Satellite Communication Systems
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Lecture - 34
Synchronisation – I

Welcome back. Today we will start with another issue other than the non-linearity what we have discussed in satellite communication another issue comes up that is called synchronisation; you are familiar with this word synchronisation. So, let us see what are the issues and techniques used in case of satellite communication in synchronization.

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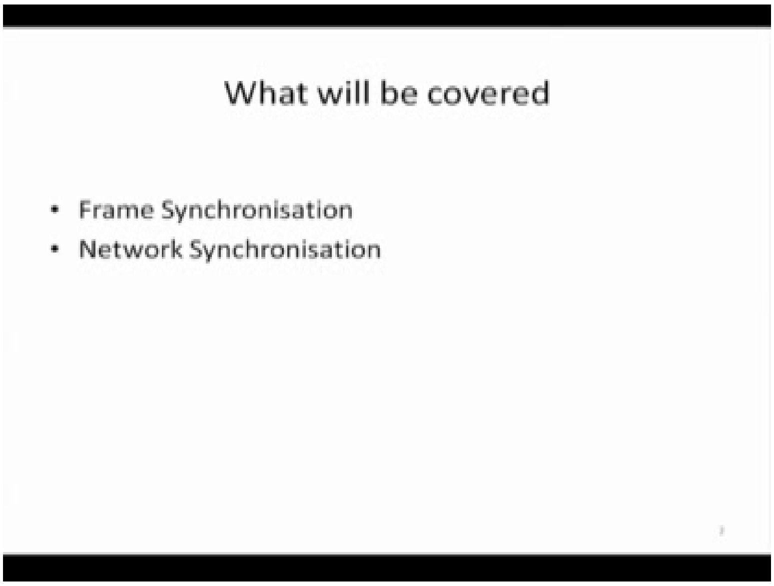

So, in the synchronisation mainly what will be covering are frame synchronisation and the network synchronisation. So, let us first see what is a need?

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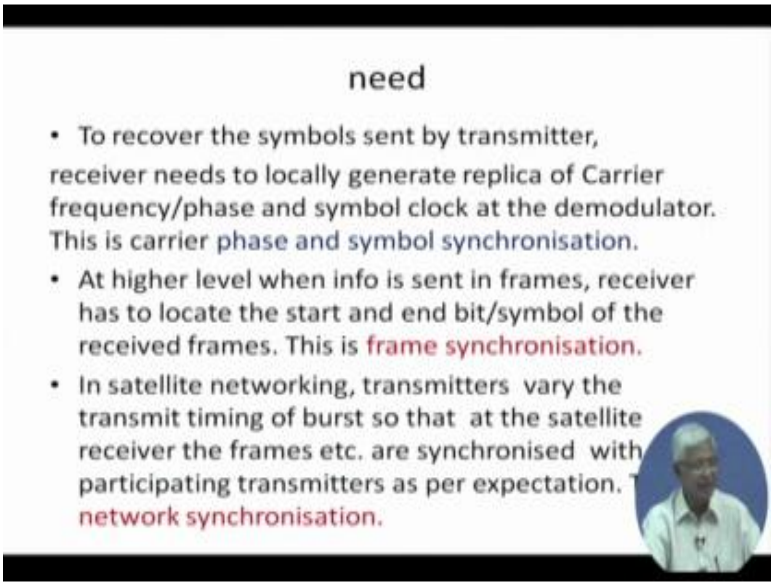

Now, to recover the symbols what is transmitted by the transmitter at the receiver side, we need to locally generate the replica of the carrier frequency and phase using phase locked loops and also that is to demodulate and also we need the symbol start and symbol end time which is symbol clock these adequate at the demodulator now this is called carrier phase and symbol synchronisation you have studied this in your courses.

So, what is further required is hire level when this information's are send in frames in most of the time it is send in frames like internet communication internet protocol use packets that is a form of a frame or in TV transmission. They use the TV frames in digital video via satellite digital video broadcast via satellite also in other cases in most of the cases it goes in the form of frames. Now this frame beginning and the end of the frame where the frame start, where the frame end that receiver has to know and to locate that the type of the technique which is used is called frame synchronisation and there is one more thing that is satellite is resource which is covering a wide area and that area when it is covered. So, many users are trying to axis the satellite resource. So, many transmitters are there we have seen this example in a t m and other cases.

So, these transmitters have to send their signals and have to reach the receiver at the satellite and in particularly in case of time division multiple axes TDMA. They have to reach in proper sequence as per the allotted first sequence. So, since many transmitters are trying to axis this we can call network synchronization. So, we will discuss this frame synchronisation and network synchronisation in subsequent periods.

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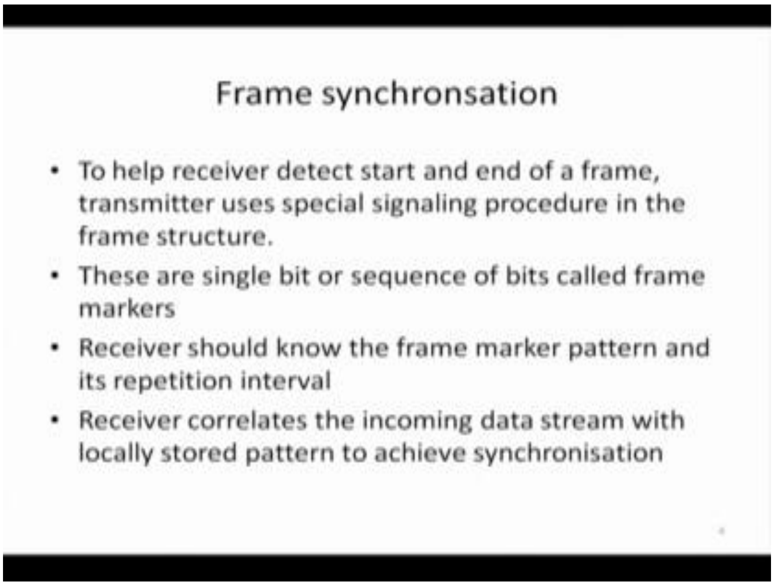

So, let us see the frame synchronisation this by definition it is to help the receiver to detect the start and end of a frame the transmitter uses some special signaling technique which is nothing, but some identification that this is the start of the frame or this is the end of the frame when the frame size varies and in some cases only the start of the frame and the frame size is known by the receiver in some cases frame size is also not known. But only start of the frame and then it gives the length of the frame. So, any way you have to know the start of the frame where the bit actual bits start and that contains many fields what type of frame it is, it maybe containing data it maybe containing control information, there are many types of frames are there, therefore, the start of the frame identification very important.

