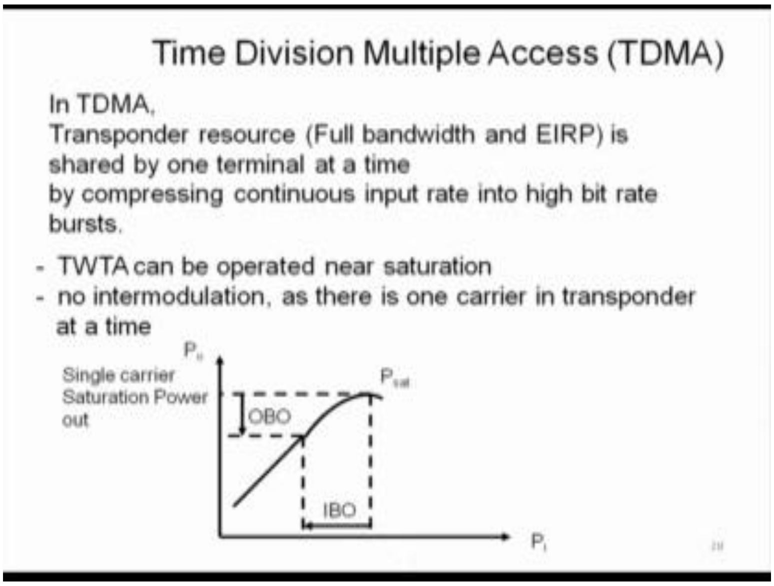
Satellite Communication Systems
Prof. Kalyan Kumar Bandyopadhyay
Department of Electronics and Electrical Communication Engineering
Indian Institute of Technology, Kharagpur

Lecture - 28
Multiple Access -3

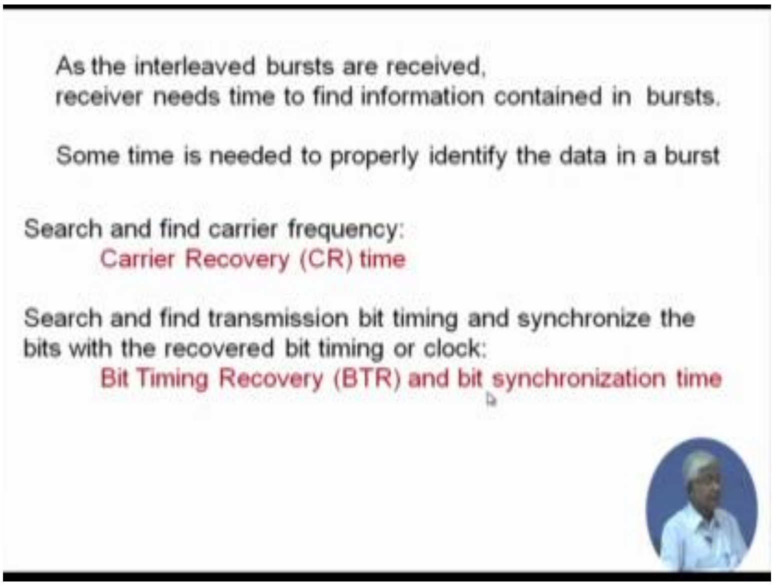
Welcome back again, we were talking about the multiple accesses different techniques out of that we have covered FDMA.

(Refer Slide Time: 00:23)



And we are discussing the time division multiple access TDMA and we started the discussion in the last period, now we will continue on TDMA. So, in TDMA we were telling that a since single carrier is given to a, I mean single user is given the full resources of the transponder as is in terms the bandwidth and power, you can operate in the saturating region and therefore, the maximum power you can operate. Whereas, in case of FDMA you have to operate linear region because multiple carries are there and in non-linear region that will generate spurious. So, that is one of the biggest advantages of TDMA.

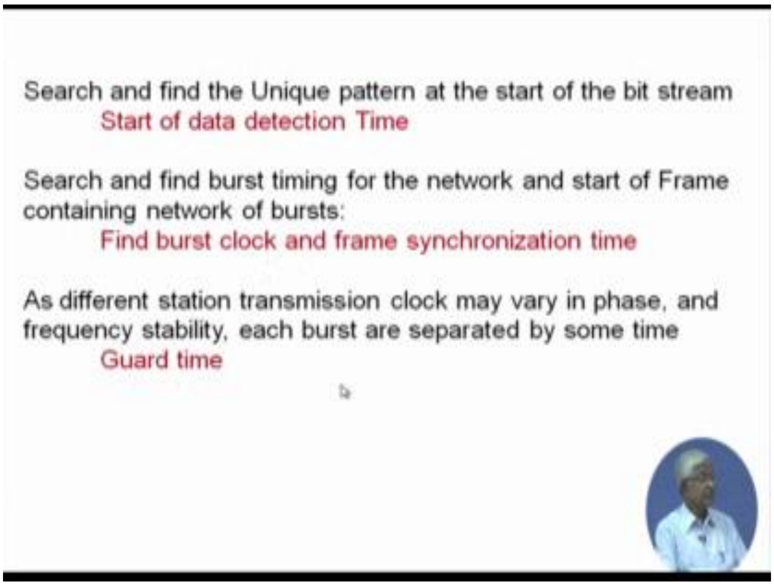
(Refer Slide Time: 01:11)



