Course on Principles of Communication Systems-Part 1
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Lecture 51
Module 8
Time Division Multiplexing (TDM), Operation of TDM, Sample Spacing in TDM

Hello, welcome to another module in this massive open online course. So previously we have seen Frequency Division Multiplexing in which several signals are multiplexed in the frequency domain, alright. So in this module let us look at another technique of Multiplexing that is Time Division Multiplexing, ok.

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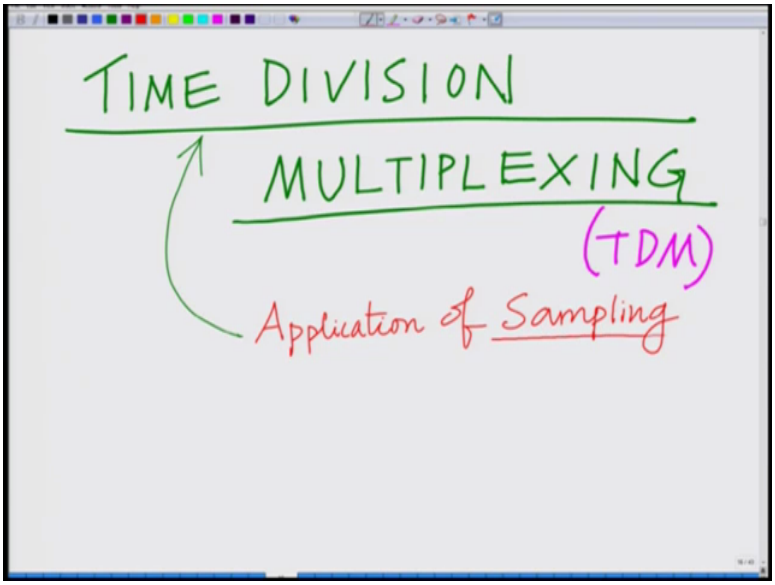

So naturally in Time Division Multiplexing alright the signals are multiplexed in the Time Domain. So let us look at in this lecture let us look at Time Time Division Multi Time Division Multiplexing that is TDM, ok. And as we know Time Division Multiplexing as we know alright. So first let us look at, so TDM first let us realize the TDM is an application of the sampling right TDM is an application of sampling. So TDM employs sampling, so TDM is an application TDM is an of application sampling, alright.

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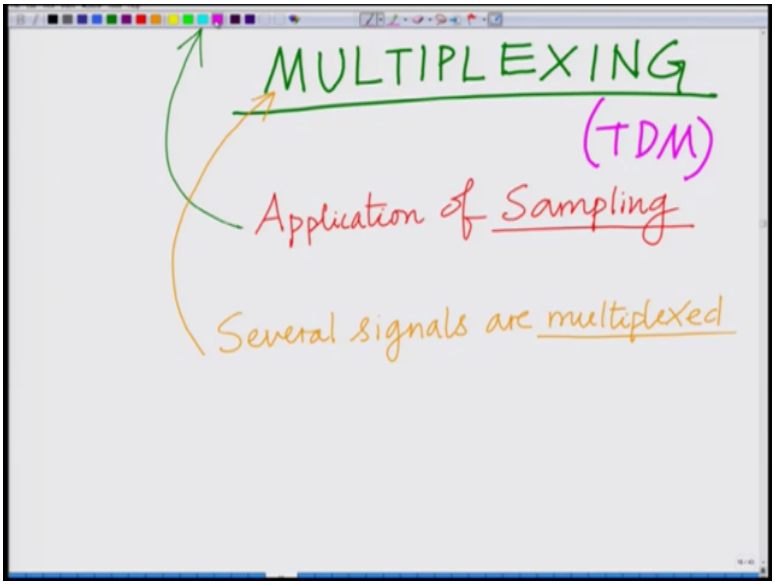

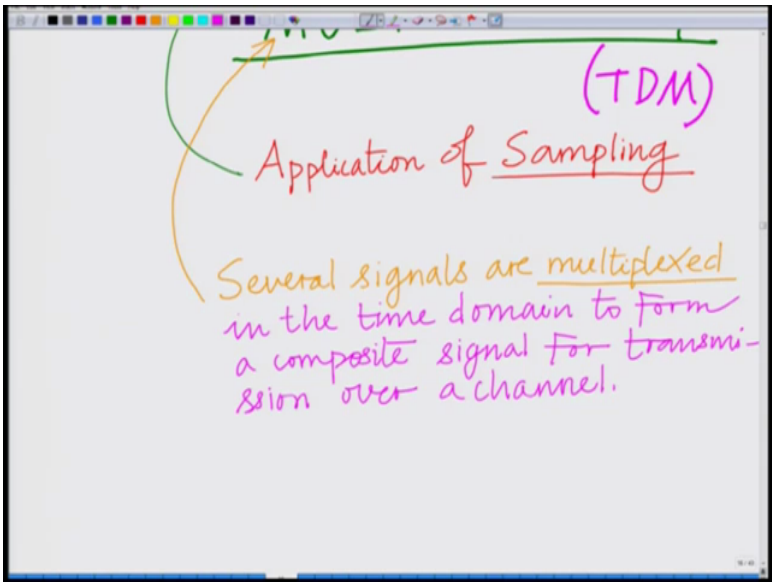

And in Time Division Multiplexing as we already seen similar to Frequency Division Multiplexing right signals are being multiplexed. So several signals are multiplexed in the time domains, so it is a Multiplexing scheme which means several signals are multiplexed or basically combined several signals are multiplexed correct these are multiplexed to form a composite signal for transmission over channel multiplexed in the time domain to form a composite signal for for transmission over a communication for transmission over a channel or a communication channel, ok.