So, the receiver has to detect the start and end of the frame, now this could be done by the transmitter by sending single bit identification for the frame or it could be multiple bit a sequence of bits it can be called as a frame markers. So, let us see receiver should know the frame marker pattern and what is the repetition rate of that repetition interval of that frame marker and then only it can take where there were markers. So, let us see that receiver then correlate the incoming data stream with the known frame marker and find out where the frame marker matches and then he knows that this is the received bits stream where these frame marker has matched.

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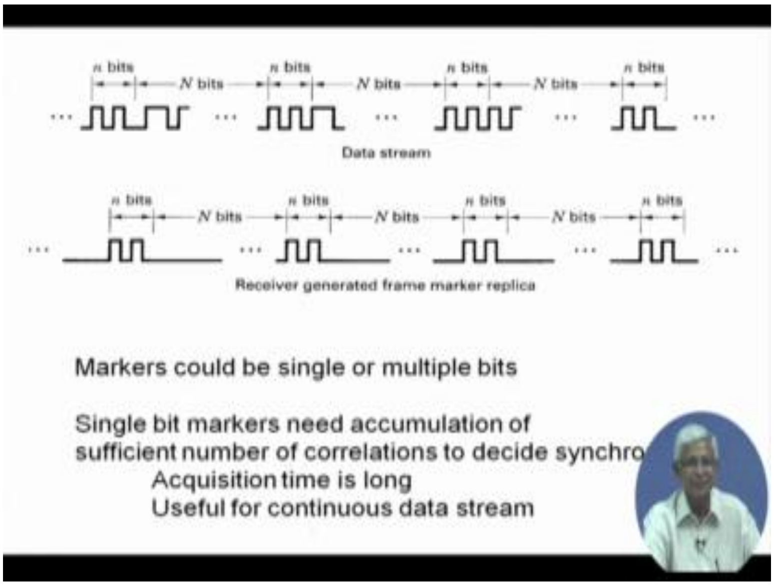

So, this is the frame synchronisation that is start pictorially it is like this let us see small n bits is a 1 0 1 0 pattern it repeats after capital n bits 1 0 1 0 pattern the capital n bits are the data pattern, which could be random you can start with 0 1 or 1 or anything, but this small n bits are repeating at certain interval after capital n bits this is the desired stream, which is coming where as the receiver knows this pattern 1 0 1 0 and this n bits he tries to match where these pattern appears and where in previous to this pattern and later the trailing part of the precedence and trailing part of the pattern sets it is a 0.

So, with this pattern he tries to lock. So, receiver generates a local frame marker replica and with that it tries to lock. So, marker could be single bit it could be multiple bit as we said. So, let us see the advantage of single bit marker, if I have a single bit marker then I have to go on seeing after many such markers are finding out whether markers have come correctly or not. So, therefore, single bit marker needs accumulation of sufficient number of correlation to decide whether the synchronisation is occurred; that means, it takes time, acquisition time is long and also the data has to come continuously. So, there has to be continuous data stream it should not be one burst and then stops there are burst communication there are continuous same communication.

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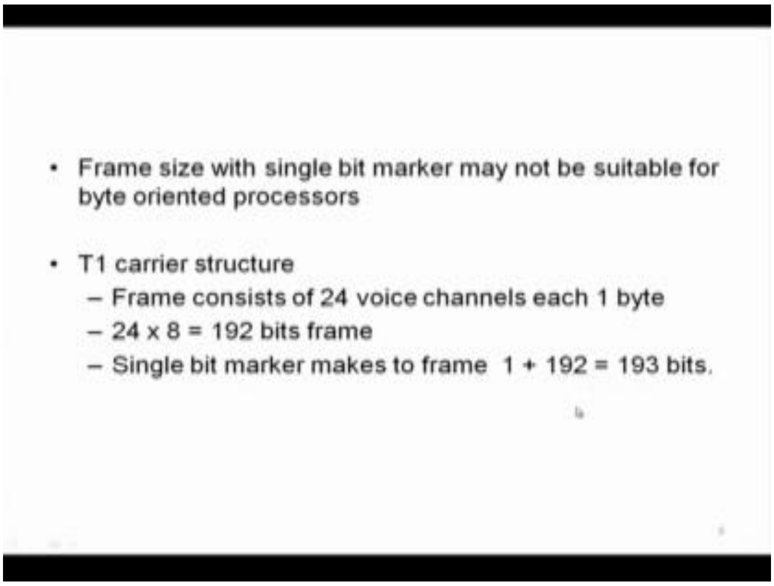

So, their data has to be acquisition time has to be long will be long and data has to be continuous there is one more problem because, there is a single bit marker the system which uses byte oriented processing they face a problem the simple example is T1 carrier is a structure which where frame consists of 24 voice channels of a byte each. So, 24 into 8 are 192 bit is a frame. Now if it is a single bit marker which is normally used single bit marker makes it 1 plus 192 bits 193 bits which is not divisible by 8. So, the 8 bit processor system is which is trying to detect and subsequently process it becomes it becomes difficult for it little more complex.

