

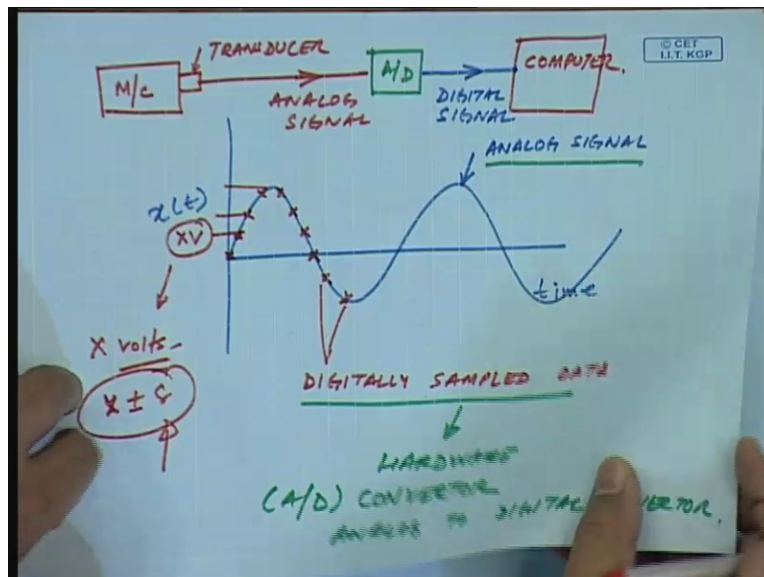
Machinery Fault Diagnosis and Signal Processing
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Lecture -10
Computer Aided Data Acquisition

Today's lecture is on Computer aided Data Acquisition. As you know, in the last class, we saw to analyze and signal, we particularly for the frequency domain analysis, we need to know the signal mathematically by a function $y(t)$, $x(t)$ whatever be it. But the problem is it not or no real world signal. We can represent it in mathematics or in a mathematical expression or equation.

So, we need to capture this real-world signal into the computer so that digital approximation of these analog signals can be made and then, we can do the analysis. We will come to the analysis later on. But today, let us discuss mostly about what this computer related data acquisition is.

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For example, this is my real analog signal, which is measured by a transducer, okay. The objective is like you plot graph, in excel, etcetera. Suppose, I sample these points marked in red and so on and if I join these red points, I will get back my original analog signal, right. But these are my digital sample data.

So, if I lay down this digital sampling data successfully, one or the other and join them, I should get my analog signal. All of you must understand that. But the question is who is doing this sampling? So, this sampling is done by a hardware which is actually known as an A to D converter, an analog to digital converter.

In this class, we will not focus on the electronics of the analog to digital converter. That is from for our friends from the electronics department to wander about. But let us see, how we can or rather what are the features of this A to D converter. And how we can use it to successfully represent the analog signal which was measured by a transducer because if I was to draw back your attention, we have a machine because as you will realize our primary objective in this course, is to find out the health of this machine.

So, on this machine if I put a transducer, I will get an analog signal. And to do any analysis on this analog signal, I have to have a computer. But this computer does not understand analog signal. So, it has to be given digital signal. But digitalize signal I mean such digitally sampled data. So, this is where my A to D converter comes in, okay.

So, now, I am interested in what is this conversion, how is this conversion is happening, what are the features of this converter, what are the properties we should have in this converter and what could be the possible errors, while we were sampling this data, because my computer would like to get the data, which is actually measured by the transducer.

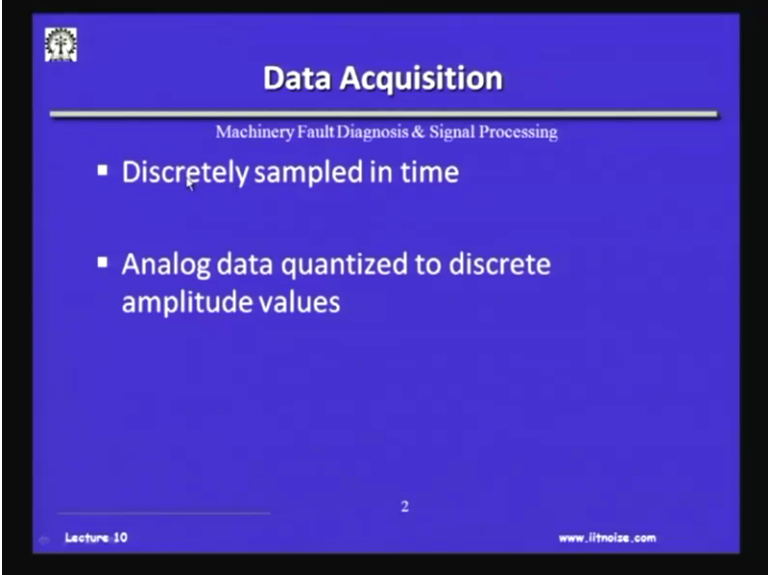
A to D converter is just a device, which is helping me to convert the analog signal to the digital signal. I would not like this A to D converter to distort the signal in any way, okay. Otherwise, you know, I will not have a true representation of my machine, okay. Now, with this, object is, let us see what possibility going wrong in this A to D converter. One you will realize is this sample data and the rate at which I am sampling the data.

Another is what kind of values I am giving to this data. Suppose, this was some say X volts in the analog signal. I want this data and the digital also to correspond to X amount of volts. It

should not be X plus, X plus minus some Δ . It should not be. So, then, this is the error in the amplitude estimation I should be almost equal to X .

But then, you will see there are the limitations that I will never be equal to the real analog signal, the amplitude of the analog signal; unless I do something. And that is what we are going to discuss primarily in this A to D converter.

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Data Acquisition

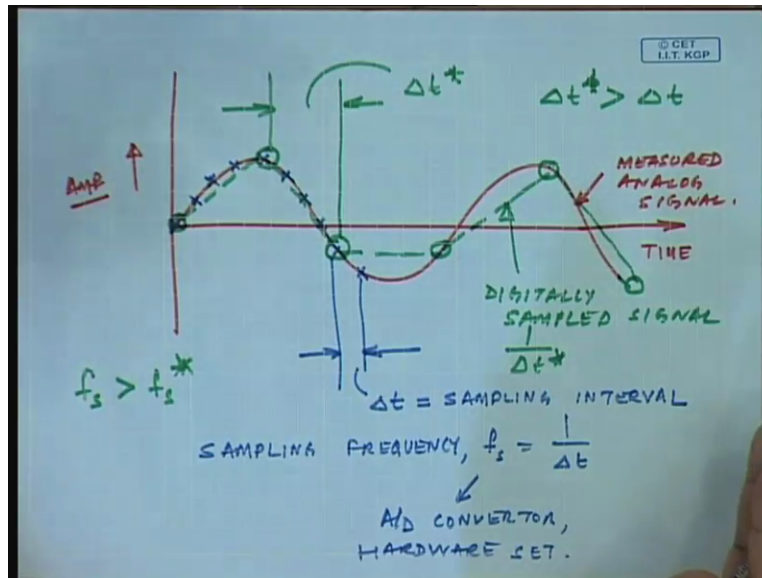
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- Discretely sampled in time
- Analog data quantized to discrete amplitude values

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So, two things you will keep in mind, while doing this data acquisition. And these are the most two important features of a data acquisition system. One is the discretely sampled in time and another the analog data quantized to discrete amplitude values.