So several signals are multiplexed similar to frequency domain division multiplexing several signal are multiplexed into a composite signal. In Time Division Multiplexing this Multiplexing is done in the time domain and this is achieved via sampling, ok.

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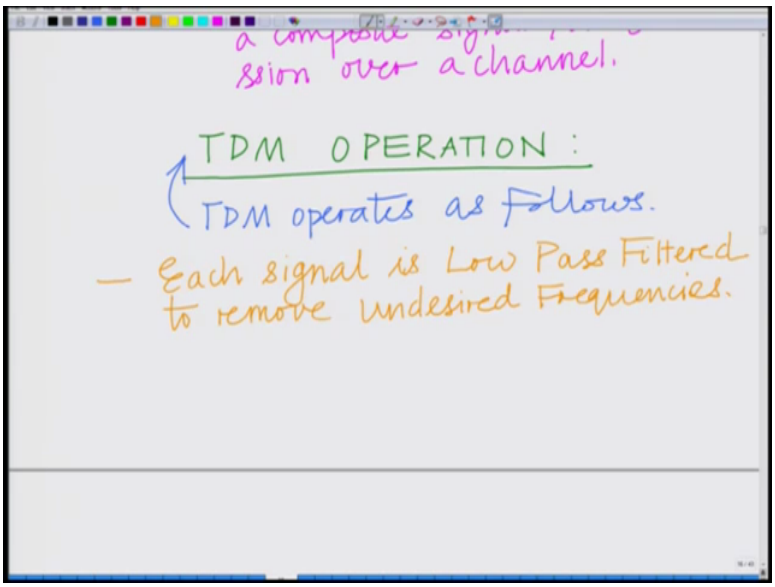

And now so TDM so let us look at operation of TDM let us look at the operation of TDM, TDM operates as follows each signal so TDM operates as follows each signal is first low pass filtered to remove undesired. So in the first step each signal each signal is low pass filtered to first remove the to remove the to remove the undesired frequencies, ok.

So the signal is low pass filtered to remove the undesirable frequencies, the signals to be multiplexed are then applied to a commutator which alternately samples the different signals to be multiplexed. So these signals these different signals which are to be multiplexed are applied to a commutator, ok. The commutators are high speed switching device which alternately samples each of these signals to be multiplexed ok.

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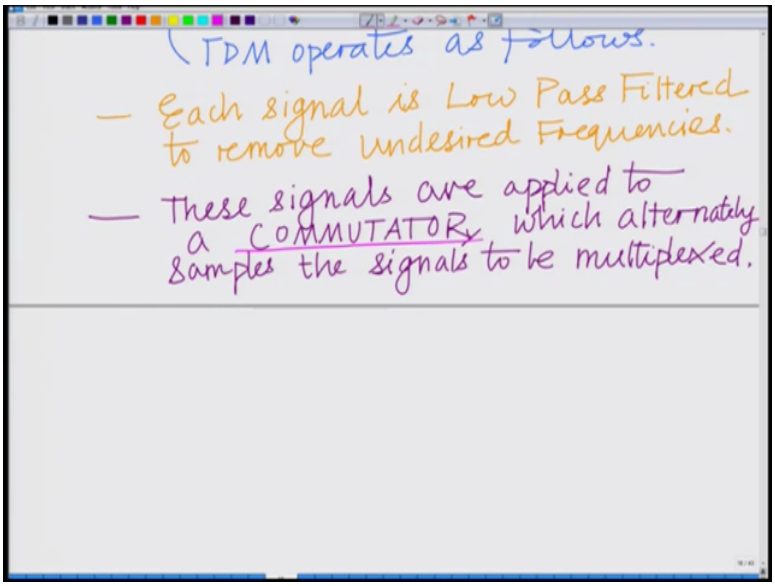

So these signals are subsequently applied to a to a to a commutator ok this is a special device commutator which alternately samples the signals to be multiplexed. So these are applied to a commutator which alternately samples the signals to be multiplexed, ok.

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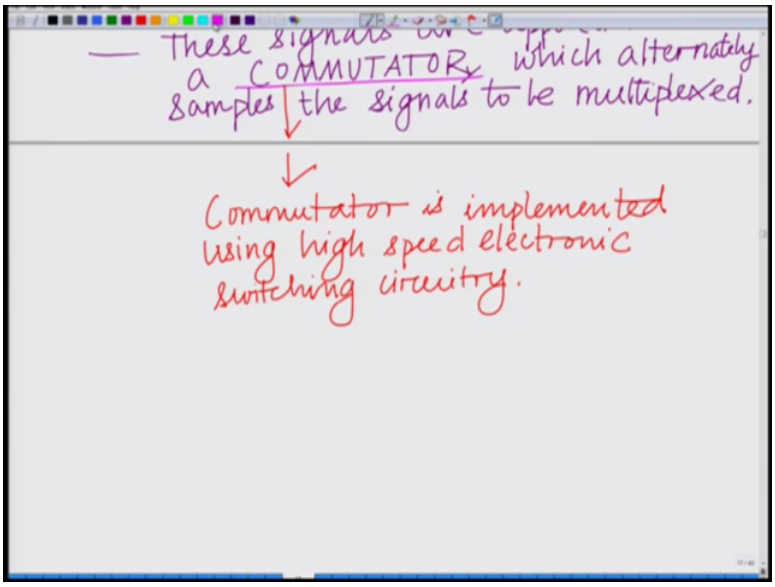

And this commutator is implemented this commutator this commutator is implemented using high speed electronic switching circuitry using high speed is implemented using high speed electronic switching circuitry.