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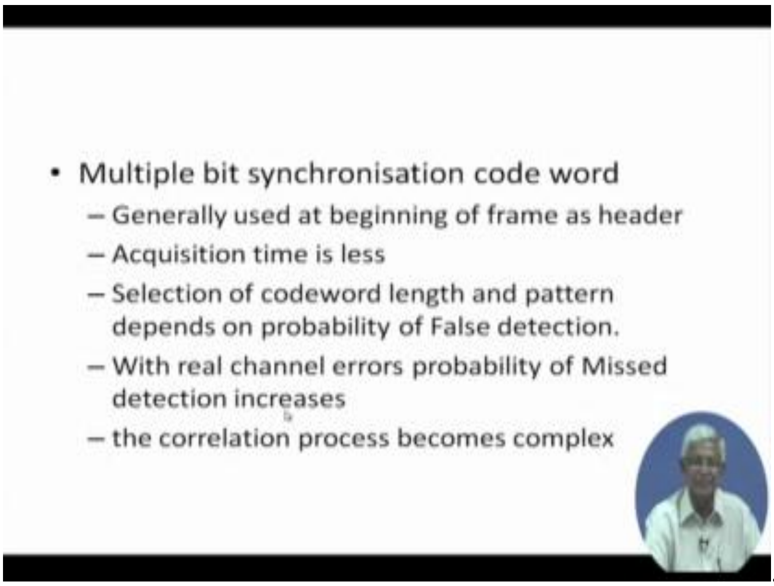

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So, that is another complexity that comes in the single bit marker it takes time as well as this type of problems appears. So, multiple bit synchronisation code words are used and generally this is used at the beginning of the frame as a header and; obviously, acquisition time is less because, if it is detected immediately you know, you wanted to accumulate many such things and selection of the code word length and it is pattern is depends on the bit probability of false detection by chance in the data stream itself. If this similar pattern comes then it will be detected as a beginning of the frame in between the frame if the data pattern, if it comes that would be a problem. So, therefore, the selection of the pattern as well as it is length is important from the false detection pattern and in real life there are errors. So, even if it is correct data frame it varies an error appears in that then you will miss that.

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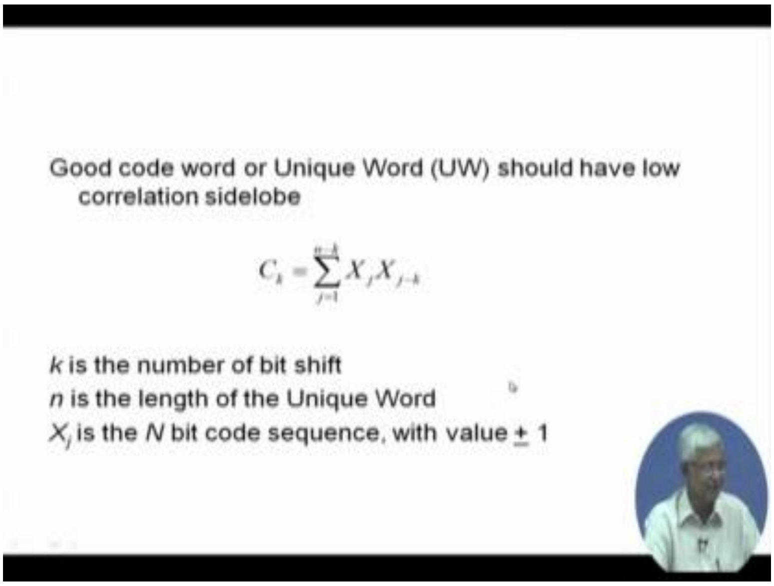

So, it is a missed detection that will increase. So, correlation process becomes complex here also correlation process is complex a good pattern, can be or you can use the code word or unique word normally this word unique word is it is a unique pattern. So, unique word it is this term is used. So, unique word should have low correlation sidelobes you know what is the correlation sidelobe, here it is shown as c k is a summation of j is equal to 1 2 n minus k x j and x j minus k with the pattern is x j and shifted pattern is x j minus k k bits shifted k is number of bit shift and n is the length of the unique word and x j can be plus minus 1. So, with this the sidelobes has to be low, if the code word selection the x j pattern is a good quality there are many such codes detected earlier it was marker code and subsequently in many codes are detected.

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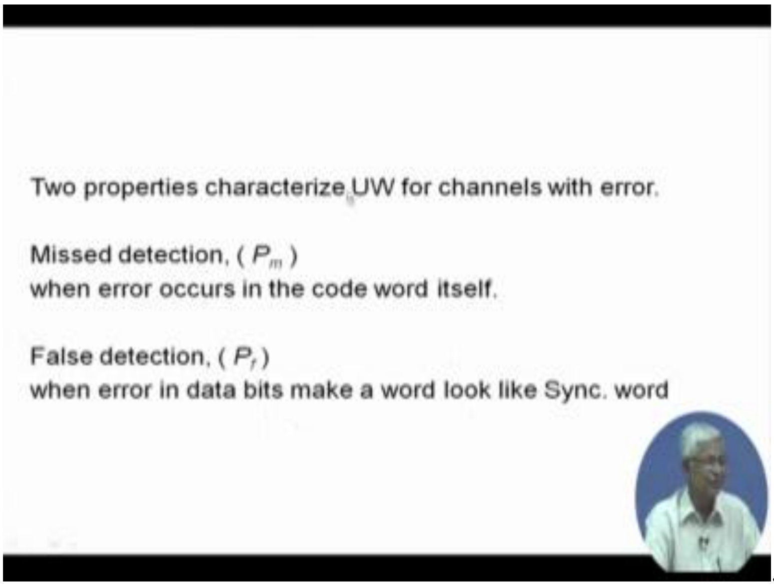

But there are 2 properties characterize this unique word of the channel with error we have seen this properties. Earlier we have mentioned these earlier which is called missed detection probability of missed detection p m when, the errors occurs in the code word itself then detection will missed. So, it is missed detection.

