remember that we have discussed three cases of choosing the signal and its systems time constants. So case 1 is chosen. So it will look like this. So the information you can say is same. So why unnecessarily I will use a quasi peak detector.



So the scenario is in practical cases assume that there are some spikes in the input signal. That spike may occur due to some interference somewhere. So then let us see if the spikes come what happens. So I have V , I have T and again let us say another spike has come etcetera. So this is my V naught and this is the spikes. So spikes are coming. So what will be the output against that? Like this it will go. Now if the spikes are widely separated with respect to the RC time constant of the quasi peak detector not a problem. But suppose the spikes are coming at a rate or at a period less than RC . I am not talking of signal period I am talking of spikes period. So what will be my V in like?

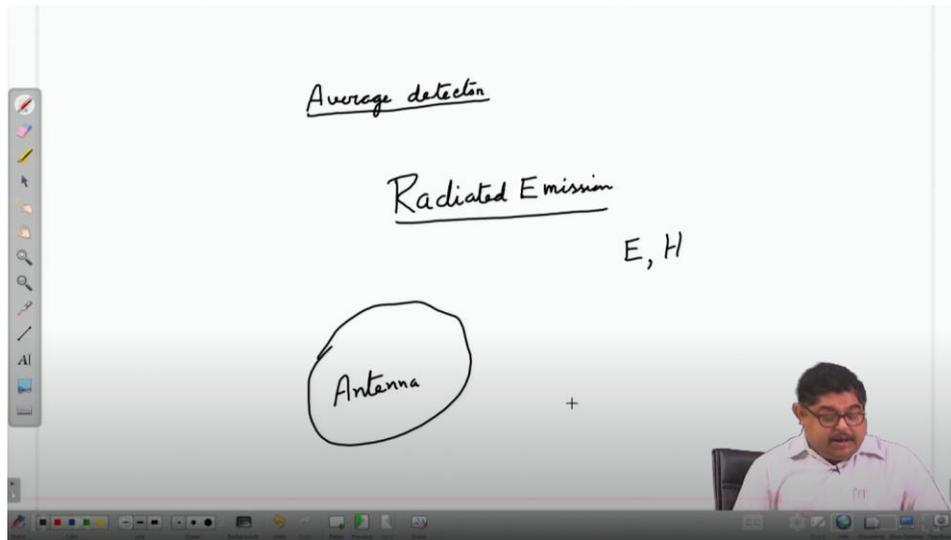


So spikes are coming at a period I have shown. And also sorry this is a sinusoidal signal. So let me show the sinusoidal part also that means the negative part also. So also the spike may come here, spike may come here also. So what will happen it will go to discharge, but then it was discharging that time you see another spike has come. So it would not be able to discharge fully it is going then it is going because now it has increased actually. So it will cumulatively now the output will go up and that may cross the regulatory limit. So the level of SA may be higher than the regulatory limit. If the quasi peak detector is above this level obviously or that means if it fails the test then the peak detector will also fail the test. So infrequent spikes and other events do not substantially prevent the receiver of the signal any disturbance like what we have seen in the previous case. This is a case of infrequent spikes that spike is not coming regularly sometimes it is coming. So sometimes it is a and our response time is such that we can basically this is not disturb such, but if regular spikes comes that is a problem and that should be detected. So that disturbs the receiving receiver of the signal. So if it is an audio signal then listener get disturbed etc. So the intent of the measurement regulatory measurement is to detect regular spikes or interference sparsely occupying spikes are not of any concern here. So this is the reason why regulatory agency said that you use a quasi peak detector which is able to detect a regular spikes.



Now another detector that also can be used is average detector. Now average detector is basically this after the envelope detector portion you place a one-huge low pass filter a simple RC filter one-huge low pass filter. So that means it passes those signals that are present for one second or more one-hertz signal so for one second or more those signals are there that are passed. In digital systems maybe a narrow band emission that is harmonic of a clock etc. is must sometimes it gets must because its level is low under a broadband emission such as arcing of a DC motor or a switching power supply their strength is much more but the in the circuit that narrow band harmonic that is more important to detect but you would not be able to detect because the broadband noises like arcing etc. those are strong. So the intent of the average detector is to filter out the wide band things you see and revealing the underlying narrow band emission. Now you can say that of course we could do the same thing with reducing the SA bandwidth SS resolution bandwidth if we have reduced then also we will be able to do that that will be able to filter out all these broadband things but that is time consuming you will have to manually change the resolution bandwidth progressively and ultimately see whether a single harmonic is present or not. But if you use an average detector then easily that one that narrow band harmonic that will be detected. So these were the intent that is why regulatory agency said either use an average detector or use a quasi peak detector but not the peak detector. So with this more or less we can say that our discussion preliminary discussion on signal integrity that is more or less complete. Now we can go to the various models. So one of such model is the emission model that radiated emission. So I just before going to that discussion formally let us recapitulate something that radiated emission. In the next lecture I will formally enter it that so the most important ingredient of any radiation is the antenna. Antenna is the heart of the radiating system. Now there are either intentional antennas, intentional antennas means which is doing their job without which no question of without which the actual function is done either communication or any radar measurement or anything they need antenna and without them EMC problems does not come because if the actual signals are not there EMC problems does not interact. So, the signals are suppose your FM broadcasting antenna, FM broadcasting antenna, radar antenna so they generate electromagnetic fields that couple to the free space and goes to the receiver and also there are for EMI EMC you have a set of antennas the same set but in a different way they are modified and you need measurement antennas to measure the radiated emission things. That how much emission is going on for that you also need antenna in EMI EMC problems they are called sensors but actually they are also antenna so we can see that they are measurement antennas for radiated emission of a product to determine whether it is complying to the regulatory limit. Also there are unintended antennas what is an unintended antenna you see that suppose you have in your circuit there is a wire now you are thinking that it is transferring energy from one part to another but it is also some part it is radiating so any wire type of structure will radiate any loop type of structure that will radiate. So these