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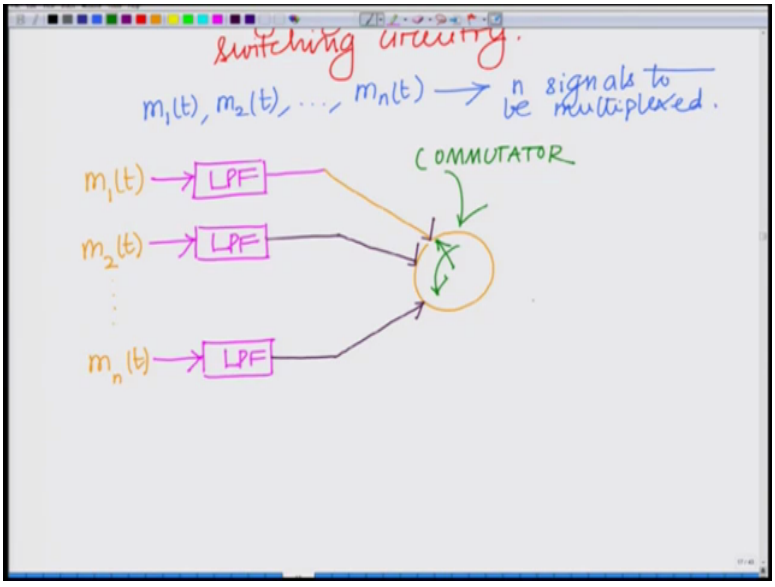

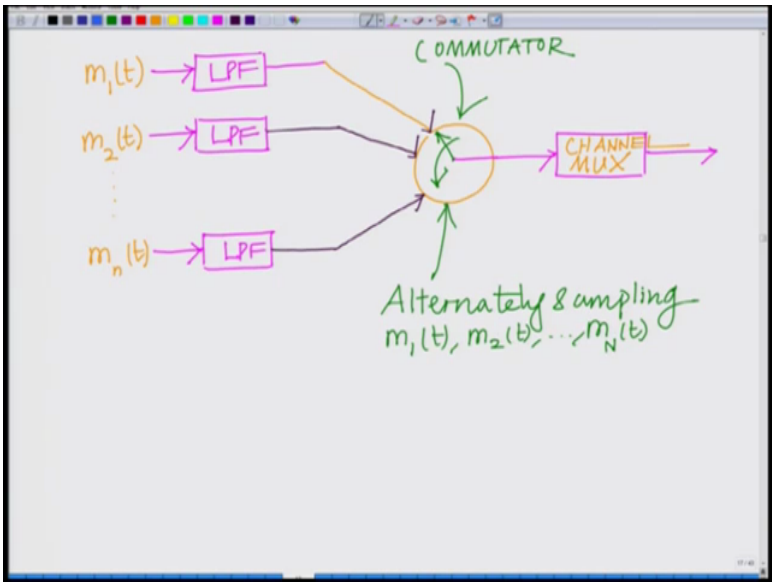

So if I look at a schematic of this diagram the schematic looks as follows. So I have m1(t) that is the first signal similar to your Frequency Division Multiplexing I have m1(t), ok which is the first signal to be multiplexed, m2(t) so on upto mn(t) these are the N signals to be multiplexed, ok.

So we are saying m1 to these are N signals to be multiplexed we pass them through each of these is passed through a low pass filter to remove the undesirable frequencies, correct each is pass through a low pass filter to remove undesirable frequencies, ok. And then each is sampled through a high speed each is sampled by a high speed commutator. So if you could look at this this will look as follows, so this is the signal correct, ok so we have m1(t), m2(t) mn(t) each is sampled by a each is sampled by a high speed commutator, ok.

So the commutator alternately samples the so this is basically your commutator, ok which is alternately sampling. So this commutator is alternately sampling m1(t) fine and then these are multiplexed for transmission over the these are multiplexed for transmission over the channel, ok. And these signals are sampled to obtain a (compo) so (alter) so these signals are alternately the commutator (alternatively) alternately samples m1(t), m2(t).

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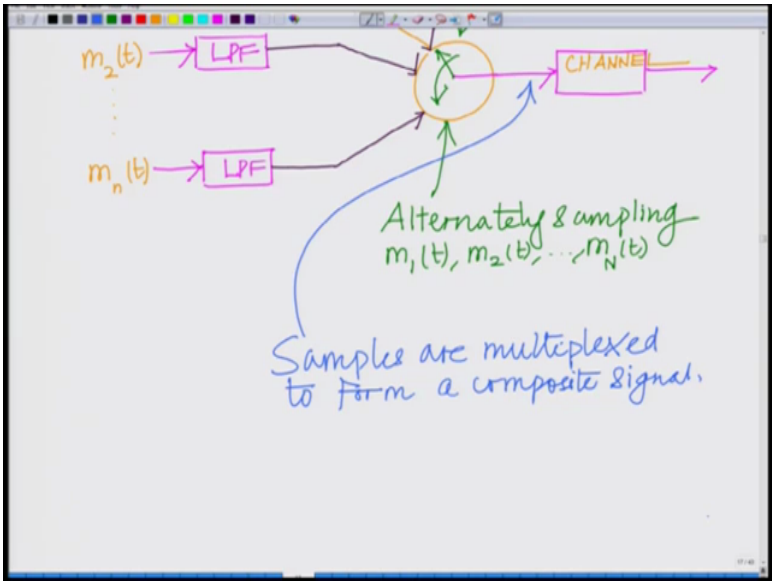