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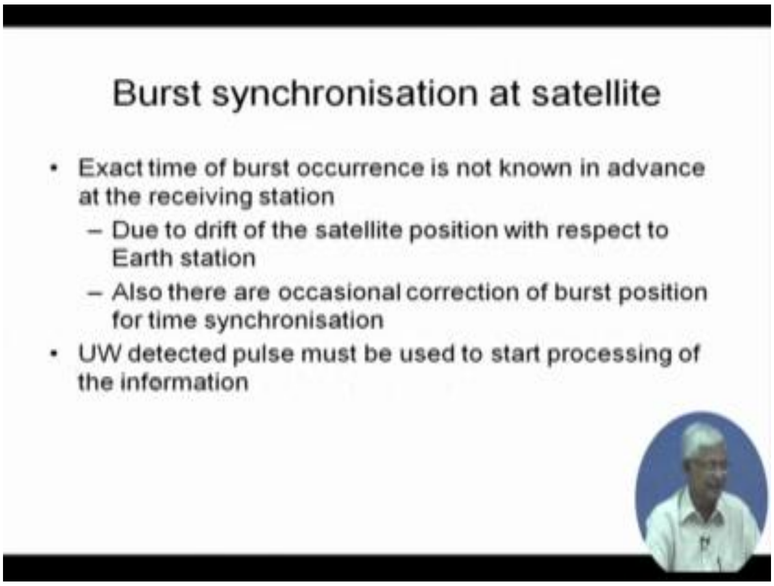

And false detection when error in the data bit in the data pattern itself either with an error will look like this sync word or it may look like the unique word. So, this probability of missed detection false detection and that we have seen, will see it little more further on that exact time of the burst occurrence is not known in advance at the receiving station let us say at the ground at the receiving station or it could be at the satellite because the satellite would be drifting. So, the exact time is not known and sometimes the bursts are getting corrected, forget the TDMA bursts. So, because of that also the exact time is not known. So, there has to be synchronisation.

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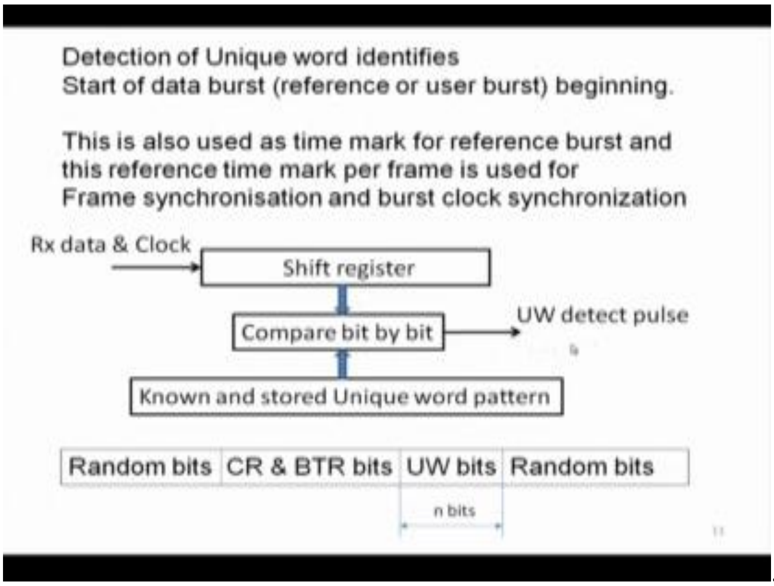

So, you look at detected pulse should start the process of the information. So, detections is very important for that from that point view also it shows this particular slide shows detection of unique word identifies start of the burst and burst could be reference burst or user burst we have seen in the TDMA discussion about this beginning of that. So, it shows that is in the data pattern there are random bits then, CR BTR is carry recovery and bit time recovery bits which is required at the demodulate for the demodulate. So, there are some bits which has a training pattern it may be once a 1 0 1 0 or some pattern this is known pattern and then, this unique word bits let us say n number of unique word bits and after that data starts in random bits.

So, unique word bits will be repeating after frame time and unique word bits pre before unique word comes, there is a known pattern is coming and after that it is, deterministic it is preceded by deterministic bits and it is a later trailed by random bits this you remember this is also used as a this unique word pattern is used as a time mark for the reference burst and this reference time mark per frame is used as a frame synchronisation or and the burst clock synchronization within the frame there are bursts. So, that burst clock also synchronize with this type of what I am telling is shown in the blocks that is receive data and clock is going through the shift register and there is a known and stored unique word pattern which is known by the receiver they are compared bit by bit and unique word detect pulse this is obviously.

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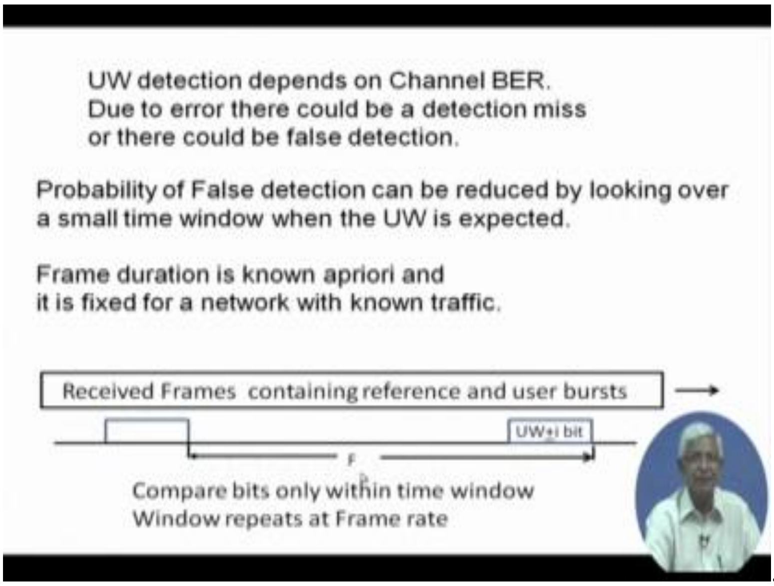

The unique word detection depends on the channel BER and due to the error that could be ah a there could be detection miss or there could be false detection that we repeating. So, probability of false detection can be reduced by looking over a small time window when the unique word is expected instead of looking everywhere over the complete data stream if we know where the unique word is there I create a window and within that, if you look then false detection; obviously, will be false detection will be much less.

