Spread Spectrum Communications and Jamming

Prof. Debarati Sen
G S Sanyal School of Telecommunications
Indian Institute of Technology, Kharagpur

Lecture - 37
Active Search Acquisition for FFH/MFSK Signals

Hello students. In this module, we will take an example of first frequency how being MFSK system, and we will now apply our, the knowledge of this active search acquisition mechanism for this kind of the systems, and we will try to find out, how in a practical system we like this FFH MFSK. This search mechanism is applied or search mechanism is accomplished.

And remember when we will discuss this typical system, we will carry forward all our previous knowledge of the basic understanding of serial search acquisition mechanism verses apparel search acquisition mechanism, and we also understand what is the first acquisition verses a slow acquisition. We learnt about the FFH MFSK signal and the systems long back. So, we will quickly revisit how the system operates, and then we will enter into the search acquisition mechanism for this kind of system.

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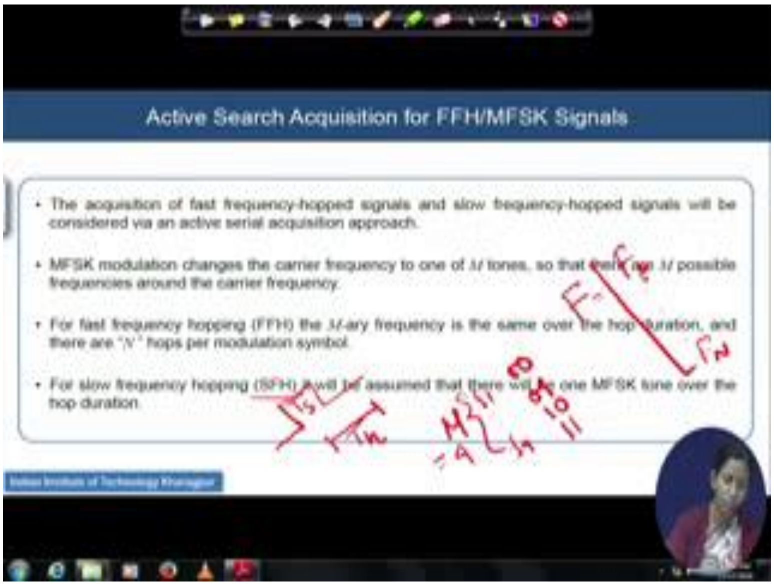

So, let us start with the quick recap of this FFH MFSK signal. FFH stands for first frequency hobby, and MFSK is the multi tone frequency shift keying modulation going on, and remember though with the slide name is FFH MFSK systems and signals, we will also consider the slow frequency hopping MFSK systems. So, we will today discuss the active serials search acquisition process for the both. As it is active serial search mechanism, so remember we will have the correlator as well as integrate dump receivers. So, multiplier and integrate dump receiver non-coherent say envelope detectors, all those components have expected to be present in the signal path, rather than the match filter kind of architecture, which was we have seen which is passive device. And let us quickly first revisit the fundamentals of FHA FFH MFSK system. We understand that what is MFSK; MFSK modulation actually changes the carrier frequency to one of the m M tones. So, we have A, bunch of M number of the tones, and if suppose my m is equal to four. So, I will have f 1 to f four numbers of the tones, or the frequencies to choose my transmitted data. So, for 0 0 transmitted data I may be choosing frequency 1 0 1, I may be choosing transmitting over frequency 2 1 0.

I may be transmitting over three and 1 1, I may be transmitting over four. So, these are the M possible frequencies around the carrier frequency over which the MFSK modulation happens and MFSK modulation can go on. And for fast frequency hopping the M arry frequency is the same over the hop duration. So, and remember that when it is fast hop or a slow hop, in order to identify that we did like this. Compare to the duration of the symbol if it is a symbol duration t s, and if this is the hopping duration th.

Then if you find that symbol duration is more compared to the hopping duration; such that within a symbol you are hopping over the multiple frequencies, we call it a fast frequency hopping. and as if actually a same tone once sent on the frequency 1 and then you sent over the, sorry the 1 MFSK tone is sent over one hop frequency to and then immediately change to another hop frequency. If that is a situation then we will call it is a fast frequency hopping, instead of the slow. Instead of the case and the slow frequency hopping, the same symbol actually will may be, within the hop duration, over the hop duration you are, within a symbol duration you know there are no hopping over the frequencies, and at least we will be assuming for this today’s discussion that for one MFSK tone is getting transmitted, over hopped one hop duration for this slow frequency hopping.