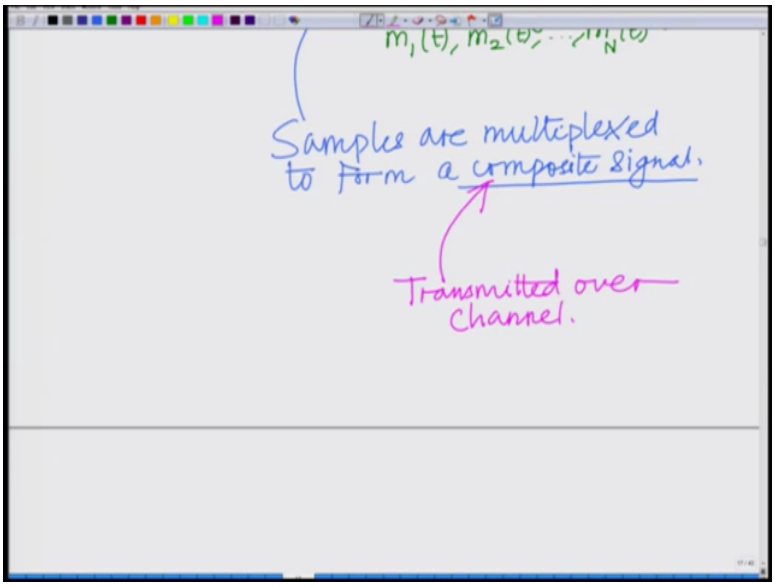

And here we have the samples are multiplexed ok. So samples are multiplexed to form a samples are multiplexed to form a composite signal, ok and this composite signal is transmitted over the channels so composite signal is transmitted over the channel, so the composite signal is transmitted over the channel, ok. So what are these so we have these signals which are low pass filtered, these are alternately sampled by the commutator ok, as we have said which is a high speed switching device alright then the samples are multiplexed to form a composite signal the composite signal is transmitted over the channel.

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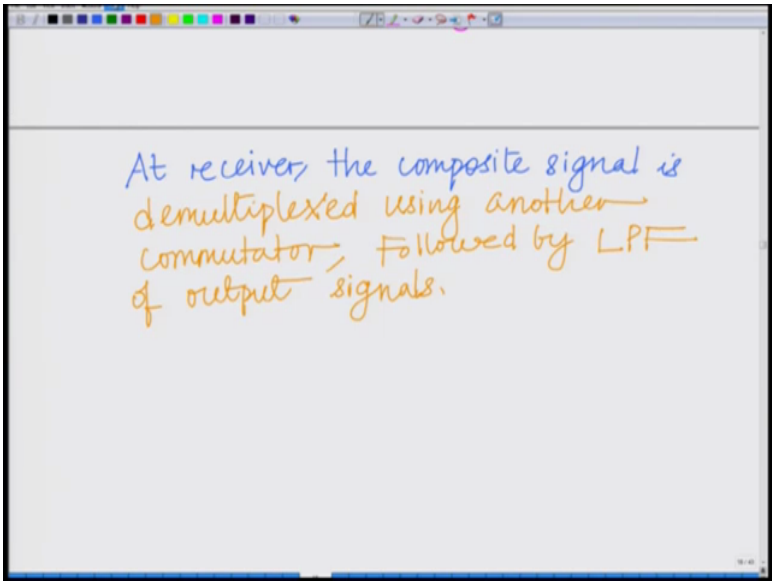

Now at the receiver the samples from this (compo) the multiplex samples from this composite signal are again demultiplexed using a commutator and again there low pass filtered to yield the respective signals, ok so this is transmitted over the channel. Now at the receiver at the receiver the composite signal the composite signal is demultiplexed the composite signal is demultiplexed using another commutator demultiplexed using another commutator followed by low pass filtering of followed by low pass filtering of the output signals, ok.

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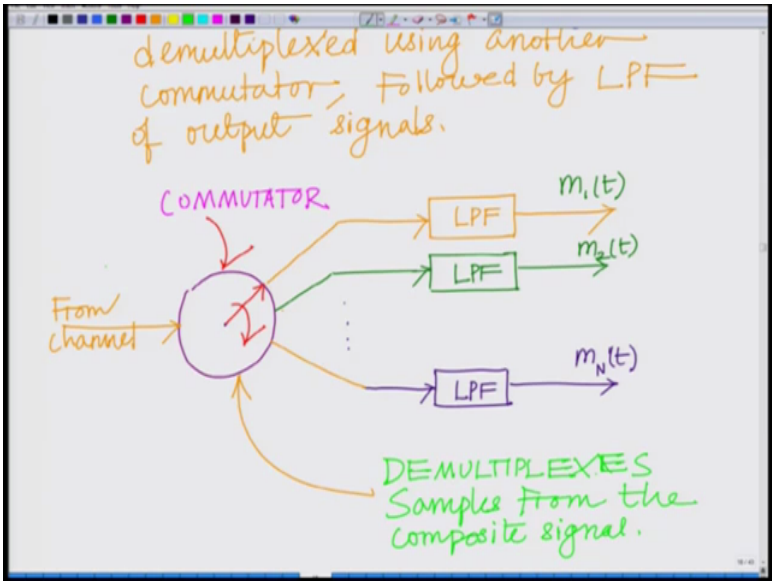

So at the receiver we again have a commutator, ok we have a high speed switching device which basically what it is doing it is basically again demultiplexing. So this commutator so this is the commutator used for demultiplexing at the receiver which is used for

demultiplexing correct and this demultiplex signals correct these are subsequently low pass filtered for instance this is low pass filter, this yields your m1(t), this is low pass filtered this yields m(2)t and this is also low pass filtered to yield mN(t), ok.