So, frame duration has to be known a priori for that; obviously, and different duration and it is repetition it is fixed for a network with a known traffic a pictorially shown that received frames containing reference burst and user burst and there are some apertures open and these apertures are the frame time or frame bits number of bits in the frame f apart and aperture will be the slightly larger than unique word bits that unique word plus minus I number of bits that I number of bits important to know what should be the m I aperture how long ah how long I should search and if it is very large then there is a possibility of for more false detection.

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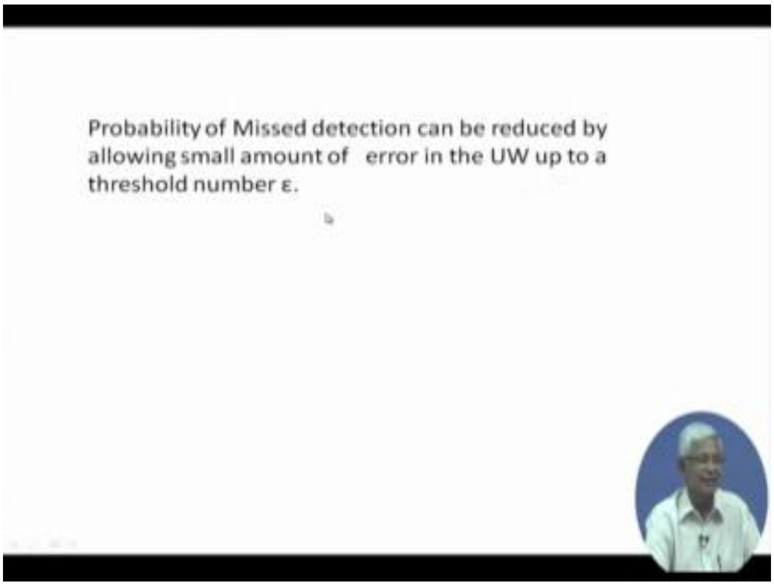

So, compare bits within the time window only and window repeats at the frame rate probability of missed detection can be reduced by that is probability of false detection reaction by aperture technique and probability of missed detection can be reduced that, if there is a error I tolerate that error. So, I allow some amount of error in the unique word up to a threshold let us say epsilon.

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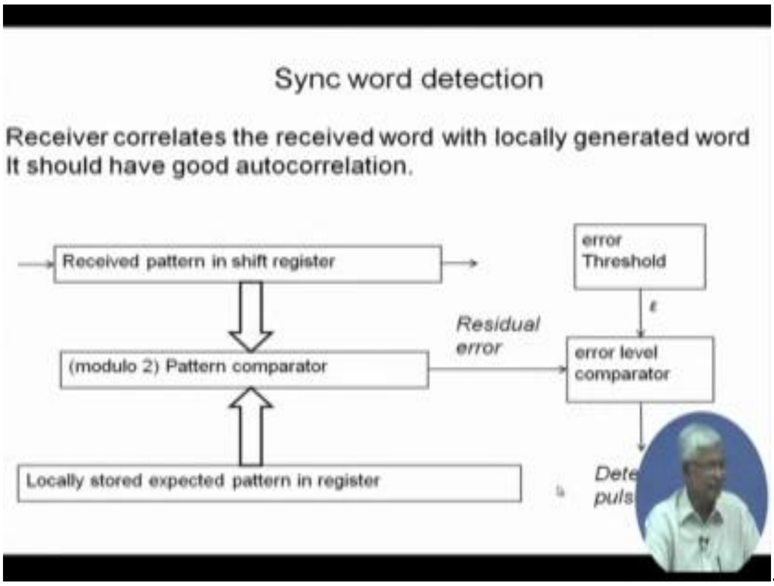

Now, let us see the sync word detection, how it is done receiver correlates the received word with locally generated word it should have a good autocorrelation function. Now, this similar type of block diagram, but with error threshold, so that is received pattern in shift register locally stored expected pattern in the in the in a register and if they modulo 2 comparison of the patterns and then we get some errors. So, that residual error is compared with a threshold comparator we set a threshold error threshold epsilon and error level is compared, if it exceeds the error threshold then we say it is unique code is detected the pulse is detected.

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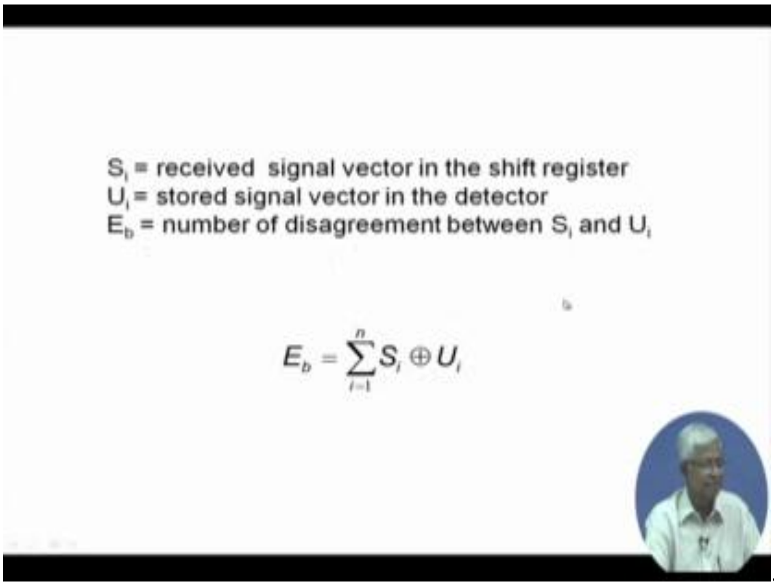