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Suppose, I take my signal and then I sampled it. Once here, once here and so on, where this interval is fixed, and this is denoted by Δt and this is known as the sampling interval. Inverse of this sampling interval is known as the sampling frequency, denoted by f_s which is the reciprocal of the sampling interval. And this is in the time domain and this is the amplitude.

We will come to the amplitude later. But suppose, and this sampling interval is fixed by the A/D converter and it is hardware set. That means, I cannot change this f_s at will, when I go to the market to buy an A/D converter, it will come with a maximum sampling frequency. Now, it is, it so happens that my sampling frequency of the A/D converter is such that I once sampled here, shown by the green circle; another here, another here, here, so on.

So, my computer will and they are fixed at some other new interval, say, this interval now is Δt^* where Δt^* is greater than Δt , okay. So, this is a higher sampling interval shown by the green circles. Now, if I ask my computer to understand what the original analog red signal is. This is my, I will put it as, measured analog signal.

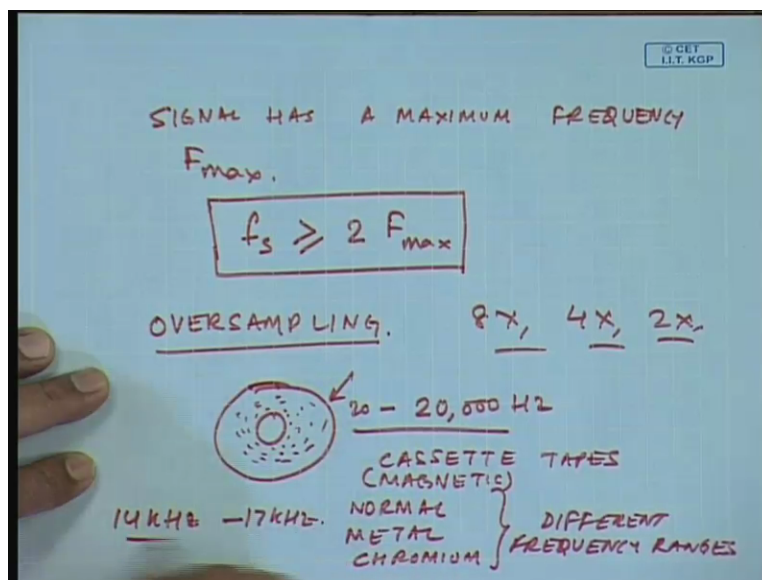
So, what my computer is going to understand is, you know, it is going to assume that there is no other data points between these two successive green samples. And thus, the computer will interpret the original measured signal, analog signal shown in red, by this green signal. This is

my digitally sampled signal at a rate of $1/\Delta t$. So that means, the original blue had shown with Δt it had a sampling rate f_s .

And the new one is at a sampling rate much lesser than f_s , f_s is greater than f^* . So, you see here that obviously, this sampling interval or sampling frequency plays a role in the representation of the actual measured analog signal. If my sampling frequency is less, I have a distorted green signal, okay.

And so if my computer will try to understand the red signal, or the green signal, I have a problem. I am not able to correctly or faithfully represent my original result or a red signal by having a sampling rate lower than the required amount of sampling, okay. So, we have to decide the higher the sampling rate, it is good. But then, there are limitations; later on, we will see.

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So, if such a process occurs, wherein if my signals frequency, signal has a maximum frequency of F_{max} , there is a theorem, which says that I should sample at the times, at least twice of F_{max} , so that this kind of errors are avoided. Errors in sampling are avoided. But now sometimes, people do over sampling. And the sample that not just twice F_{max} but on or 6 times, 8 times, 10 times over, over sampling is done.

You must have seen in the CD players etcetera, you know, it is written eight times over sampling; because see, what is the CD player? A CD player, you know, I will just relate to you this. Because we have in a CD, ok. The data's are set by, you know, if you look at a CD very closely, there are a lot of bits, okay. And which is read by an optical light because of the reflections of the optical light and pulse will be obtained.

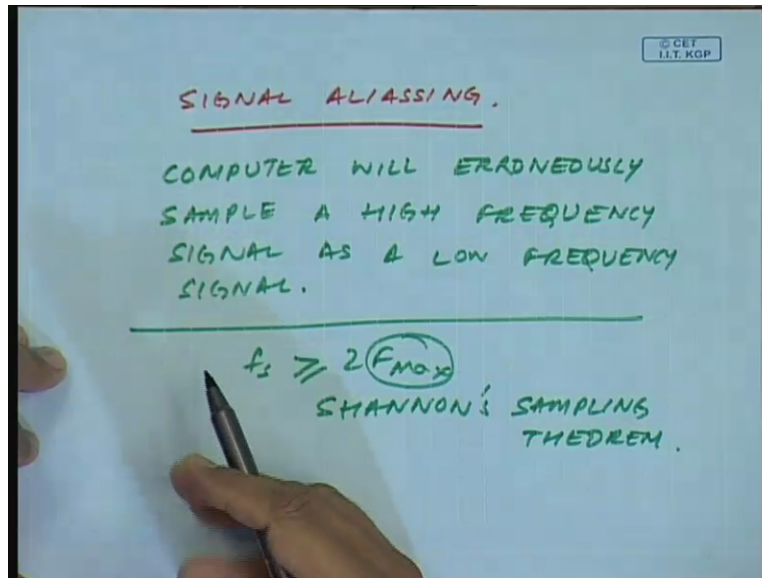
And then we will be having ones and zeros and this sampling here, because our human audio arranges 20 to 20,000 Hertz. So, if my maximum frequency of interest is 20,000 Hertz, I should at least sample it at 40000 Hertz and so on. But sometimes, the sample is at 44, 98 kilohertz, okay and so on. So, they are doing some amount of over sampling, okay and because the original signal is 20 kilohertz and that has been reproduced.