So these are low pass filtered ok and these are. So this commutator and this commutator is performing so you get the input from channel ok, so you have the channel so we get this from the channel this commutator is then demultiplexing, ok. Demultiplexes samples demultiplexes samples from the demultiplexes samples from the composite signal, ok. And an important aspect ok so demultiplexes the samples from the composite signal followed by this bank of LPF low pass filtered.

So each of these devices each of these demultiplex team of samples is individually low pass filtered to yield the appropriate signals. So the samples corresponding to m1(t) are filtered to yield m1(t), m2(t) so on upto mN(t). And now it is important to note that these two commutators C1 and C that is C transmitter the transmitter that is we call the commutator the transmitter CT and commutator at the receiver CR these have to be synchronized alright, ok.

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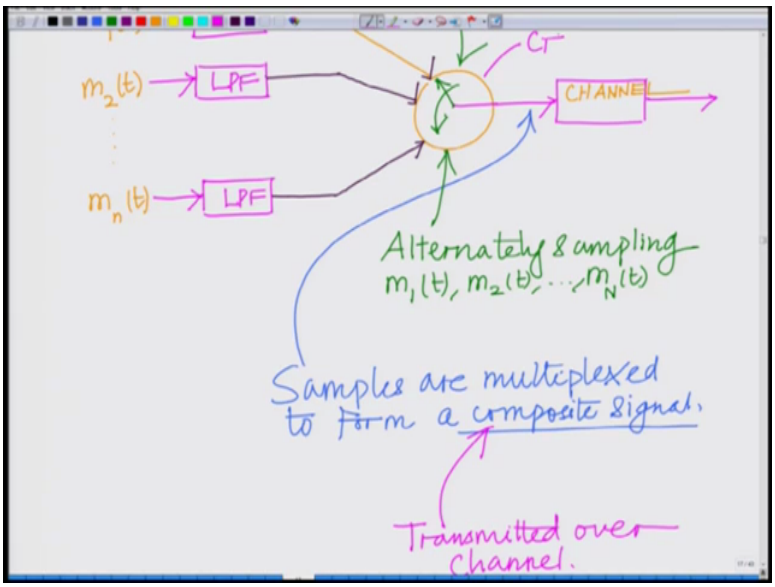

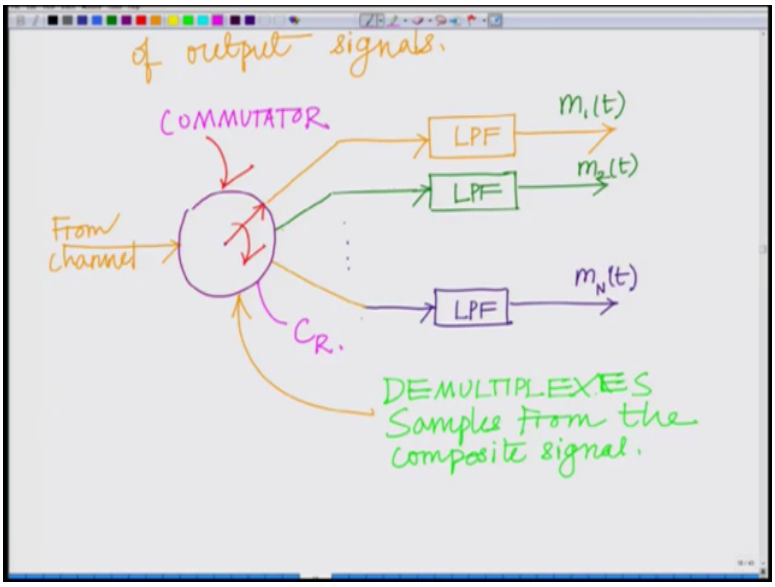

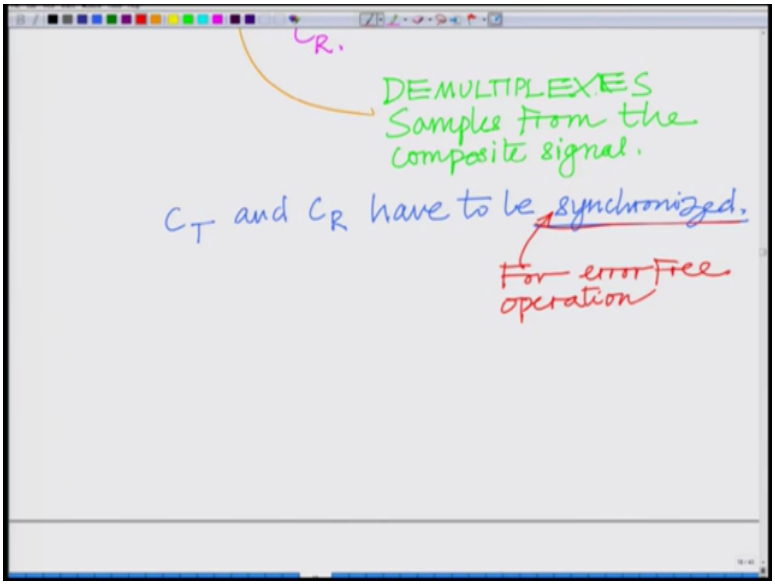

So these commutators because the switching frequency alright so we have to have CT is the commutator the transmitter and if we call this as CR notice that CT and CR have to be both synchronized CT and CR have to be synchronized. For example ok so this CT and CR have to be synchronized for well for error free operation, let us call it that way because otherwise for error free operation alright they are not synchronized then what you reconstruct the reconstructed signals will not be similar to the transmitted signals, ok.