So, it can be say the mathematically that is the Si is the received signal vector in the shift register Ui is the stored signal vector in the detector and Eb is the number of disagreement when we do a modulo two addition o for the n number of bits

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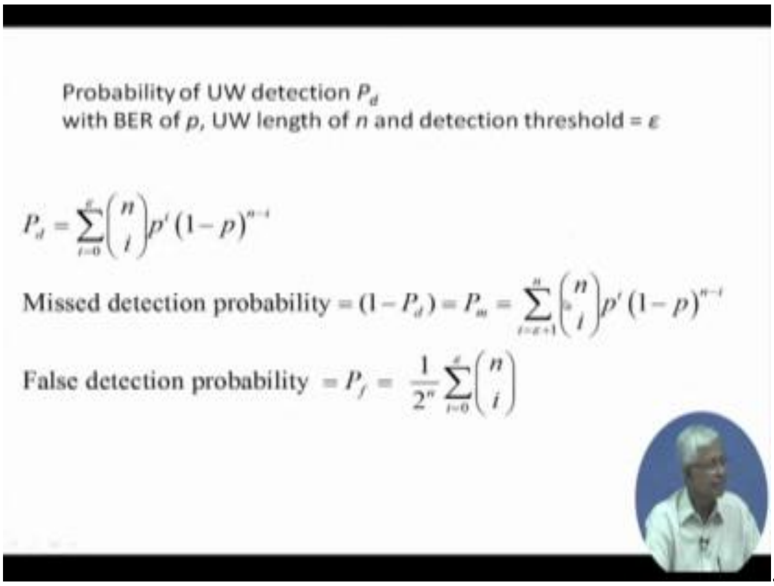

Now this probability of detection is you know this type of expression probability of detection o for with the error tolerable error is I equal to 0 to epsilon n c I small p is bit error a probability and small m is the length of the unique word. So, I minus p to the power of n minus I and error threshold is epsilon.

So, miss detection probability is one minus that detection probability then it makes up to epsilon was detection probability. So, epsilon minus epsilon plus 1 to n that is the missed detection probability and n c I p to the power I 1 minus p to the power n minus I and probability of false detection is 1 by 2 to the power n sum of 0 to I equal to 0 to epsilon n c i.

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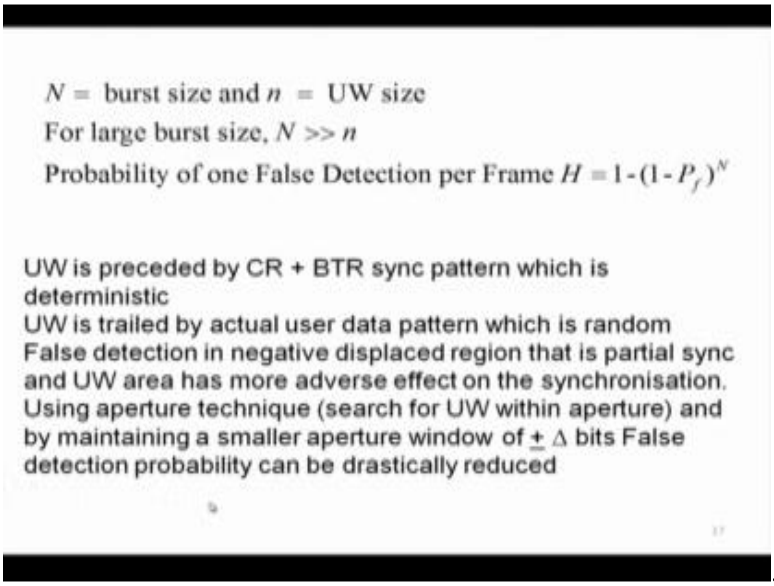

Now, if the n is the burst size capital n and small n is unique word size burst size is unique word plus data as the burst size becomes larger the unique word size probability of false detection per frame can be expressed probability of false detection per frame is 1 minus 1 minus p f to the power capital n this is a expression therefore, per frame false detection probability which will be very low.

Now, unique word is preceded by CR BTR sync pattern, which I told you it is deterministic and unique word is trailed by random pattern which is user data pattern. So, the false detection in the negatively displaced region that is the partial sync code and the unique word area, if a false that has more adverse effect on the synchronisation because we would detect it wrongly we will get I will show you pictorially how it is using aperture technique such as unique word searching for the unique word within the aperture and by maintaining a smaller aperture window plus minus delta bits the false detection can be drastically reduced.

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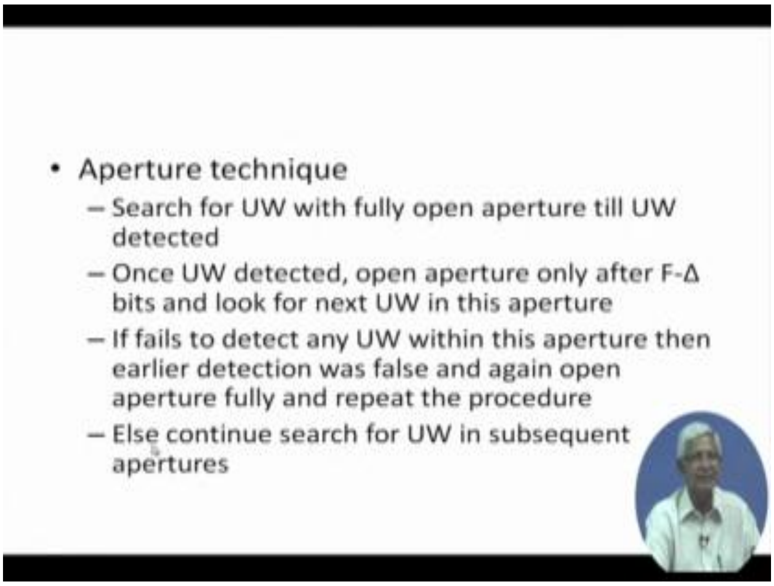

The aperture technique is what first you say search for the unique word with the fully open aperture I mean you search for all bits which are coming in till the unique word is detected.