Now, in terms of time interleaved bursts that will be transmitted down to the ground the receiver needs to find the information which the information, where it is the information meant for him in the bursts. So, let us see what is the additional information that has to be sent along with the data. There are for the receiver some time will take to properly identify where is properly identify a bursts; a demodulator has to identify where is the bursts in terms of frequency? So, it has to search and find where is the carrier frequency? Because the demodulator might be having some (Refer Time: 01:58) frequency (Refer Time: 02:01) frequency in free adding conditions and suddenly at the input another one carriers come which may have a slightly different frequency, because of various reason because this receiver and transmitter and inter training thing, there may be different in frequency. So, it takes some time. So, that time is called carrier recovery time, there are techniques available how to recover. We are now discussing about technique right now, let us see it takes some time. So, that is an additional time.

Now, then after finding the carrier, you have to find out where the transmission of the bits are occurring. So, the we have to search and find the transmission bit timing, and bit timing that was a frequency is the bit timing and synchronize your local bit clock which that recovered clock is to be as we found. So, is called bit timing recovery that is the bit timing to recover the bit timing you needs some extra time, and the synchronized to them. So, it is called BTR.

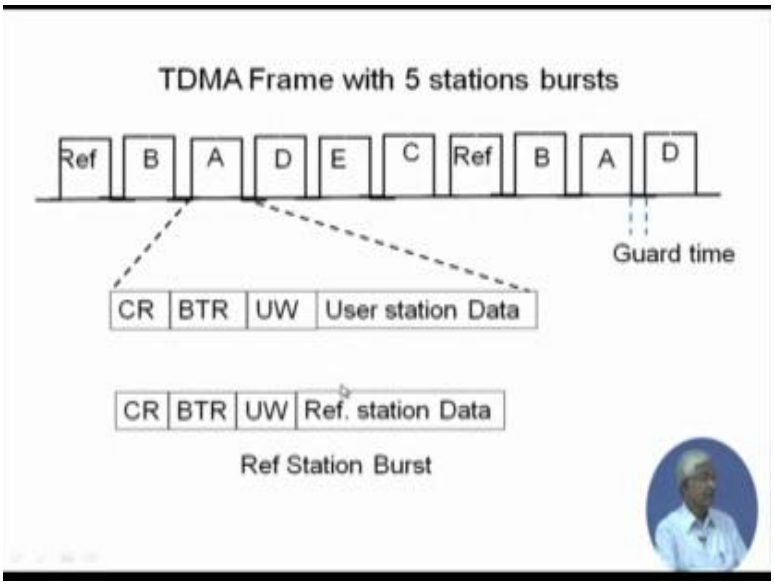
(Refer Slide Time: 03:11)



And then after getting the bits, you do not know exactly where because you are lost some time. So, you do not know exactly where the, your data starts. So, to beginning of the data there is sink pattern or unique pattern is given. That is called search and find out that unique pattern at the start of the bit stream like a frame as a header. So, this header is unique pattern. So, the start and detection time of the data. Data start time has to be detected is called unique word detection time. And then in a total frame, when you have to transmit get search and find the burst timing for the network and start of the frame containing the network bursts, see is station is switched on and some TDMA network is running in that transponder.

So, you should know where that the frames of this are the transponder the frame where it has started? Because if a receive is looking you will receive continuously data burst one after another now which data bursts is from whom there has to be identification. So, they identify in terms of frame. So, timing is given to each frame, sometimes is given to each station to find out the frame timing. So, you have to find the bursts clock and the frame synchronization time and as the different station transmission clock, may vary in phase each a station clock timing as well as phase may vary. So, when it reaches at the satellite the bursts may drift this way that way cheater. So, they should that overlap. So, therefore, there has to be a certain guard time giving just like in terms of FTMA we had given guard band, here in frequency here you have to give some guard time.

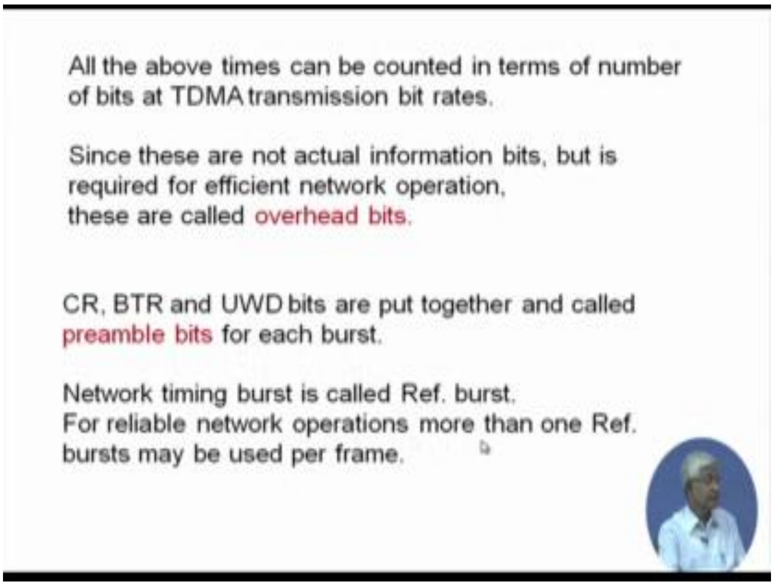
(Refer Slide Time: 05:17)



So, these are given certain extra times which are required the you can see in a satellite there is on another transponder, if it is continuously looked you can see that the TDMA frame with five different station A, B, C, D, E is shown here there is a reference bursts and then say first burst time is given to station B second one for station A and then D and E and C like that, and it repeats after.