We have a better fidelity or frequency response from CD players than the original tape cassettes, because of these reasons. With the full frequency range of the audio signal, is reproduced in a CD okay as opposed to the earlier tape. You must have seen there are there is to be cassette tapes or magnetic, is the right word wherein you had normal bias, metal bias, on my VF they call that chromium bias, etcetera.

They all had different frequency ranges and typically they were anywhere from 14 kilo Hertz to about 17 kilo Hertz, okay; metal being the highest. But with the cassette tapes and magnetic tapes, came in the CDs and CDs we can faithfulness total 20, 20 kilohertz. And then, he can sample this data digitally and then, get a very good reproduction of the high frequencies.

And so that, you know, in a CD when you listen to a guitar or a string instrument, you will hear it, to be much clearer and pleasant than in a cassette. It is because the high frequencies are reproduced in a much better way in a CD. So, that all relates to the sampling frequency.

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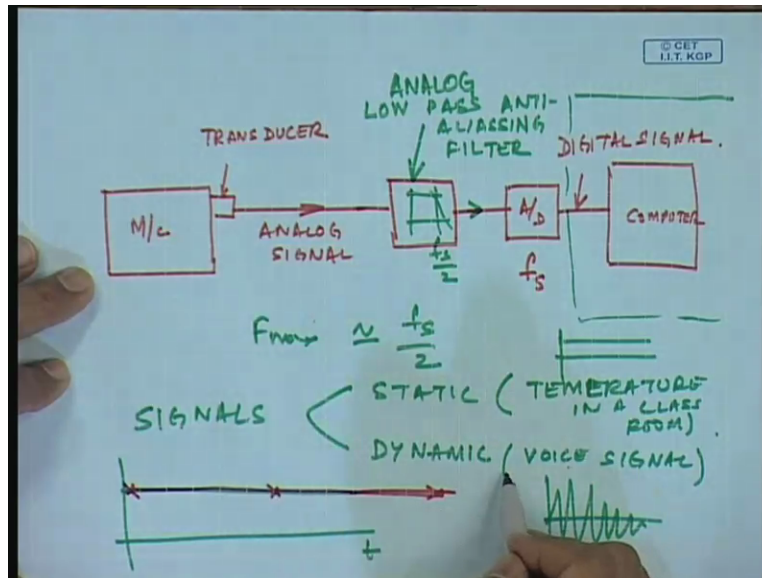


But coming back to our machines so if my sampling frequency is not adequate I will have what is known as this signal aliasing; because in Signal Aliassing what happens, the computer will erroneously sample a high frequency signal as a low frequency signal, okay. I will go back to the previous example or the figure which I had drawn. If you look here, the original yellow see green, sorry, red signal will be misunderstood as a low frequency signal.

If your sampling is not adequate. And then, the FFT will have lot of low frequency peaks in the frequency domain. So, this has to be avoided. I mean, we will be thinking that sampling frequency whatever the computer has obtained by this sampling is correct. But that cannot be true. So, to ensure that the sampling theorem is obeyed, okay we have to do certain things.

For example, I do not know F_{max} , why because, I am measuring this from a machine; I have not analyzed the signal. So, I would not know what F_{max} is. So, for an unknown machine, how do I ensure that the Signal Aliassing is not occurring, while I am sampling through an A to D converter. So, we have to do a little hardware modifications to this.

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In the sense, this is my machine, I have put my transducer. I am having this analog signal and then I am having my A to D converter. And then, I am having digital signal computer, where all this data is being stored and analyzed. This is my digital signal, now this A to D has a maximum sampling frequency of f_s . So, how do I ensure that any signal which is coming on to the AD card, or AD device is not going to have a aliasing problem.

If I can ensure that the signal coming in here has a maximum frequency of f_s by 2, I am going to ensure that f_s is always greater than equal to twice of F_{max} . So, if I limit my f_{max} to f_s by 2, I will then obey the sampling theorem. So, what I will do is here, very important is, I will put an analog because this is an analogue domain; a digital only happens here after the A to D converter.

So, I will have analog low pass, known as an anti aliasing filter where this is your cutoff, f_s by 2. So, there are many A to D devices wherein, in the front end before the A to D conversion, we will have an analog low pass and aliasing filter so that the Shannon sampling theorem is obeyed and I will not have any aliasing problem. So, not all A to D cards or A to D devices come with anti aliasing filter, because I will tell you, regarding the signal, you know, could be a static, could be dynamic.

We will take static signals as to mathematically, that means they are not fluctuating or changing with time. For example, temperature in this room that is almost a constant with time. Now the

entire duration of the class, this temperature is almost a constant. So, this can be an example of temperature in a classroom. It is almost not a time varying signal, okay. For example, dynamic; while I am speaking, my voice signal some time that is I am speaking, sometimes I am speaking louder, sometimes I am pausing.

So, it is changing with time and this is almost a constant. So, one is a DC signal or a static signal and that is the dynamic signal. So, if a DC signal, I am passing through and I want to do a sampling process, you see the CFA. This is my DC signal I can sample it here, I can sample it here, I can sample it at much lower rates. But the signal is not going to change, is it not?

Because it is a DC signal. So, temperature signals need not have a low pass anti aliasing filter unless, of course, the process is such that the temperature is changing very fast, the pressure is changing very fast. For example, the combustion pressure in an engine, inside an engine it is fluctuating. Those are dynamic signals, vibration signals, and noise signals.

So, in, in such dynamic signals have to be careful that the aliasing is avoided and I need to have a low-pass anti aliasing filter. So, whenever we are talking about machinery condition monitoring, where we are you going to use vibration signals as a monitoring parameter, we would be mostly dealing with dynamic signals.

And then, thus, we need to have a low pass anti aliasing filter. And another thumb rule I should tell you right now, while we are getting into machinery condition monitoring and signal analysis.