Now, that unique word it may be the correct unique word or it may be unique word in the data pattern which is look like with a error which looks like unique word assume that it is detected something is detected. So, unique word is detected then you open an aperture only after f minus delta bit f is the frame bit. So, assume that, this is the correct unique word. So, unique word will repeat after f. So, f minus delta is the aperture there you open and look for the unique word there, if you get unique word there then you are through if you do not get it then the first detection is wrong if it fails to detect any unique word when you open the aperture within this aperture then the earlier detection was false detection and you have to again open the aperture fully and repeat the procedure and if you got it else you continue for the unique word detection in the subsequent aperture.

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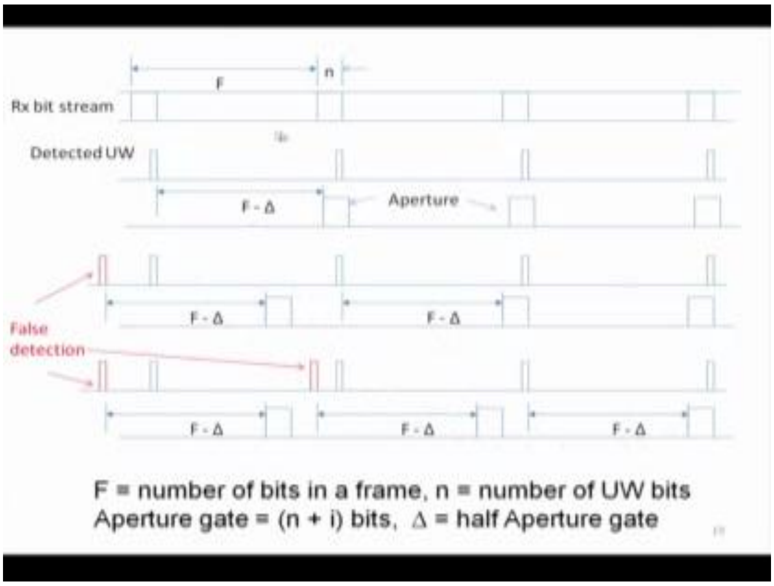

So, like that it goes it is a aperture technique pictorially it can be shown like this you see the frame is f and the n small n is the unique word pattern and then aperture gate is n plus minus I bits plus minus I bits should be and delta is a half aperture gate; that means, this is the this is the unique word aperture will be opened a little bigger than that little bigger than this unique word detected unique word detected pulse add the end of the unique word you get this pulse. So, whatever the unique word slightly bigger than, that you open the aperture where the delta is half of the aperture gate and then the let us say the aperture technique. Let us see before the actual unique word comes you got a false detection and you got a false detection open the aperture, but actually unique word is suppose to be detected here where it is unique word suppose to be come here which will repeat after here, but you open the aperture area based on the false detection. So, you would not find unique word here.

Therefore, you open the aperture again fully though you detected here. So, once you detect again you open your aperture here and now this time you will get unique word in that. So, if the first detection has occurred once here and you discovered that is a false detection opening your first aperture then you should go for complete open search now if you get another false detection here let us say the second false detection false detection occurs, when you open the aperture again. So, you will open a wrong place another window again you do not get unique word. So, you open the aperture again you look for the correct, you get the unique word and then you open the aperture f minus delta you get that.

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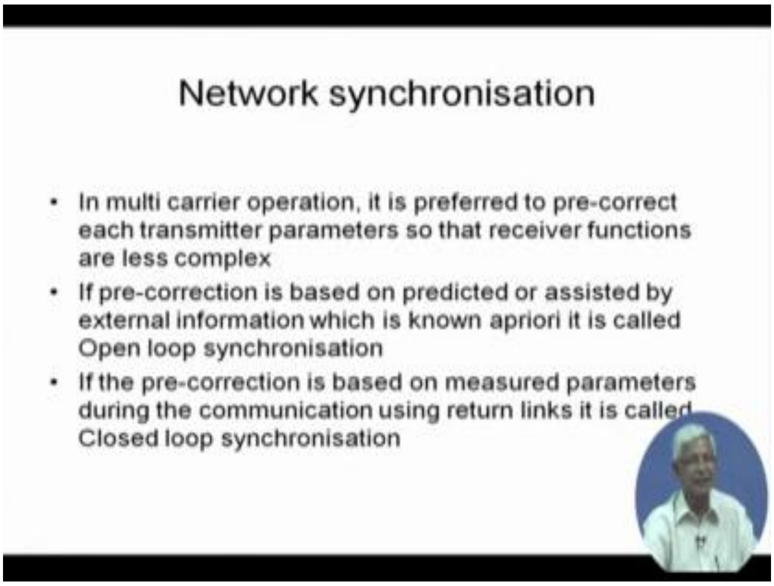

So, this is how the aperture technique what is picture, it shows now ah the for the network synchronisation that was a frame synchronisation now at the network level in a multicarrier operation it is preferred to pre correct it is preferred to pre correct by each transmitter the parameters. So, that the receive functions are less complex I told you the example of TDMA type of thing at the satellite, when there is a receiver and there are n number of transmitters which are trying to access in TDMA to the satellite receiver. Now in that case the satellite receiver for each of the burst each of the burst it has to have the arrangement of synchronisation instead, if it is known that that the satellite at the time at the time frames where the burst is. So, the transmitters can pre correct and transmit. So, that the receiver does not have to make a complex arrangements the complexity is distributed over the transmitter.