So, we will have one set of M number of the frequency set for the modulation, data modulation, and there is carrier hopping. for hopping actually I have another set of the frequencies say F, where the components of the F is a f 1 2 f 1 to say F n, where over those frequency the they are the hopping frequencies over which the hopping is going on. So, one is actually, because of the MFSK modulation, you are having a set of the frequencies, which are getting use for modulating the data, and this modulated data are now hopping over the multiple frequencies in case of FFH, hopping speed is very fast, and in case of SFH pan modulated symbol one dedicated hopping frequency is there. So, that was a fundamental idea and fundamental understanding that we recap for understanding, what was the MFSK signaling scheme, and what is the meaning of this SFH MFSK or FFH MFSK.

Remember whenever you are thinking that there is a FFH MFSK, for each and every hop, there are, we will consider that there are total N number of the hops, and the number of the hop par symbol duration that is not varying; that is constant.

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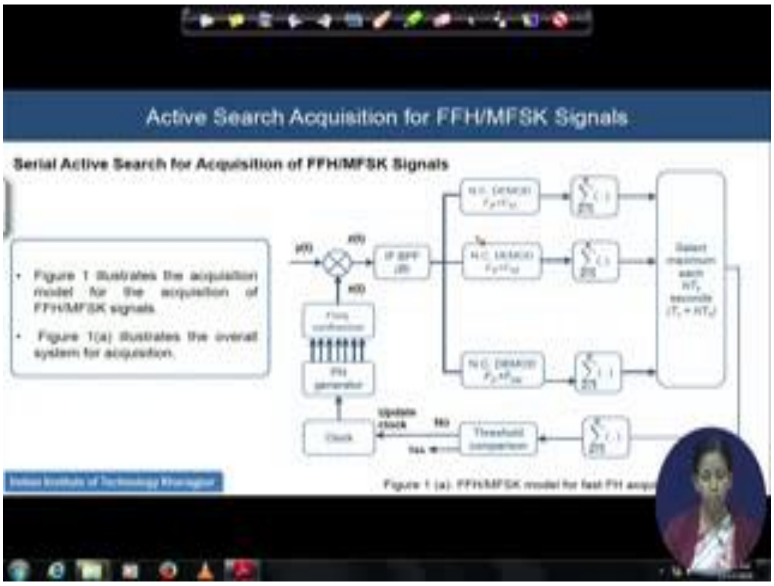

So, this is the circuit for this active search acquisition methodology for FFH, as well as SFH MFSK signal, structure will little bit vary, when the modulation, when the scheme changes from SFH to FFH. I have given here two different figures. Figure one a is the combined figure of the acquisition mechanism, where actually the non-coherent de modulator architecture, is separately given in figure 1 b. So, for 1 b is basically zooming inside this blocks, and showing the architecture what is there inside the block, and we understand the overall system acquisition is such that, you are having the incoming signal, and the local p n generator is generating the codes and driving the frequencies synthesizer, to choose a typical half frequency, based on the control by the codes and.

We understand that the code used for the hopping in the transmitter is well known in the receiver. So, the code that is getting generated exactly, actually the same that is there in the transmitter, as well as they are perfectly synchronized, for the time being. So, if they are perfectly synchronized, then your whole output, then you will be getting a perfect output, well synchronized actually down signal in the z t, then main pass filter it will be simply passed by the filter activities. and the demodulator will be demodulating them exactly at the frequency i f in the inter module intermediate frequency plus the wherever the data modulation frequency is residing from f s 1 to f s m. squalor detector output will be detecting it, and then the output of all the detectors, outcome of all the detectors, see here again the maximum will be selected over for each and every th seconds n into th.

Second, as we are having n number of the hops within a symbol durations. So, symbol duration will be consisting of how many number of the hops you are having, with the hopping time, and the maximum value will be again sent by the threshold comparator to update the clock. So, that is the whole block. Remember once you are getting a perfect synchronization situation there with which i started, and then actually the outputs of these detectors will, output of the detectors as well as the squalor envelops, and addition, detection and the adders the output of all the adders. So, will be exactly high, and demodulator or architecture output will be high, for all the shifted modulation schemes, and while the different kind of the hopping. I mean modulation schemes, and then it will be giving you the perfect one and.

There will be actually no changes in the update, no update is required, and there will be any threshold comparator output will give you perfect 0, and there will be any changes required for the clock, which does not happen in the practice. So, though p n sequence generator and they are sitting in the receiver has some knowledge about, what is the p n sequence used for the transmission. It has no clue at all actually about the phase information about that.