So, there is a frame here one reference to the beginning of the next reference, this we call frame which is being repeated and each individual bursts is having certain guards that is guards time that is guards time here it depends on the burst of the of the burst from which station there are clock cheater. And then each individual station bursts as information like carrier recovery time CR, bit timing recovery time BTR unique word is there then, user station data is there actually data is sitting here. Similar the reference burst which says the beginning of the frame we have CR BTR u required reference station. If they if it as transmit data mean for all this is the reference station data now these extra things that is the guard times and then this is that overate including the unique word and the reference bursts are not useful bits they are not the useful bits which are been exchanged. So, these are the losses.

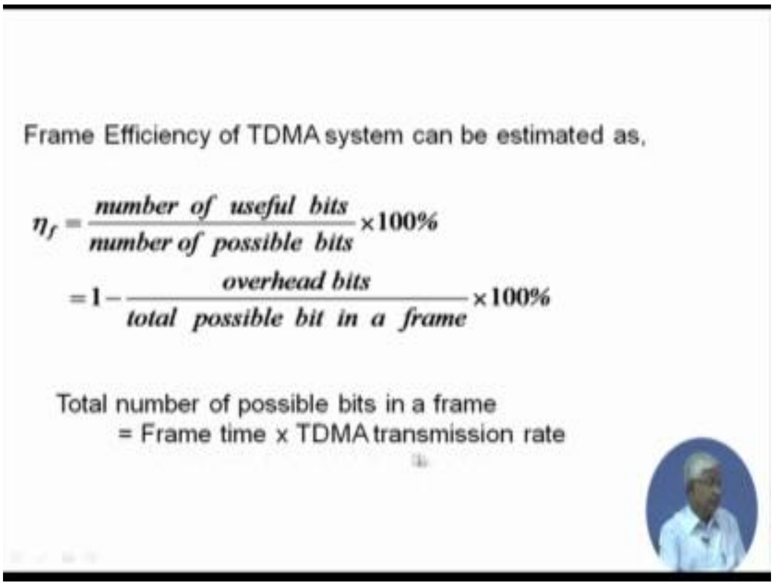
(Refer Slide Time: 06:55)



Let just look at it the above times can be counted in terms of number of bits in TDMA transmission bit rate, since these are not actually information bits that is required for efficient operation of the network these are called overhead bits.

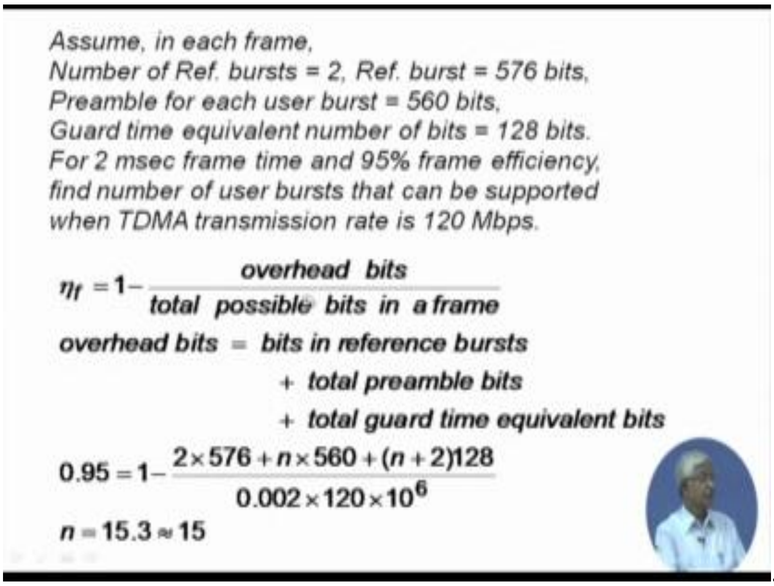
Now, CR, BTR unique word detection bits are unique word bits are put together are called preamble bits for each bursts, that is each user bursts there are preamble bits similarly there is a reference burst which contains the similar thing in addition certain network reference of network operation information are there. So, total reference bursts are not user bursts user is not exchanging that is operation for the network that is also a overhead for the network.

(Refer Slide Time: 07:43)



The frame efficiency of the TDMA system can be estimated as eta f that is frame efficiency is number of useful bits which is user is exchanging divide by number of possible bits; that means, the overhead is our loss in terms of percentage. So, it can be expressed as number of useful bits is 1 mines overhead bits of the possible bit in a frame. Total number of possible bits, bits in a frame is frame time and the TDMA transmission rate. So, if we total frame time is known and the TDMA transmission rate is known then you can find a total number of possible bits that is the denominate.