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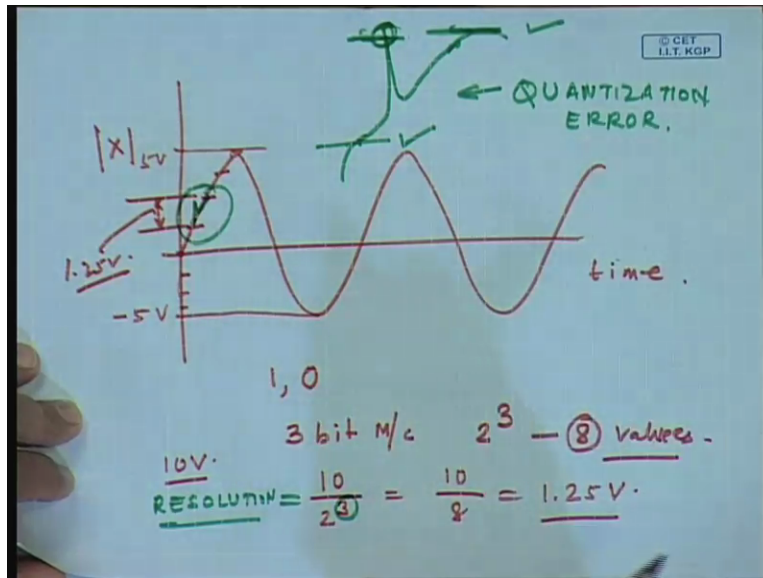
	<u>F_{max}</u>	
IC ENGINES	—	<u>5000 Hz</u>
AUDIO SIGNAL	—	20,000 Hz
ULTRASONICS	—	2 MHz
TEMPERATURE	—	LOW FREQUENCY
GEAR BOXES/PUMPS BRGS	—	<u>5000 Hz</u>
	f_s	SAMPLING FREQUENCY

For example, in IC engines because as an engineer, if we do not have an estimate of F_{max} , we may not be having a clue as to what sort of sampling frequency I should select in my A to D card IC Engines. We know, we are good enough if the maximum frequencies are up to 5000 Hertz. If I would not do, any analyze, any audio signals, it will up to 20,000 Hertz, okay. I want to analyze any ultrasonic's for machines, they can go up to know 1 to 2 megahertz.

I am talking about, you know, very set temperature signals; low frequency almost constant, okay. So, these kinds of, say for example, gearboxes, pumps, etcetera, bearings, we are good up to 5,000 Hertz, I would say, ok. So, these are typical F_{max} of signals. So, when I am going to analyze the signals, I know that this is the level or amount of F_{max} which possibly could be there in the signal.

So, I can then decide on the hardware, which will decide on the sampling frequency, ok. So, I hope I am clear on this regarding how to avoid the aliasing by having a low pass anti aliasing filter. And the problem of, if you have an aliasing, signal will be misrepresented as a low frequency signal. But this is what we have talked about the x-axis.

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There is another issue to this data acquisition.

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Data Acquisition

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- Discretely sampled in time
- Analog data quantized to discrete amplitude values

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And this is this analog data which is quantized it has to have a discrete amplitude value. So, what kind of value do I give to the data which has been sampled? For example, this is my sample. This is my signal weather. And this has certain amplitude X, okay. Now as you know in computer data's are stored either as ones or zeros, okay. And say for example, if it is a three bit machine, it can possibly have 2 to the power 3 combinations of ones and zeros, okay.

And then, this gives a maximum eight values. So, that means a three bit machine, of course, you know, this is an, no machine is three bit. Nowadays, but it is, it to begin with if the three bit

machine the possible values this data can be stored are only eight, okay. So, let us assume that this is -5 volt; this is 5 volt so the entire range is 10 volts, okay.

So, this data can only be broken up into 10 by 2 to the power 3, 10 by 8, this is close to 1.25 volts. That means, if this data is there, the computer maybe, I will put 4 values here and so on. It can have a zero value as well, okay. So, this will only understand a difference of 1.25 volts, okay. But, say for example, in my signal because of some operation, my machine had a small kink here. Let me enlarge this value here. Suppose, in a signal, I had this value here.

Now, I will not understand this is one level the computer recognizes, this is another level, then, the next level the computer; it does not understand where I will put it; whether I will put it here. And there is some intermediate value, this is some intermediate value. So, either the computer will put it here or put it here. So, it is going to lose the amplitude sensed by the machine, okay. Now, how could this be improved? And this is actually known as the resolution.

This can obviously be increased by, if I increase the bit size of the hardware. So, this kind of error is actually known as the quantization error, okay.

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Handwritten notes on a whiteboard showing calculations for quantization resolution. The notes include the formula $\frac{10}{2^n}$, a list of values for $n=12, 16, 32, 64$, and a calculation for $n=3$ resulting in $1.25V$ resolution.

Top left: $\frac{10}{2^n}$

Top right: $n = 12 \text{ bit}$
 $= 16 \text{ ''}$
 $= 32 \text{ ''}$
 $= 64 \text{ ''}$

Center: $\frac{\text{Range}}{2^n}$

Bottom left: 3 mV (circled)

Bottom right: $\frac{10}{2^3} = 1.25V$
 $0V, 1.25V, 2.50V, \dots$

And this can be avoided by, obviously if I 2th power n , n could be 12 and could be 16, could be 32, could be 64 and so on. So, the resolution of a 64 bit, A to D hardware will be much lesser,

much finer, than a three bit or a four bit or a 16 bit machine, okay; because there are more levels like, when you draw a graph, you know, if you want to draw a crude graph, you have large boxes for if you draw a very fine graph, your division reduces.

Then, you can capture all this transients which are occurring. So, if we can have the bit size increased, I can sense any small variations, okay. And the least value, the computer can sense depends on the maximum range by 2^{th} to the power n . I can reduce the range or I can increase the bit size, for example, typically, when we are dealing with thermocouples.

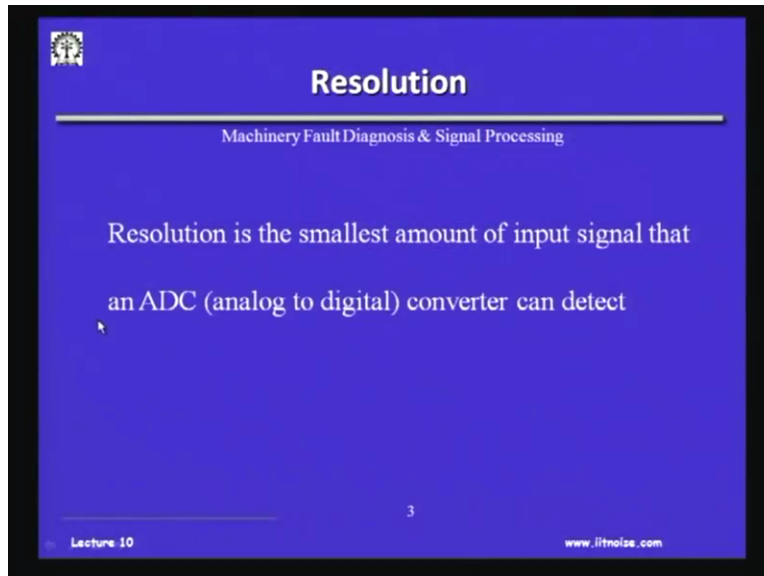
Thermocouples give signal in the range of milli volts. So, if I have a hardware having a resolution of 1.25 volts, so that means, it senses zero volts, it will sense 1.25, then, 2.50 volts and so on. So, I can possibly not sense; Suppose, I have a signal of three milli volts, this cannot be sensed by certain A to D device.