And hence it is, there is it is heavily expected that the incoming signal and the local generated p n sequence will not be in sync, and there is a requirement of the active search acquisition mechanism. Here in this block diagram all this n c demod stands for the non-coherent demodulation; that means, I wish to remind you that non-coherent demodulation means, you do not have any information about the carrier phase, and carrier phase synchronization is not yet done in the receiver. in presence of the carrier phase ambiguity you are trying to do the active search acquisition, and hence it is a demodulator, and the squalor detector output with which we are relaying on, and the selection of the maximum will be given, all will be given almost the same kind of the values if they are perfectly aligned, if the two codes are perfectly aligned, and hence there is no output at the output of the comparator.

Before going into the explanation in detail, let us see little bit what is there inside the non-coherent demodulator architecture inside the non-coherent demodulator architecture.

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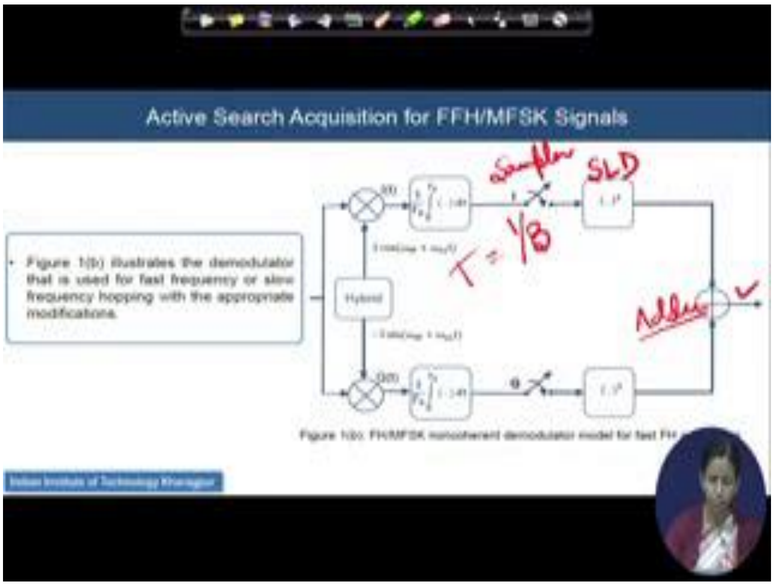

We are. This demodulator is sitting inside the demodulator they are, there are the i path and the q path, and the signal here is getting generated for the, it is generating both in phase and the q phase carriers, where the carriers will be in the intermediate frequency plus the modulated frequency shift. It is the shift over the modulated frequency that is expected to happen some, with respect to the center carrier of frequency. And the i and q signals, the carriers are getting multiplied with the incoming signal, that incoming signal here is from the output of the band pass filters.

So, remember the signal band width it will be B only. And here is the integrator. The integrator is expected to integrate the whole signal over duration of hopping times. So, it is 0 to th now for both the in phase and the outer phase carrier, remember this particular diagram is based on the slow frequency hopping. For the first frequency hopping actually, we have to speed, we have to give a speed and we have to move fast and the architecture will be also switching fast in between the carriers, and it will be little bit different, the architecture will be little bit should be updated according to that.

The integrator output we understand that it should needs to be sampled, and it is a it should be fair into a squalor detector. So, this device is a squalor detector. And the switch is these are the cases were the in phase i phase and q phase sampling is going on. And remember the sampler is sampling at the rate of one by the band width. So, this bandwidth limitation came from the frauntained i f filter the (Refer Time: 13:49) portions after (Refer Time: 13:49) output of the both in phase, as well as the q phase component of each and every non-coherent detector, will be added in the adder in the final adder circuit and you will be a expecting the output at the output of the adder. So, where are we now? We are here. So, inside this NCD modulated output, we have seen that, we have taken the signal, we have down convert it is that Wif class actually thus Wist is there with us.

Basically this down conversion to the i f it may actually the choice of this i f may vary, and it completely dependent on you that, how low you we do, you wish to have this i f for your typical circuit design. And finally, the output of the sky units to feed inside the integrate and the dump receiver, because that is architecture of a non-coherent detector. And this integration is done over the hopping duration, and we consider is actually now if it is as it is a low frequency hopping going on.