(Refer Slide Time: 08:41)



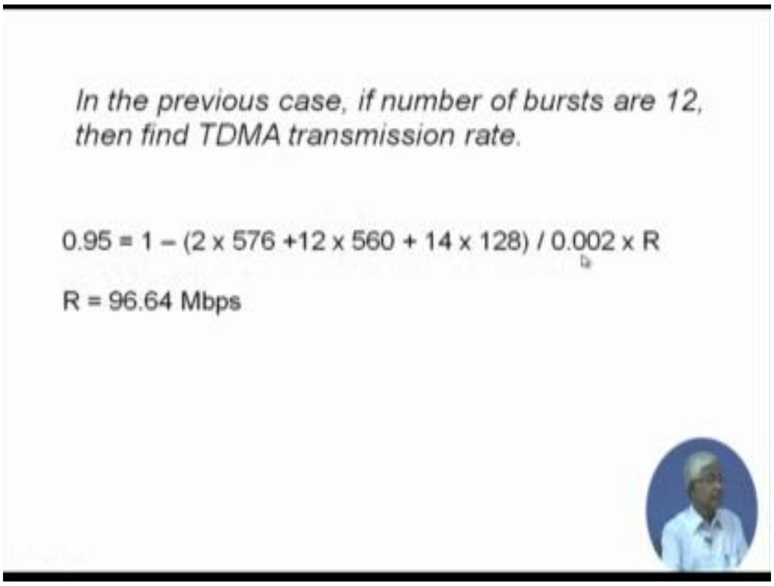
.

Let us take some quick examples. So, that we understand the meaning of each example there is assume in a each frame there are two reference bursts. Two reference bursts that put because in case of one reference bursts failure, there are network synchronization failure people cannot communicate because they well know where the frame start is. So, therefore, normally there are two different bit stations are there who transmits at two different locations were two bursts each reference bursts is 5, 6, 7, 6 bits these are some entellus types of TDMA numbers, practical numbers.

Preamble for each user burst for 560bits rest of the bits in a use of bursts is a useful bit. This is the preamble bits that are overhead bits, you have reference bursts 2 times of reference bits and users preamble in times if there are end users and guard time equivalent bits are 128 bits. Let us take a 2 millisecond frame time and efficiency of 95 percent and of course, the bit rate is a 120 mega bits per second that is a transmission rate or the user busts. So, total number of bits can be calculated because a frame time is given and bit time is given.

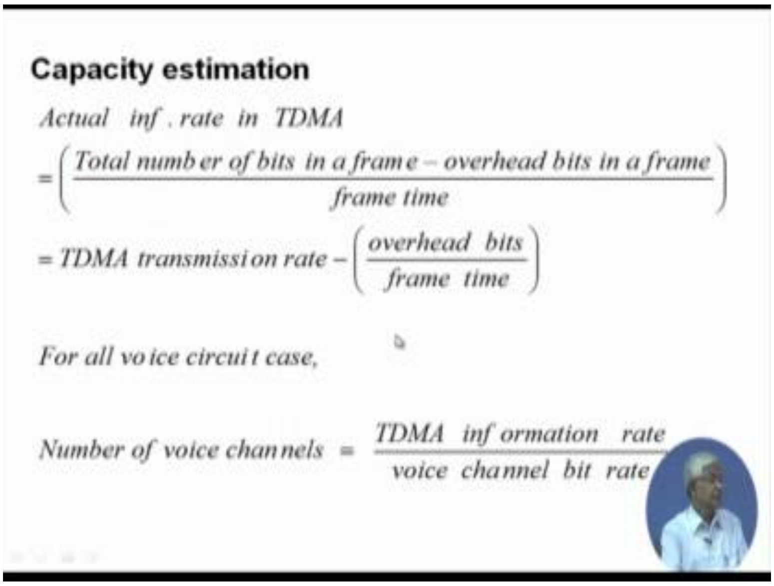
So, efficiency is we have seen this expression one mines overheads bits by total possible bits in a frame and overhead bit’s are bits in reference bursts total number of preamble bits and total guard time equivalent bits and the efficiency is 0.951 mines 2 times the reference busts 2 into 576 n times the 560 bits that is a overhead preamble per busts and n plus 2 because 2 reference bursts are there. So, between the reference bursts also have been guard time and. So, n plus 2 into 128 and since n users are there. So, n user bursts, 128 guard time’s n plus 2 times the guard bits divided by the bit rate multiplied by the frame time. So, here comes out to be n is equal to 15.3 obviously, the lower number has be given this argument has been explain to you in FTMA. So, fifteen users are possible.