Either I have to increase the bit size or I have to amplify this, this signal. Amplification means also you are amplifying the noise, so a lot of signal to noise ratio will decrease. And then, they will be noise in the signal or the best way is to increase the bit size. And thus about the quantization error, okay; because every data point in your signal should be mapped to a discrete sample value.

That is what I am saying. Analog data quantized to discrete amplitude values; because there are no two data points which are distinct in the analog signals should have the same digital values. Then, the whole purpose of bringing A to D conversion is not done, okay. So, no two analog signal values should have the same discretized digital data that has to be avoided. How can I avoid that? By having more bit size.

So, you would have heard of, you know, 32-bit computers or 64-bit computers are much, much costlier than the 12 bit computers; because the accuracy the resolution is much, much finer in such systems. And because of this reason, so, if I also define the resolution.

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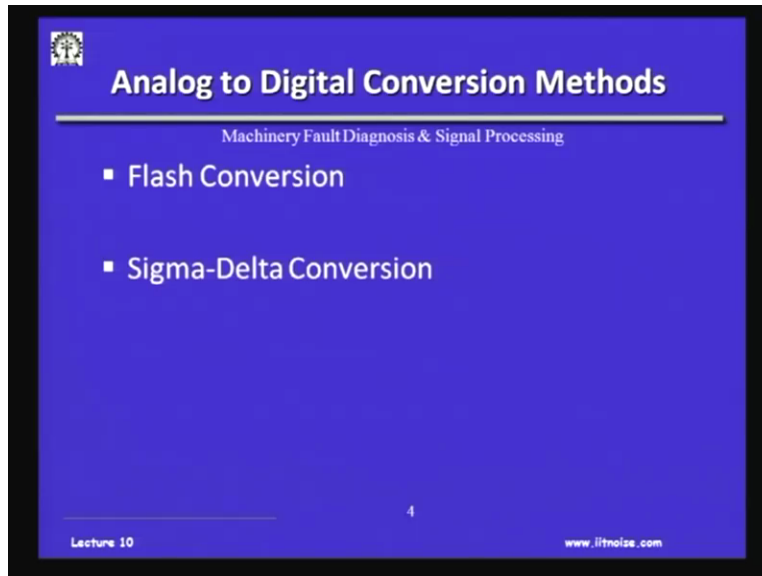


So, resolution is the smallest amount of input signal that an analog to digital converter can detect. Input maximum voltage of 10 volts, distance, a 3 bit computer can only detect 1.25 volts. And I am sure you can calculate for the other bit sizes, as well. So, the higher the bit size, the lower will be the resolution and I will be very accurately detecting this small amount of signal inputs, ok; a smaller amount of input signal, fine.

So, with these two important aspects of A to D converter, in fact these are the two most important, I would say features or properties of an A to D converter. One is the sampling frequency; another is the resolution, okay; because you know wrong sampling frequency leads to signal aliasing. Inadequate resolution leads to quantization error, the error in quantifying the real data.

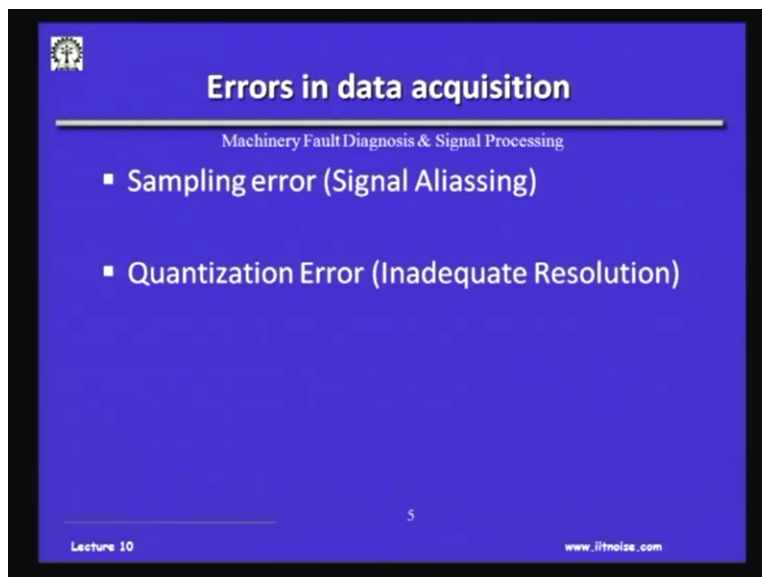
So, these two errors have to be avoided while we are doing the A to D process. When I go to the market today to buy, hardware manufacturer will tell me the bit size and all so the sampling frequency. So, knowing my application what my f_{max} is, what my voltage levels are, I can say you know, well this suffice or not. I am sure with this knowledge you all can go to the market and buy A to D devices for your system.

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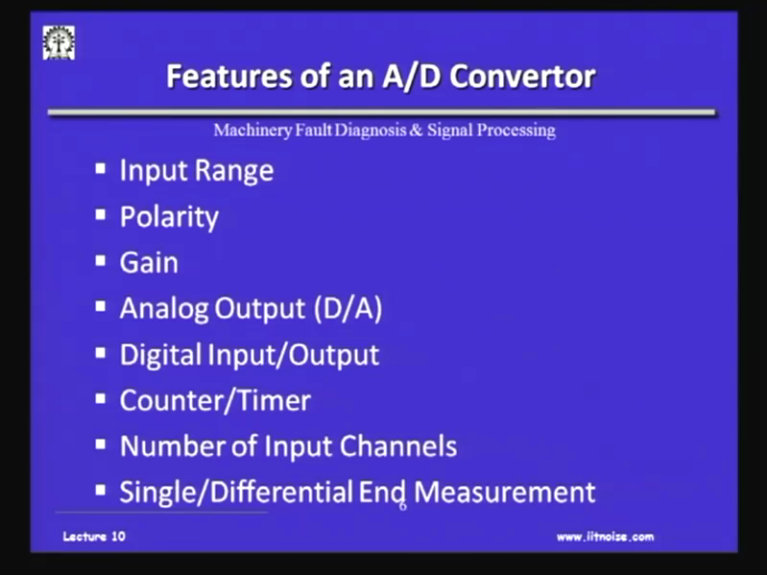
Well, what is the process of doing A to D conversion method? There are two popular conversion methods. One is the flash conversion and other is a sigma delta conversion. In this course, I will not be going into the details of how the A to D process is done inside the card. But it is suffice; it will suffice to say that this sigma delta conversion is the most popular A to D converter cards available in the market.