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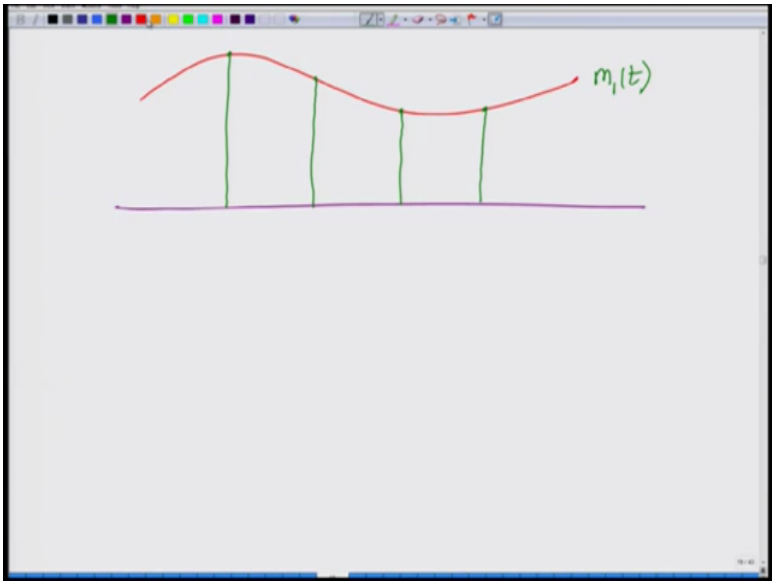

So let us took a take a simple example a pictorial example of this Time Division Multiplexing operation alright so it is let us look at a simple example of this Time Division Multiplexing operation ok. For instance I have one signal that looks like this it samples so this is your m1(t), ok these are the samples.

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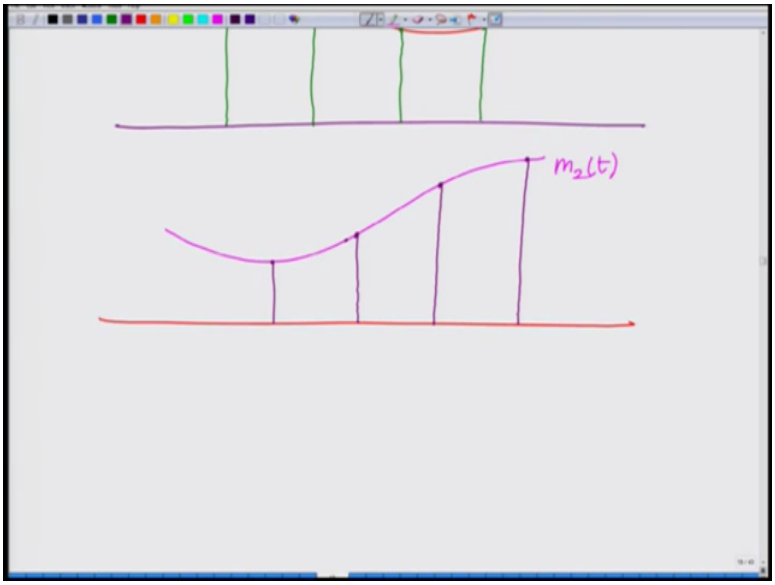

And let us say we have another signal m2(t) now remember the sampling instance of m2(t) have to between be between those of m1(t) because we have a commutator which is sampling let us say m1(t) followed by m2(t) and alternately repeating this procedure so we have the samples of m2(t), these are the samples of m2(t).

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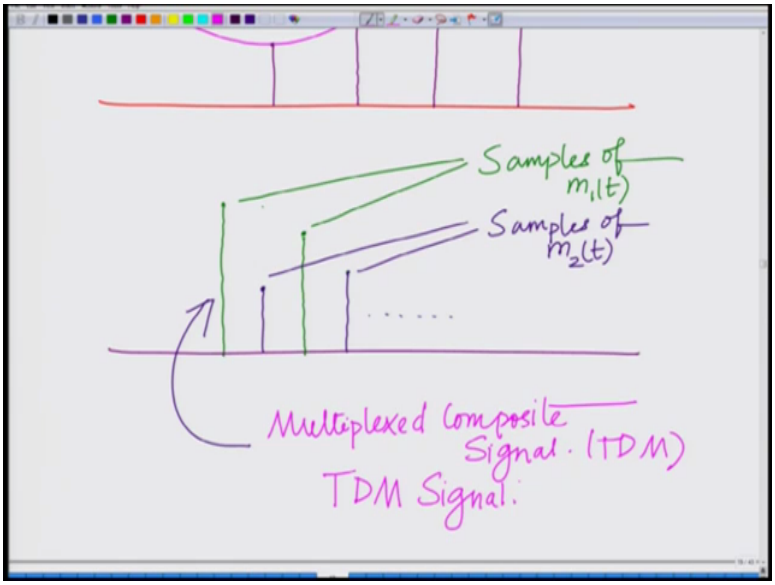

So what we are going to have over here are basically if you look at this what we are going to have is we are going to have a sample of m1(t) correct we are going to have the first sample of m1(t) followed by the sample of m2(t) correct. So this will be followed by the sample of m2(t) then we will have another sample of we will have another sample of well m1(t) followed by another sample of m2(t) and this will proceed so on and so forth.