(Refer Slide Time: 11:02)



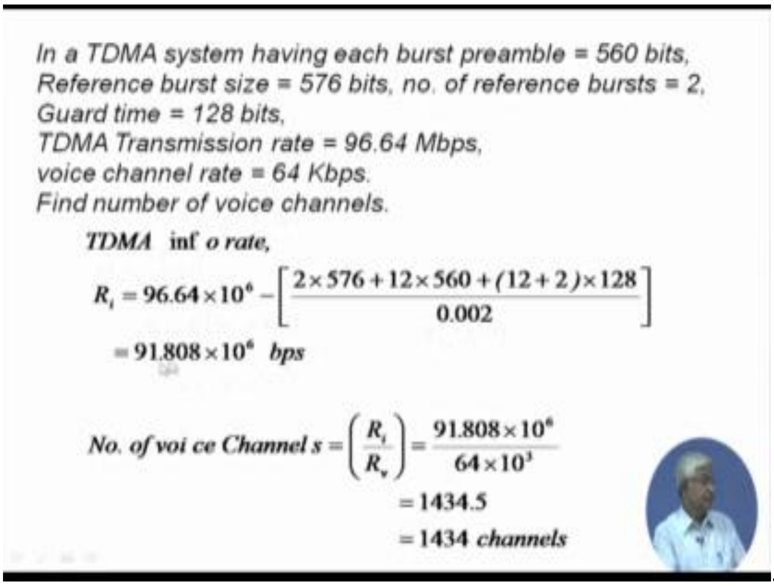
Let us see if the number bursts are 12 and then what is the transmission rate you can find out efficiency is known 12 bits and then frame time is given. So, you can find out that any number is missing you can find out those.

(Refer Slide Time: 11:18)



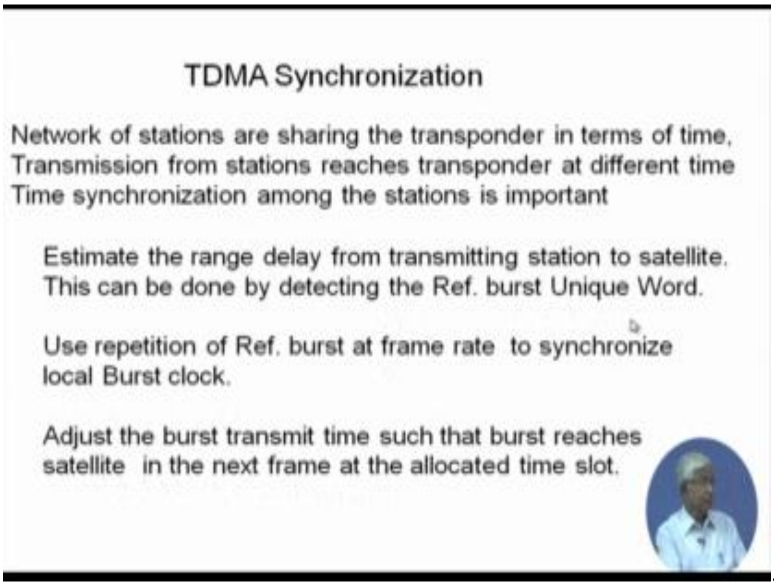
Yes, now when you do the capacity estimate let us do in terms of here in terms of let us say voice circuit. So, actually information rate in a frame is total number of bits in a frame minus overhead bits in a frame divided by frame time. So, information rate in a TDMA that is TDMA transmission rate mines overheads bits by frame time for voice circuit. So, TDMA information rate information rate and transmission rate are not same and you have to remember that because they have overhead. So, TDMA information rate divided by voice channel bit rate is 64 kilo bits normally taken. So, you can take the voice channel number of voice channel a if the voice channel bit rate code x are used it can be different.

(Refer Slide Time: 12:15)



Let us take a quickly calculation that is that is a TDMA system having each burst preamble is 560. Similarly to last one reference burst size 576 bits number of reference bursts 2 just like last time guard time is 128 bits, TDMA transmission rate is 96.64 and voice channel rate is 64 kilo bits number of voice channel you have to find how do you proceed that is TDMA info rate h you that is information rate transmission rate is given find out the information rate base on the expression it comes out to be in this case 91.8 mega bits per second. So, that divided by the voice channel rate here given as 64 kilo bits you get 1434.5 channels. So, the lower numbers is to be given 1434 as to be taken as number channels that.

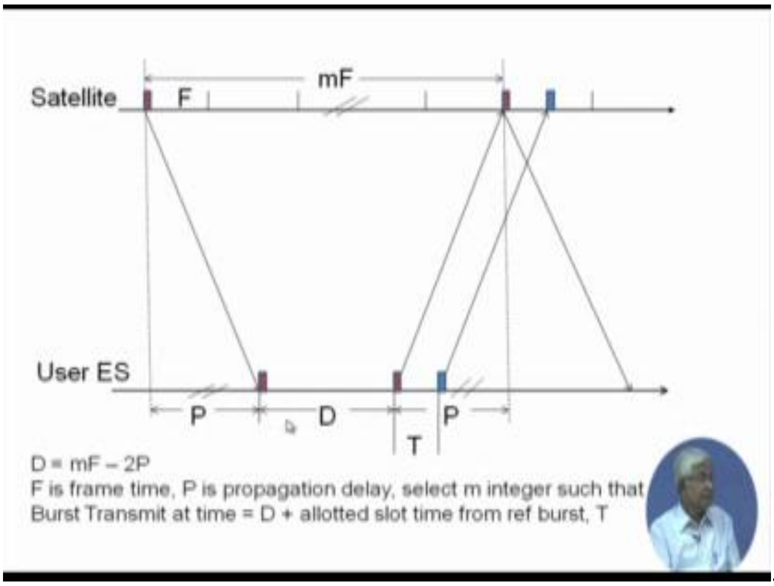
(Refer Slide Time: 13:14)