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And we can now, see what are the other features which are available in this A to D cards. And we have discussed about these errors. Errors in data acquisition, which we have to avoid: Sampling error, because of which will need to signal aliassing because of inadequate sampling frequency. Another is the quantization error because of inadequate resolution.

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Features of an A/D Converter

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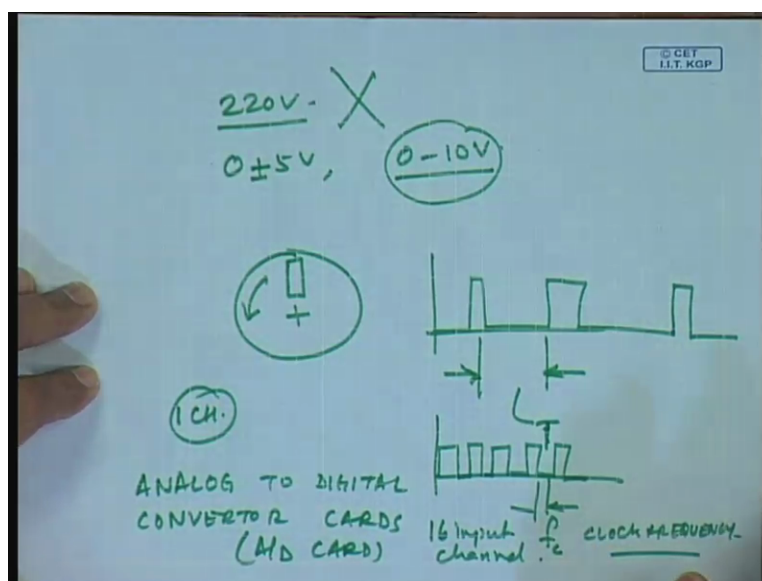
- Input Range
- Polarity
- Gain
- Analog Output (D/A)
- Digital Input/Output
- Counter/Timer
- Number of Input Channels
- Single/Differential End Measurement

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So, what are these features of an A to D converter because we need to do the features of an A to D converter, so that we can have the proper specification of the A to D card to be used in our machineries so that we can very faithfully collect the analog data? And then do the analysis and do the interpretation about the machine's health.

First is this input range, usually, in this A to D converters because the data has to finally go to the computers. We obviously cannot have a 220 volt input to the A to D card, okay.

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So, maximum are about, you know, from the TTL logical circuits, maximum about 0 to 5 volts or if it is 0 to plus -5, or maybe 0 to 10 volts. So, no matter what your signal is, it cannot have a maximum voltage of 10 volts; so that means, it cannot straight away again your 220 volts AC line to your data acquisition card. You will fry the card, okay; that should not happen.

So, the maximum limit is 0 to 10 volts which is to be fed to the card, it could be bipolar or Unipolar. That means, by unipolar, I mean, 0 to 10 volts in the positive side. Bipolar means it could be minus to plus this input range. Sometimes, as I was telling you, the example of a thermocouple, the signal levels are so low that they need to be amplified before even doing the A to D conversion.

So, some of these cards can have an A to D, sorry you can have an amplifier, which where we can set the gain so that we can increase the voltage, okay. Next is, some of these cards, you know, nowadays, come as a combo pack. It is not just A to D conversion, but also sometimes we to do, digital to analog conversion. Also because sometimes and some of the particularly not in machinery condition monitoring.

But particularly in controls wherein I have to have a control algorithm sitting on my computer. And this algorithm wants to drive a mechanical actuator. I need to give an analog signal to the relay or to the actuator so that, it can operate. So, such a card sometimes also has an option of having an analog output through a digital to analog converter, just the reverse. Sometimes we need to communicate between many cards or between many computers.

So the, the communication inside a computer is always digital. So, we, it should have a provision to have what is known as a digital input and digital output provision sometimes the computer or device, particularly a rotary encoder or a trigger or a rotated triggering mechanism. Suppose, I am, these are shafts, which are rotating; and every rotation I am getting a pulse. If I know the relative distance in time, this time is known to me.

I can find out by the universe of time, what the speed of this relative machinery is. But who gives me the sense of the relative time? So, I need to have a clock or a counter, okay which will give

me a pulse. I know this is my pulse cycle. And this has a definite clock frequency. So, I can compare with this clock rate with the pulse actually measured. And then, say, was relative to this clock. What is this gain speed? So, this clock is given by an A to D which has a counter or a timer, okay.

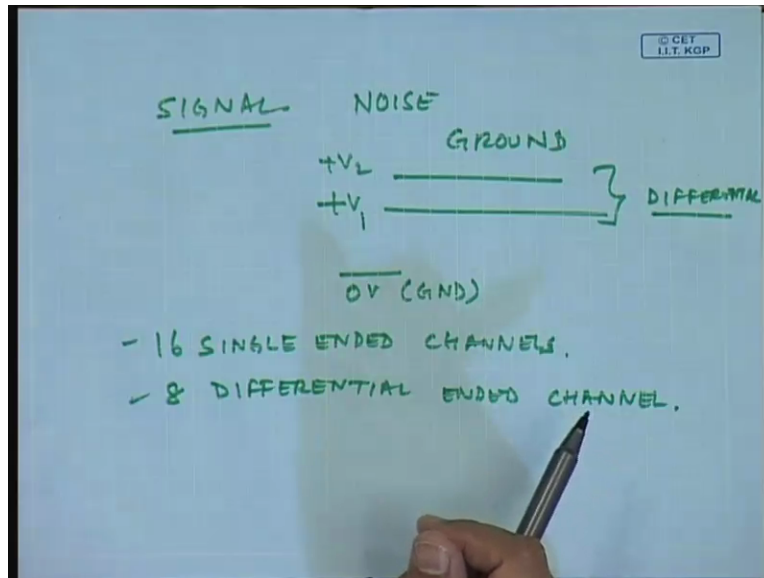
And these are very high frequency clocks, when we talk about measuring and using rotary encoders to capture phenomena from mechanical machines. I will go into details on this then. And this A to D conversion need not be just for one channel. For example, if I am talking about the machinery, okay I need, you know, and it may be a multi stage gearbox there are just not one bearing; there are many bearings.