So, for one symbol you will be getting over the duration of the th, only the one FSK modulated symbol coming inside. Sampler is sampling at the rate of the one by b where b is band width; that in controlled by the initial filter, I mean i f filter squalor detector is, simply squaring them up the sampled signal. And finally, they should be added and here your output is fed towards the maximum select each NTI th seconds remember if i I am having this kind of the architecture.

So, the frequency synthesizer, and initially whatever the output it is giving to the band pass filter. If we does not know actually what exactly, where these demodulation is going on, in which we consider the demodulation is going on. So, you will put the all parallel that is why we have put. So, many number of the demodulators detectors here in the receiver path, and all the outputs all this kind of the parallel inputs that check all the time for each and every input, creating actually some output of it.

So, out of all this, with whom they input will be perfectly synchronized nobody you know, but once it is actually synchronized, then the output of that typical demodulator will be higher. it is added over the N number of the samples, and this added output for each and every branch or the path, is entering into the select block diagram, and it chooses basically the maximum value, wherever it is intuitive that whoever will be matching with the input signal its detector output will be maximum compared to others. So, fundamentally these blocks our target is to choose a maximum output, out of all the paths and once that is detected, then he will be sending this information to the threshold comparator to compare the incoming signal, the difference between the incoming signals and locally generated one the output of this.

If it is some output is there. So, then it will be included, it will be utilized to update the clock phase information, inside the receiver section. So, this was a architecture, receiver architecture or a detector architecture at the receiver.

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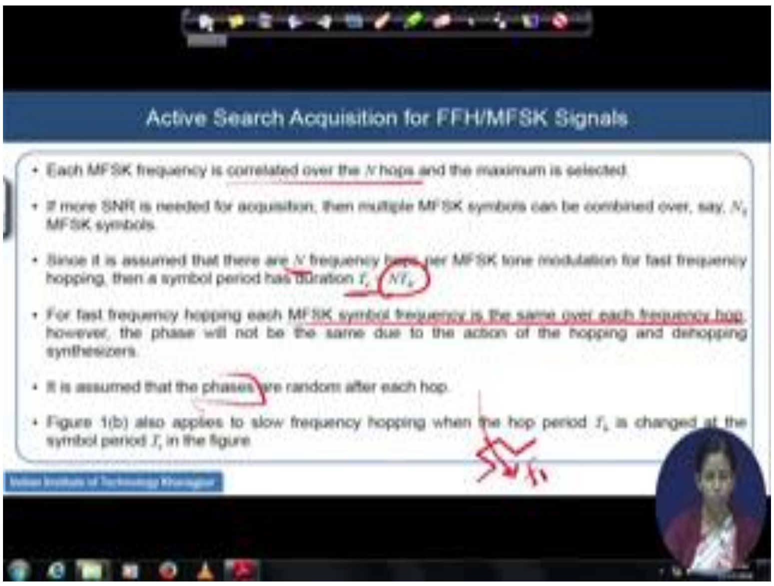

Now, see some facts if MFS the frequency is correlated over the N hops it should be, because what I told that, if it is a FFASK signal, the same signal is transferred once in the hop number one and frequency number one, and then within that equation was completed it was actually, before that computation was done, it was driven, it was actually driven to the other frequency to hop.

So, the component of the same signal is there over the multiple hops. So, for the decision and the detection of that kind of the signal over the fast frequency hopping, we can have a good point that, we can choose, we can choose the value of the SNR, we can calculate the value of the SNR over this multiple hops, and we can take the best out of it, or we can do some kind of the addition weighted addition over all this different hops to get a choice to have a better decision about the transmitted signal, and if more SNR is.

So, overlapping is obvious. So, over the n hops the maximum selected, and if more SNR is needed for this acquisition, the multiple MFSK symbols that can be combined over; say ns number of the MFSK symbols that needs to be combined now, in order to have a more SNR required for the acquisition mechanism, and since we have assume, since more beginning that the N is the frequency hops per MFSK tone, and now if it is the symbol duration is ts. So, duration of the symbol should be always given by the N into th, because one symbol means you are having N number of the hops, and each hop is having the duration of th.

So, the total symbol duration for these N hop will be N into th. And for fast frequency hopping, this each and every MFSK symbol frequency, this vacancy will be same over the each hop, that we have also discussed at the beginning and; however, the phases remember, though the frequency will be same over the multiple symbols, but phases can never be same, and and hence actually due to the action of the hopping and dehopping synthesizer itself, we can never think of actually the, there will not be any effect on the phase.