So, that is what the network synchronisation at if the pre correction is based on, now pre correction can be done in various ways it can be based on predicted that is modeled or calculated o a of knowing when it is suppose to reach there at what frequency is supposed to reach there or it could be assisted by some external information somebody else has done certain measurements and supplied that information and then it is given as a pre correction parameter. So, it is known a priori it should be known a priori to the transmitters. All the transmitters for their each individual pre correction then, it is called open loop you are going in one direction. So, it is called open loop synchronisation there is no loop formation in this and if the pre-correction is based on some measurements by each of the transmitter is based on measured parameters during communication.

Now, if you want to do a measure parameter particularly one of the important parameters is how long it takes to reach the satellite that distance. So, during that time over there my frequency is changing or time is changing or the distance is changing the delay is changing. So, so you do the measurement; that means, if the each transmitter has done the measurement and it is not the information is not supplied by anybody else. So, it has to do a round drift measurement; that means it needs a return link which is transmitted as well as it will be receiving. So, it is called closed loop synchronisation that is loop is closed. So, pre correction could be open look or it could be close look synchronisation.

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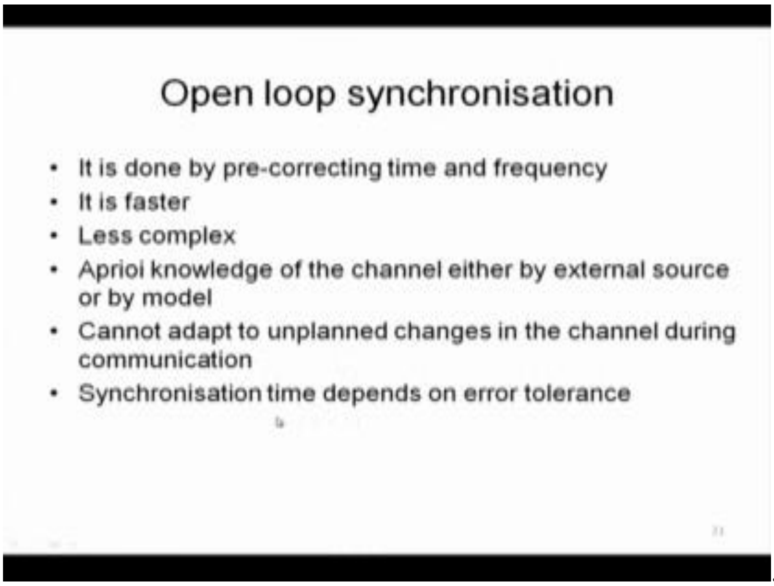

Will see both of them now it is done by pre-correcting time and frequency in open look synchronisation both time and frequency has to be same, let us go a little more deep into the subject in it is faster; obviously, because there is no return link and it is known that a priori that when it is to be pre-corrected and sent it is; obviously, less complex comparatively and a priori knowledge of the channel either by external source or by a model let us say in case of TDMA the reference station. If you remember the TDMA lectures there is reference station which maintains the network the frame timing etcetera.

So, it has the complete information of a the satellite position it is ephemeris as well as the position or the location of each of the stations which are participating on that since the coordinates are known and in terms of time also the satellite coordinates are known the propagation delays for each of the transmitters can be known by the reference station. So, they the reference station giving it is reference burst transmission it can supply this information ah to each of the transmitters if you remember in TDMA there was a reference burst and reference burst has certain pre-correcting and some data portion in that data portion it can supply that point time to time it will update the information of the propagation delay for each of this station.

So, it is a external source knows about it or it can be done by some modeling that is you know the drift of the satellite you know the sun moon drag of towards the satellite and therefore, the satellite movement can be modeled and, if that model is supplied to individual transmitters individual transmitters the earth stations they have their own location and from the model at a particular point they can find out the position of the satellite as per the model and as per that model it can find out what should be the propagation delay between the station to the satellite.

So, therefore, it can be modeled or it can be known by the external source. So, they can supply this, but only thing the problem is this whole thing cannot adapt to the unplanned changes of the channel during the communication during the communication. If there are certain changes these are at an certain instant of time this model will work this at instant of model this information is supplied, but unplanned changes sudden changes, it can cannot track and synchronisation depends on the synchronisation time depends on the tolerance of the error.

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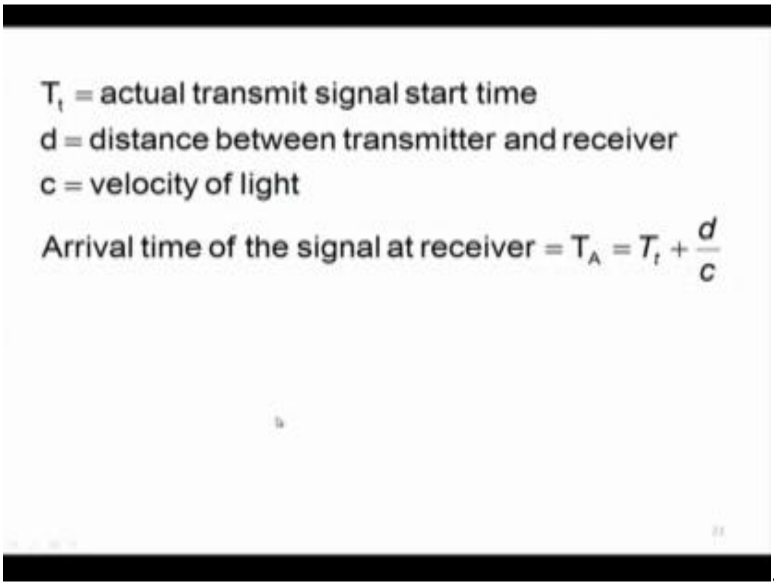

So, we will stop right now, and we will continue the discussion in the next period.

Thank you very much.