And this vibration is not just in one direction. There are the, at least in three directions. So, if I want to capture all the phenomena together simultaneously, I need to have just not one analog input channel but multiple analog input channels. Nowadays this A 2 D devices come as what is known as analog to digital converter cards or you know call them as A 2 D card. And they are very similar to look like, you are in your PC like your multimedia card like the Ethernet card, ok.

So, this card actually plugs into the bus of the computer and then, these cards typically, cards are available with 16 input channels. With few digital to analog output channels, couple of clock channels, some giving a voltage signal. A 5 volt supply, some having ground, etcetera. So, this cards, now, you can understand, it is the size of about, you know, maybe a 6 inches to 2 or 2 and 1/2 inches in width. And such cards will fit into these architectures of the bus lots of the pc.

And then, you can from the external volts, you can plug in wires which are carrying the analog signals into the A to D card and then after the conversion, the digital data will be going in the computer bus. And then, the computer memory devices will have access to that and the control CPU will have access to such data.

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And another important aspect of these cards is whether the signal can have noise with respect to ground. So, one is a positive voltage signal, another is the zero voltage or the ground, okay. And then, we will have for all the signals. Suppose, this is channel 1, channel 2 and so on. There will be a common ground. So, this is known as a single ended input, okay. Suppose, there are sixteen single ended channels as inputs, there will be noisier than if I took channels.

Wherein I take one as V_1 , other as V_2 and take the difference and these are known as the differential channels. Then what happens? The noise which was there because of V_1 and V_2 , if you subtract them they noises will get separated. So, a differential ended input or 16 channel single ended channels will be converted to 8 differential ended channels. And thus the noise will be less, okay.

Because in the A to D conversion process, I should be also ensuring that I unnecessarily do not bring in a lot of conversion noise or measurement noise into my system, okay. So, this is a one feature which is also available in the A to D card.

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Features of an A/D Converter (Cont'd)

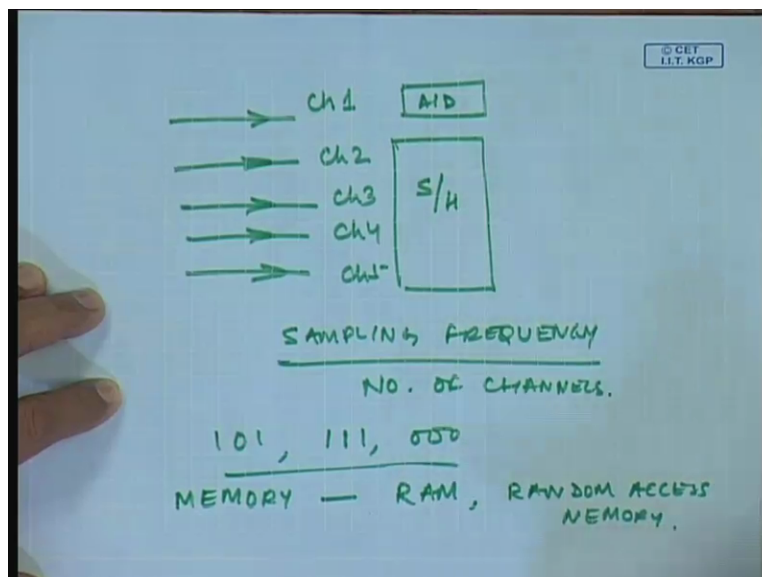
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- Multiplexing/Switching (Sample/Hold) Circuit
- Onboard Memory
- Separate ADC for each channel (Realtime)
- Triggering and Synchronization

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The other important feature is suppose, I am having in lot of signals, coming in. Suppose, when my signal is coming in. In channel 1, usually the inputs are known as channels and A to D conversion. I have few more signals coming in, in the remaining channels, okay.

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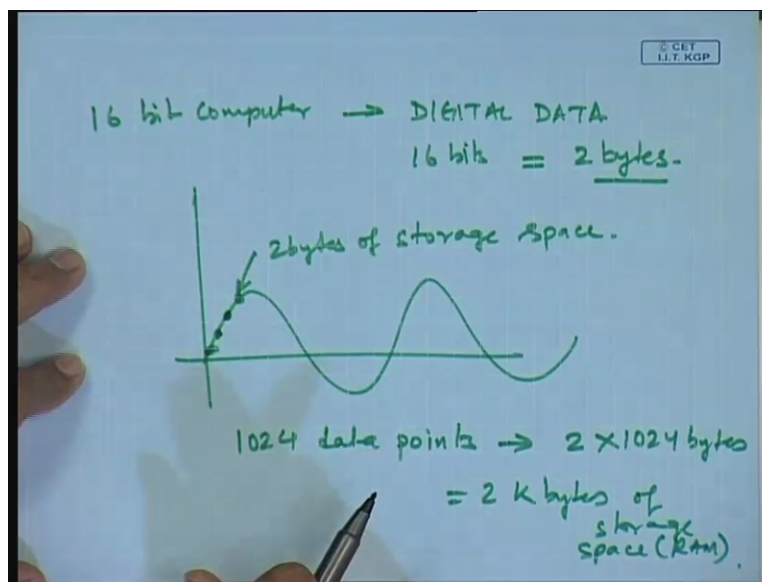


So, because the A to D conversion takes certain time, so, one, when I am doing the conversion of A to D for channel one, what is happening to the channel signals, in channels 2, 3, 4, and 5? So, they are put in, what is known as the sample and hold circuit, ok. And then, one by one, they will be, once channel one is done, it will go to channel 2, channel 3 and so on depending on each one sample by sample.

So, the effective sample rate per channel becomes the sampling frequency divided by the number of channels. And such a way of, method of holding this signal is known as the multiplexing or switching, okay. So, A/D cards have these multiplexers built-in. But, nowadays, there are cards wherein real time operations are there. There are individual A to D converters, for each channels, okay.

So, the every channel samples at the same frequency and we do not divide it by the number, number of channels, okay. But once this data has been obtained in digits, etcetera, this digital data needs to be stored in the computer. So, it should have some amount of memory which is usually a RAM memory because this should be reasonable. So, this is. And let us see, how much memory is required to store a given amount of data.

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For example, if I have a 16-bit computer, that means, every digital data which is obtained from the sampling process is of sixteen bits. That is 2 bytes. So, every data point, every data point requires 2 bytes of storage space, okay. Now, if I say, I require 1024 data points, so, it will require 2 in 1024 bytes so that is 2 kilobytes of storage space or RAM, ok.