So we have a Time Division Multiplexing operation correct so these are samples of m1(t), these are the samples of m2(t) and this is your multiplexed composite signal. This is the multiplexed composite signal this is your Time Division Multiplexing this is the TDM signal basically correct this is the TDM signal that is you are sampling alternately sampling to signals and you are multiplexing them in the Time domain by taking the taking alternatively taking samples from each of the signals to be multiplexed alright.

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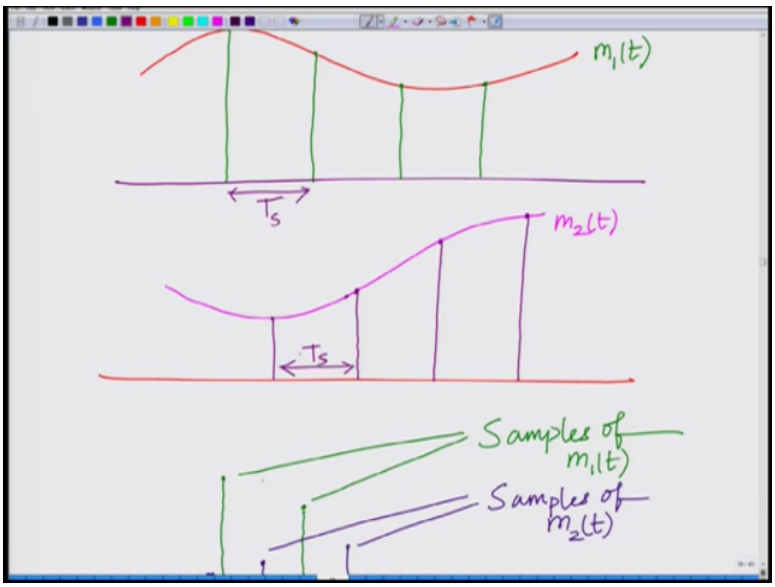

And you will also observe that if these sampling durations now if you look at this if this sampling duration is TS let us say both of them have equal sampling duration TS.

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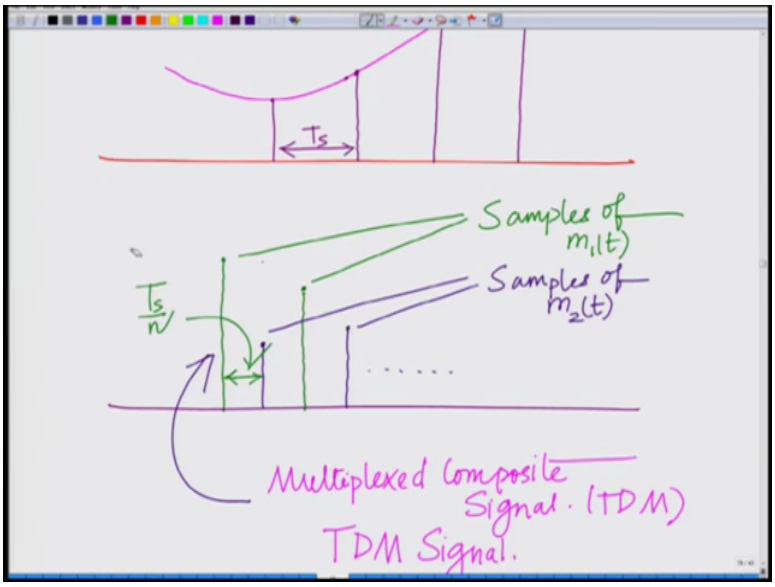

Then in TS if N signals are sampled well you have N samples for each TS duration therefore the duration between these samples of the composite signal is well TS divided by N, in this case it is TS divided by 2.

So the samples between the signal correct, so because in each sampling the interval TS you are sampling you are generating N samples right, one sample each from the sampled signal the duration between the samples correct the duration between the samples in the Time

division Multiplex signal is TS by N where N is the number of samples alright so let us also note this.

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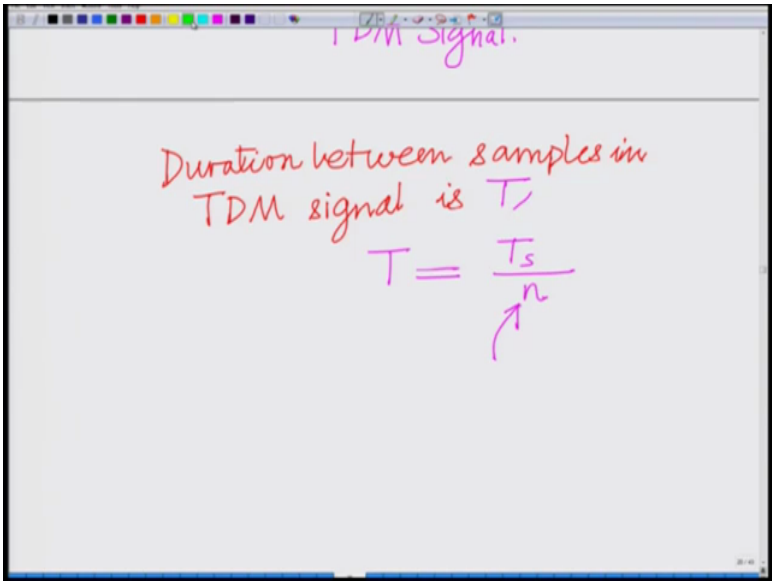