But there are important issue in TDMA is synchronization their particularly the network synchronization this network of station, they are sharing the transponder in terms of time. So, they must transmit with the synchronized bursts clock the transmission from station reaches the transponder at different time that is the idea. So, that in the frame it has to be put in proper time internet. So, this time synchronization among the station is very important now for that from individual stations they are at different locations the range delay is different the delay from the station to the satellite will be different from each station the delay comes it to play. In this case this can be done by sending and receiving your own burst or it can be done by detecting the reference unique word burst. Now you have to other TDNA frame has to be synchronized in terms of reference bursts which is at the frame rate and from that you have to find out burst clock, and at that rate transmission has to decrease now to adjust the burst transmit time this burst must reach the satellite in the next frame at the allotted time slot.

So, first you have to detect where is the reference input burst and based on that you have to transmit and you should know the range, but exactly the reception of you are unique word burst are the reference burst may not be the seem as the allotted burst time.

(Refer Slide Time: 15:14)



Let us look at it the way what I am telling, let us look at it example see at the satellite this are the satellite this are the frames f is standing for frame and the beginning of the f is reference for the bursts is appearing. So, these are frames.

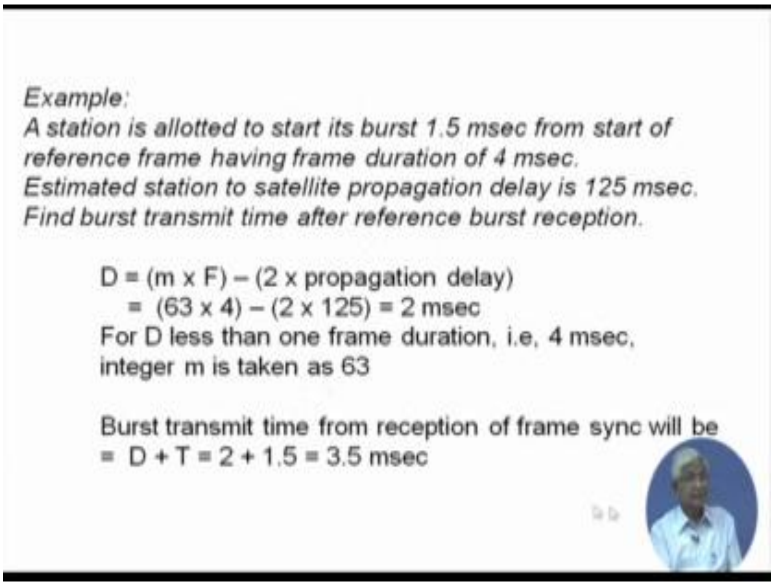
Now, at the satellite some reference was same frame is there the reference bursts will be received after a delay propagation delay p at a user station. Now from the reference bursts at the satellite it is already allotted that this particular user station is a user a station after. So, much time it has to reach. Now since the propagation delay has to be brought into picture it would find out that from a reference station reception of the reference bursts after how much time you should transmit. So, that calculation is shown here in the form of a picture. So, when you receive the reference bursts actually it is time delay is of that 225 millisecond and this frame timings are of that of two millisecond four millisecond like that its very, very small compare to that.

So, by the time you receive couple of frame by the past. So, you do not know where you will be reaching. So, only propagation delay is known to you and then, let us assume that aft assume that you are your self is a reference bursts you are transmitting then, with respect to the reference bursts the allotted time t is to you if you transmit with respect to that reference bursts you will reach the satellite with the propagation delay after reference bursts. So, if this is in times the frame which your imaginary your reference your reference station. If you are which will reach the satellite exactly at the reference station reception the at the reference station reception at the satellite, it is the other reference station transmitting.

Now here it is imagine that you are transmitting with respect to that after time t, but this point is not known to you. This time is not known to you with respect to the reception of the reference bursts what you have received this time has to be calculated, but in this we can equate that m time f m is unknown m time f could be the propagation delay reception, propagation delay transmission. So, two times propagation delay and this unknown d and your allotted time t. So, this can be equated m time f is equal to p plus D plus T plus P. So, you can reach at the reference bursts and then, after t you will reach there. So, you can find out d or t plus t any one of them, but here d is unknown and m is unknown. So, you have to do it iteratively.