But there will be rather, there will be a very big effect also, and the variation of the phase, where the FSK signal one FSK signal to the next will be really very high. And we have assumed in the in this situation that this phases are random in nature after each and every hop. And now we have also shown that frequency number one be which is a detector details, that the slow frequency hopping will be applied, when the hop frequency th is changed at the symbol period duration ts.

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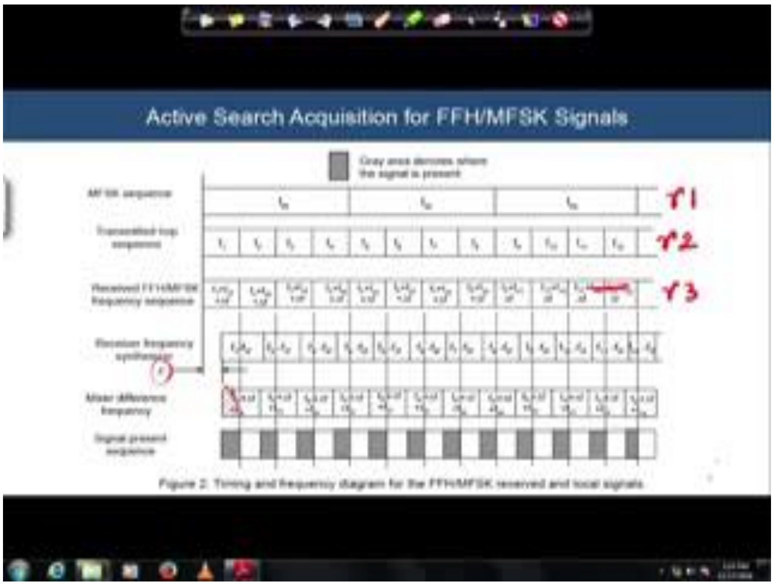

This is time frequency diagram of the search mechanism or search acquisition mechanism; I will refer and come here once more while explaining this figure. Just to remember one thing and note one thing, that receiver and transceiver, receiver and transmit and now they are not in seen, because of which actually the search process has started. remember the difference between these two, I mean we say denoted here the frequencies in receiver frequency synthesizer is a time gap, with respect to the original original transmit form is around around EPSA. That EPSA is needs to me minimized as minimum as possible, but it should not be actually on the opposite weight cannot be exceeding the time intervals.

Now, we will come back here. These timing assumptions in the figure number two and the relationship of the frequency hops for FFHK FSK and the MSK symbols all are illustrated.

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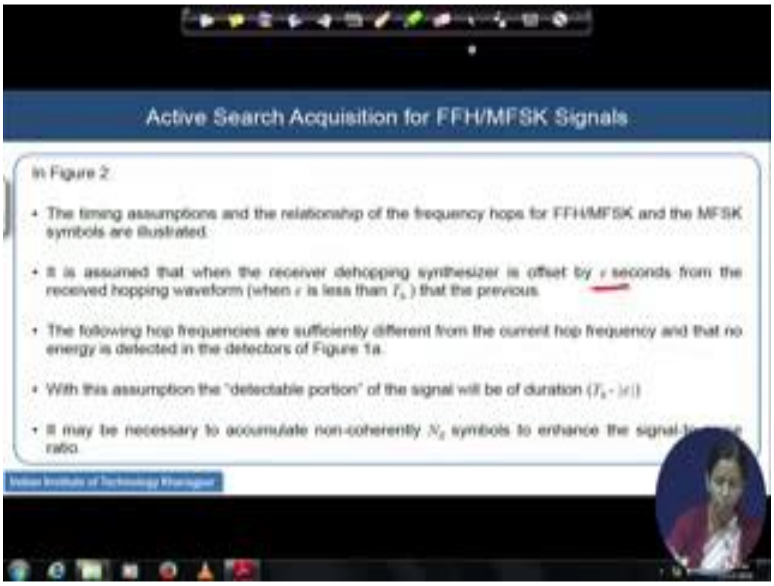

It is assumed that when the receiver dehopping synthesizer, is offset by say EPSA seconds as I have shown in the earlier slide, from the received hopping waveform, that the previous one, and the signal of the previous one, and the signal of the next one will be actually quite different, from the immediate one. And hence you can never actually; that is why actually there will be typical detector output wave can never be uniform, over the time interval when before the EPSA came, before the EPSA duration and after the EPSA duration also.