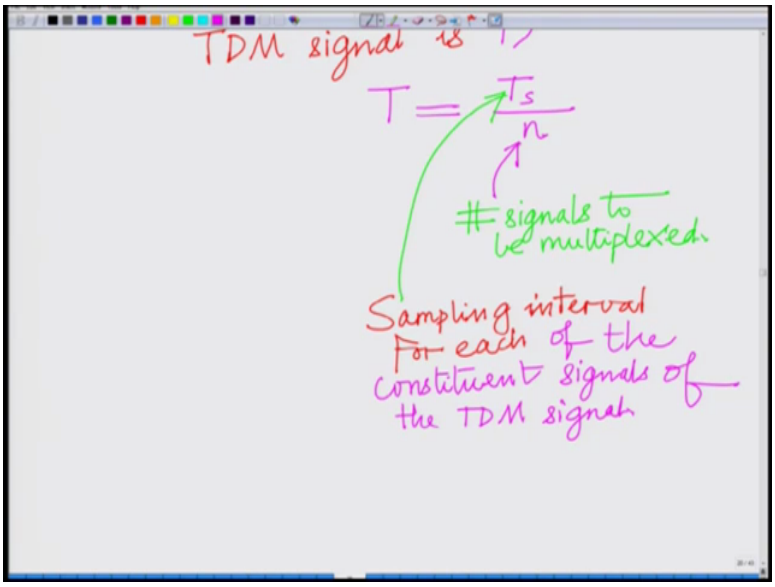

So duration between samples is T where T equals TS by n, so this is the duration between samples n we have noted is the number of signals to be multiplexed and TS is the sampling duration TS is the sampling interval TS is the sampling interval for each let us right this sampling interval for each individual signal or each of the constituent signals in the TDM signal each of the each of the constituent signals of the TDM signal, ok.

So the sample the spacing between the samples consecutive samples of the TDM signal is TS by n, where n is the total number of samples alright. And Time Division Multiplexing has

wide applications Time Division Multiplexing used in telephony that is telephone communication systems, it is used in telemetry, it is used in data processing systems alright.

So Time Division Multiplexing has wide applicability because of its simplicity right, it is simpler in comparison to for instance a Frequency Division Multiplexing system for instance even the cellular standards such as GSM correct right. The global system for mobile communication which is the 2G wireless communication standard also uses TDM, where the users of the different where the signals of the different users are multiplexed in the time domain, alright. So TDM has wide spread applicability, ok.

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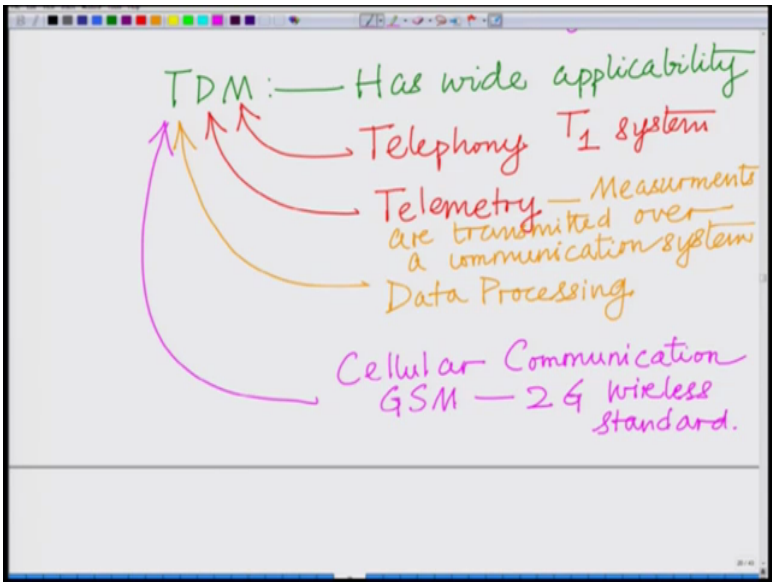

So TDM which is Time Division Multiplexing of the signals this has wide this has wide applicability, this is used in telephony, ok. For instance we will see later this is used in a T1 system where a large number of signals are multiplexed on a channel, this is used in telemetry this is used in telemetry, it is used in well telemetry is basically where measurements are transmitted over a over a where measurements are transmitted over a communication system, this is used in data processing, this is also used as we have said in cellular communications for instance GSM for instance GSM which is a 2D which is a 2D wireless standard. So this has a large number of applications.

So TDM Time Division Multiplexing has a lot of alright key technology and has a lot of applications in a variety of communication systems communication data processing right data transmission telemetry, correct telephony landline telephony systems correct, PSTN Public

Switch Telephone Networks so on and also cellular networks that is your GSM which is a 2D wireless communication.

So it has a several applications that is a very popular technology because of its lower implementation complexity and which makes it well suited for application which makes it well suited for wide appeared applicability in communication system alright. So we will stop here and continue with other aspects in the subsequent modules, thank you very much.