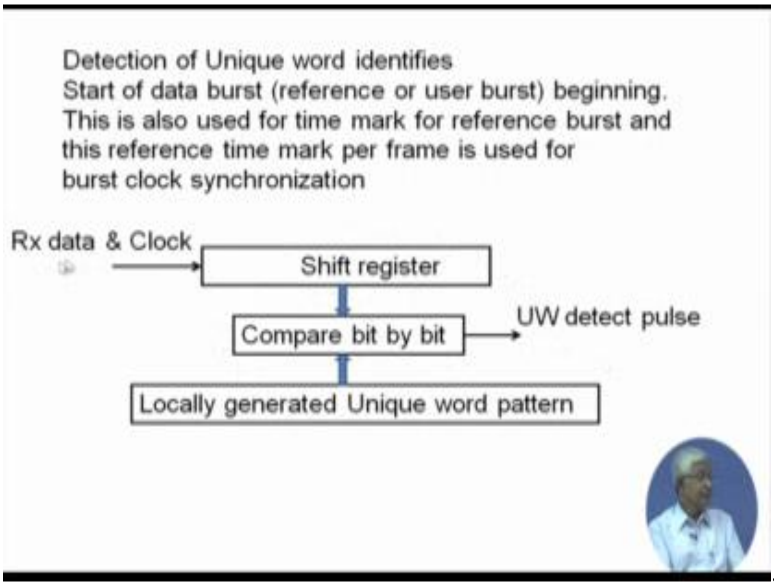
So, if you put into expression the d becomes m time f mines 2 times propagation delay propagation delay has to be known to you, either by your on ranging experiment or by knowing the satellite position and your position there may be some error because satellite will be drifting on the broad castigation based on knowing the satellite drift it can model and send you at that particular time along with the reference bursts what is your propagation delay that you will get. So, somehow you have to know the propagation delay burst then, frame time is known to you. So, only this small m that is which is integer number of frames and d is unknown. So, you have to iterate this, that f is a frame time p is propagation delay, select m integer such as the t is less than the frame time and then once you know that bursts transmit time t with respect to d is the d plus allotted slot time from the reference bursts. So, from the reception reference bursts d plus t is the time when you are transmitting.

(Refer Slide Time: 19:42)



Let us take a quick example a station is a allotted to start its burst at 1.5 millisecond from the start of reference frame having frame duration of 4 millisecond estimated station to satellite propagation delay is 125 millisecond find the burst transmit time after reference burst reception at that particularly station. So, d is m into f minus 2 times propagation delay and the by iteration you go on changing m. So, that. So, that d becomes less than the propagation delay time, and the for d a less than one frame duration that is from 4 millisecond integer m can be taken as a 63 and d comes out to be 2 millisecond. So, your actually transmission time is d and 1.5 millisecond from the reference burst. So, that is 2 plus 1.5 is 3.5 millisecond.

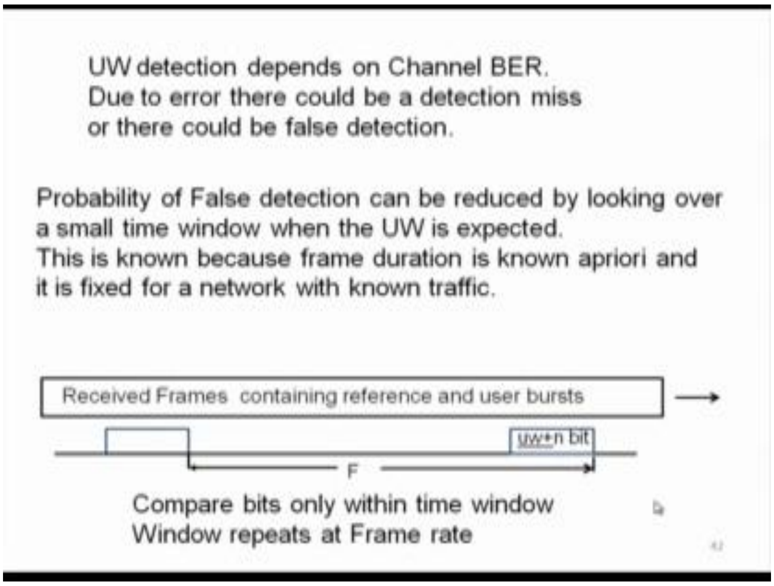
(Refer Slide Time: 20:37)



Now, this is the network synchronization part and, but in all these process you have to detect the unique word, which tells you where the data burst start or reference burst data starts. So, detection of the unique word is very important unique word is beginning of a burst. Where they actually data is there this is also used to time mark for the reference burst and this reference burst time mark per frame is used for burst clock synchronization.

Now for the network synchronization part times, but your detection of the unique word is important how it is done that is, you put the receipt data and clock it in to a shift register and you know what is the unique word pattern transmitted? It is known to all station. So, locally generated the unique word and keep in a register and compare the received pattern with this locally unique word pattern bit by it and you get a unique word detection pulse simple this must be known to you.