The following hop frequencies and the sufficiently different from the current hop frequency that it will previous hop frequency, and the next hop frequency will be quite different from the current hop frequencies; that is detected and detected in the detectors of this frequent number one a. and with this assumption the detectable portion of the signal will be of duration th minus mod EPSA. This is a portion that I have shown in the earlier graph, come lets go back. So, detector will only get the overlapping section of this, this gray area, this gray area. So, the because of the mismatch between the transmitter and the receiver frequency synthesizers, this is the only area or the time interval, over which the detector can provide you some output.

It may be necessary to accumulate non-coherently all the ns symbols to enhance the signals to noise, it should definitely, because the structure itself is non-coherent architecture. So, the process and the mechanism will be of accumulating the signals to noise or have to be means non-coherent in nature.

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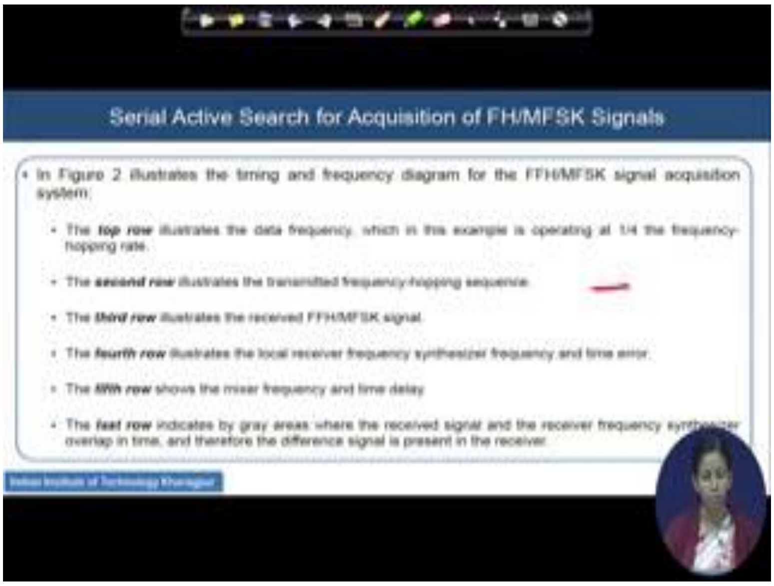

The figure two now let us comes to the row by row. Figure number two illustrates the time frequency algorithm, and the top row of this figure illustrates that data frequency, and lets go back. This is a first row, and this first row detects and first row talks about the transmitted MFSK sequence and their corresponding frequency, and we see that the rate of transmission of this frequency rate of transmission of the signal is actually one fourth than the hop sequence; that means, per symbol you will be hopping four times. So, transmitted hop sequence is part symbol wise for.

So, we are saying that the symbol frequency is one fourth than the hop frequency. So, this is the row number one, saying the modulated frequency rate, sorry modulated frequency rate this is a row number two, who is talking about the transmitted hop rate, and row number three come here. So, who is talking about the received FFH MFSK frequency response, where you see at each and every time duration this is the time axis and what exactly the frequency you are receiving over the time axis is there diagram about. in the first case you will be receiving f one plus the FFSK, because that is the modulation, total modulation frequency that you will be receiving plus some del f changes you are getting, that del f is actually, because of the frequency of, because of the timing, there is a some mismanagement and some mismatch over the frequency also, between, and that is a constant del f that is going on for all kind of the, for over all the symbols, and for all the kind of the frequency for the transmission.

And we understand that the receiver frequency synthesizer is not matching with the timing information of the transmitted one, and hence that timing gap or match is mentioned here as EPSA, and if that is there, so the whole received signals will have some shift, and mixer output, mixer different f output if I now try to see, you will be actually; obviously, getting the output for this zone this in the left side of this dotted line, and that will be you are FIF plus your del f plus your some amount of the FSK. Here actually FFSK will be, in this typical case this say FFSK is equal to one.

So, this is the way the mixer difference output will be there, and we are really interested actually the output of that detector, and when the signal present sequence is there detector has got only this much overlapping area to detect, and hence the detector output will be looking like high after the EPSA time interval and of the received sequence, and it will holds good actually uniformly like this. Here is the understanding of the. Here we end with the understanding of how this acquisition happens in FFHA as well as SFH MFSK signal FFH SFH MFSK signals, and the systems.

And with this in next module we will continue with some detailed derivatives of this FFH MFSK system, to understand what exactly, how the acquisition process is going on, and what exactly is acquisition time for, acquisition time required for this active search mechanism in these FFH MFSK systems.