are also antennas also they will take up signal from outside they are taking those signals from outside there are lot of things actually you see all the signals is permitting this whole space you see now if I switch on to any FM radio station the signal is there I am just picking it up. So now any wire type of structure in your path any trace in the PCB circuit any loop you have created in some path suppose there is a oscillator which is having a circular type of loop that is also picking up signals so they are giving rise to susceptibility problems so these unintentional antennas are responsible for producing radiated emissions that are measured by measurement antennas and may result in the product being out of compliance. So we should be aware of these that there are also unintentional antennas everything in the world is radiating something in most of the cases from our intended operation these radiations are insignificant but in a EMIMC test we try to detect that and find out whether after all it is within the limit because I cannot stop the intended ones also I cannot those radiators but if they are creating problem they are going above the limit we can desensitize them or make them inefficient so that they do not radiate much unintentional radiation or receive those unintentional radiations. So with this thing I think you know that there are basically for any antenna actually I will assume that in your electromagnetic class you have studied a current element or sometimes it is also called hertzian dipole but we prefer the term current element so a small uniform current carrying very infinitesimal antenna hertzian dipole or current element so we assume that you know that analysis actually for any antenna suppose this is an antenna now if I know the antennas current distribution on it from the current distribution I can find in the whole universe what is the E and H fields and or even in free space even if I know one of the fields so I know both the electromagnetic fields and far from the antenna or near the antenna also I can if I determine E and H then I know everything so anywhere any emission limit etc I can calculate but this is easier said than done because finding the distribution current distribution on the antenna is not so easy and also from that current distribution this E and H are found by some integrals those are called radiation integrals. Now evaluating that radiation integral for any arbitrary antenna is quite difficult but fortunately for some regular structures for some typical cases people have researchers previous researchers they have found those E and H field will be using that so I will assume that in your electromagnetic theory class you know the how to calculate for a current element the E and H at any point near the antenna far from the antenna those things or far from the antenna I will do but near the antenna if you not you can either see any NPTEL lecture or any book on EM theory or you can refer to antenna NPTEL course I have an antenna NPTEL course where you can see that also so see those things I would not teach that thing here for current element the electric and magnetic field I will assume from there I will try to go to what is needed for our radiated emission.



So first we will start with a that current element. This current element is not a realistic antenna but it is fundamental to understand the antenna concept as we will see in our subsequent lectures also that this is very, very useful because from this we can generalize many things for a arbitrary antenna. So what we say that suppose I have this is the current element shown in green color that it is having an eye where from that eye came no one knows where conceptually that it is carrying a current its length is dL and the product of them is called IDL . Now obviously you see that if nothing is there, there is no feed etc. So that current cannot come from anywhere but it is coming and after this it is radiating because there are displacement currents so through that it is going. So I am assuming that I but here I am taking suppressing the time harmonic so I is a phasor, phasor I denote by putting a tilde on the head of the thing and let us say that I am observing green so I am observing at a point P which is given by r theta phi. Generally it is easier to find that observation point is P and it is its coordinates as specified in spherical coordinate. So how I will draw that R so this is R then this angle is theta and if I take a projection of P on XY plane then this angle is phi. So this is the geometry with which we will attack this problem that what is the radiated electric and magnetic field from this thing. We are assuming that infinitesimal current element of length dL carrying a phasor current I , I is assumed to be constant in magnitude and phase at all points along the element length dL the observation point P is at coordinate r theta phi and the elemental so at P we can say at P the unit vector u_r will be in this direction then I think all of you know these things and the u_θ unit vector will be in this direction and to both of them so these two are let us say in the this white boards plane and to both of them perpendicular to this plane there is a u_ϕ component. So with this background I

will just write that what is the E field H field of the antenna at any point either near or far at a distance r what is the field that we will do in the next class. Thank you.