(Refer Slide Time: 21:58)

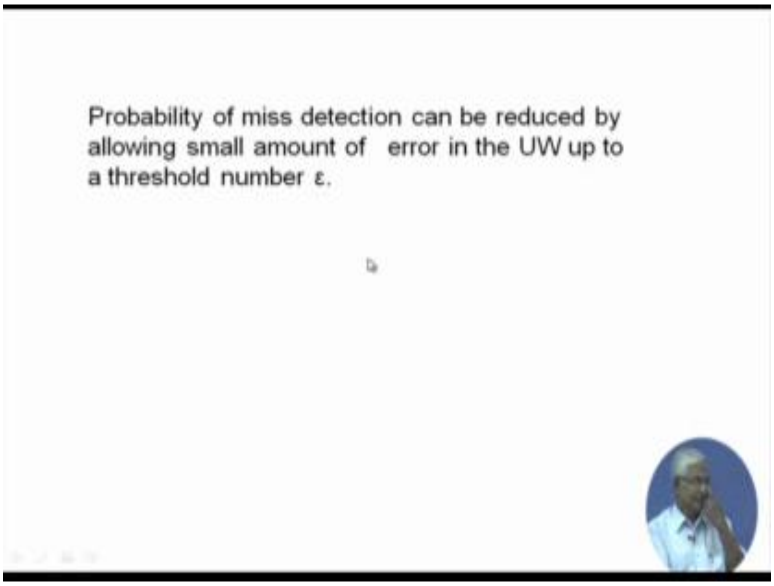


The problem is that what happen if the error occurs there may be error in the unique word or the data. So, unique word detection depends on the channel bit rate and due to error there could be detection miss. If it is the error is occurring at the unique word itself or in the data pattern if due to error one of the portions of the data looks like a unique word then it is a false detection. So, there it is two probabilities there is a miss detection probability and false detection probability both are based on the channel b e r also based on the size of the unique word probability of false detection that can be reduced by reducing a window through which you check because unique word is not always happening. It is expected after referring time and the frame size is known to you.

So, therefore, you can generate a time window once you detect a one unique word you can generate the next unique word detection time window. So, in the data portion if there is error and it creates like unique word you not looking at it. So, this unique word time is expected because frame duration is known a priori and it is fixed for a network with a known traffic. So, let us pre put it pictorial that is received frames containing the reference bursts and the user busts going through shift access as going out and unique words windows are generated. So, let say you get a unique word in this window. So, after a frame time minus the unique word size are a slightly size is larger than that because, if there is some error in the in your clock. So, better put a extra n bits over that. So, here the other unique word will appear.

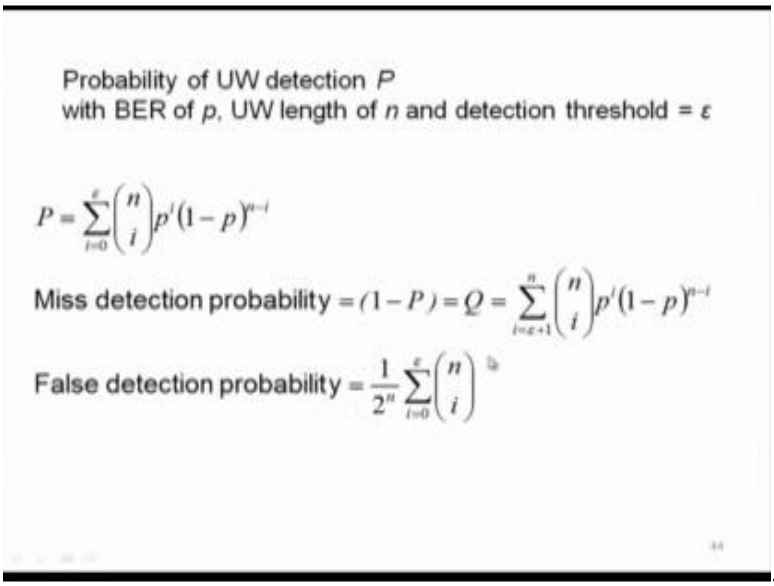
So, compare bits only within the time window. So, in between during this time you are not looking for the unique word. Because, this is supposed to be data and in the data because of error if some patterns look like unique word and not looking at it. So, you are looking at the location where the unique word.

(Refer Slide Time: 24:19)



Therefore, your false detection probability can be improved, now probability of miss detection of course, can be reduced by if there is one error you can tolerate, if there are two errors; you can tolerate.

(Refer Slide Time: 24:43)



.

If there is epsilon, number of errors you can tolerate depends on how much tolerance in your system you have that is you can put a threshold of error tolerance and this expansion is known to you. That is miss detection probability is 1 minus p that is probability of detection and which is with tolerance I is equal to epsilon plus 1 to n and n is a header size and the n c i. Small p is the probability of BER. So, p to the power I 1minus p to the power n minus I and the probability of false detection is 1 by 2 to the power n I is from 0 to epsilon.

If you have epsilon for tolerance and n c i, based on probability of miss detection we have reduced the probability of false detection. So, in some cases people do not tolerate the errors. So, epsilon is 0. So, this summation has to be one to n that is the header size or unique word size in some cases the tolerance is there. So based on that you can have miss detection probability calculation, these two are the important design criteria for the selection or the length of the unique word and of course, the pattern of unique word will depend on the auto correlation function when (Refer Time: 26:08) function etcetera for the unique word. Since time is up we will continue a discussion in the next period for the time being.

Thank you very much.