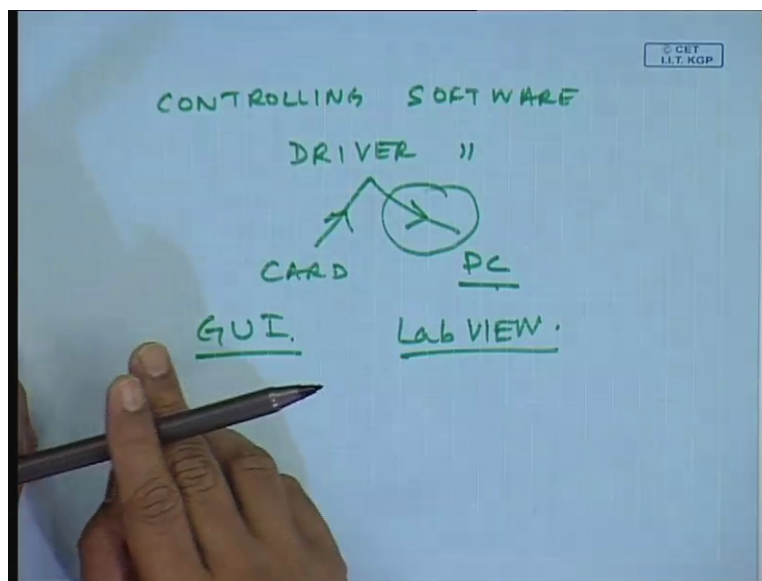
So, this, once these 2 kilobytes of space are used up, while if you are still going to do more A to D conversion, either it will overwrite or it will abort some process. Cards are available at 128 kilobytes, nowadays; cards are available with 2 megabytes storage space. Obviously, I am going

to gigabyte, of course, the more the storage space the more costlier, they will become and so on; because this is the amount of data which is stored on the memory of the A to D converter.

And this data can be also accessed by the CPU of the computer, in which this A to D card is placed, ok. And sometimes on the A to D converters also there are lot of signal processing chips available nowadays. We will come to that later on. But this is what you need to know. So, I need to specify the amount of RAM which is there on the, because once it is temporarily stored in the RAM.

Then, the computers architecture is going to pull this data out and store it in its hard disk, store it, in its computer RAM; this is very specific to the A to D card converters RAM, okay. And then, there is a provision for triggering and synchronization like when to start collecting the data. If I tell the A to D converter, it is usually through software because all this operations of an A to D card converter will be controlled by software.

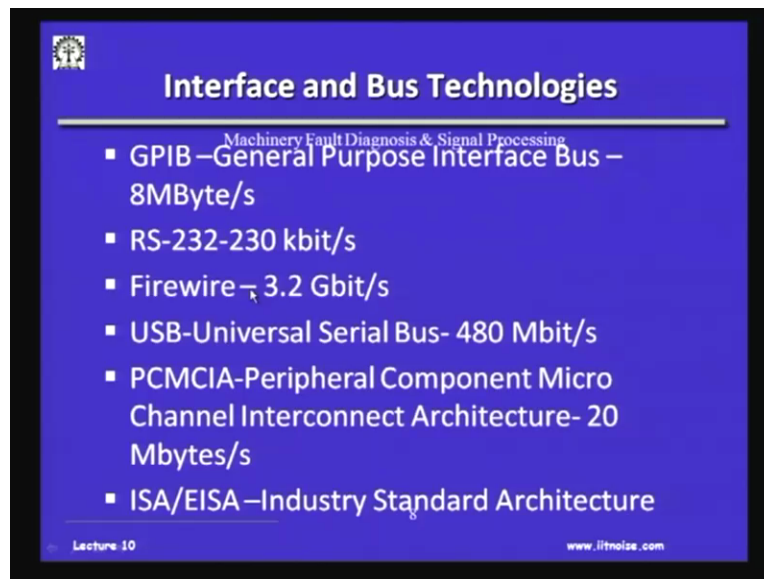
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So, there will be controlling software which is known as the driver software, which will communicate to the card and the PC, okay. And this software sits on the PC of the computer. So, all these operations can be done by a frontend GUI, ok. There are many such software's available in the market. One commonly is the Lab VIEW which is there from National Instruments, which is ,which we all use in the in our classes.

In our labs, to do measurements from using the direction cards, ok. So, once this data has been captured by A to D card stored in its RAM, it now needs to communicate to this PC, ok. The PC's or the personal computers have a particular set of architecture. And the speed at which if I can communicate is good enough, fast, then it is ok, because I would have sampled data stored it in my RAM. But I am not able to transfer it to the computer. Then, I have a problem.

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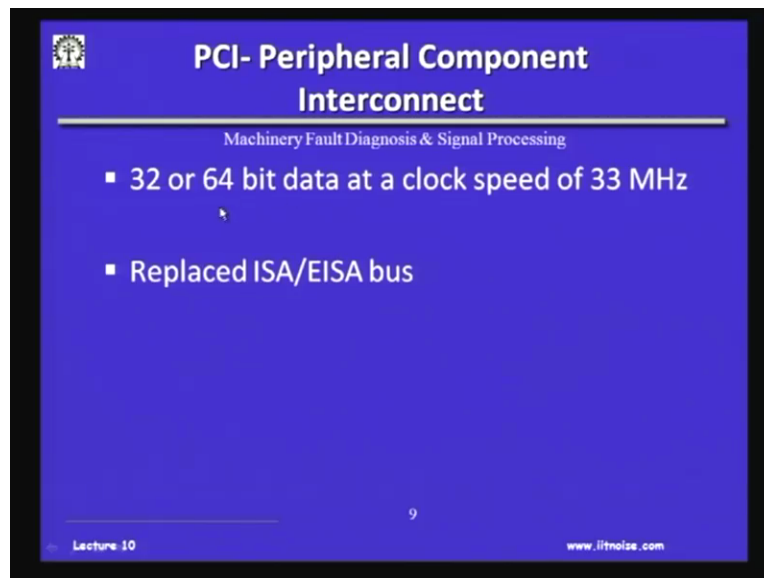
So, traditionally there have been many technologies for transferring this data. One is the GPIB is known as the general-purpose interface bus. And it used to have an 8 megabytes per second sampling rate. The traditional serial port communication RS-232, it has a much, much slower rate of data transfer; these are all digital data transfers. 230 kilobit per second, of course, recently, the Firewire, by particularly, you will see in all of this max, etcetera.

Very high speed transmission 3.2 gigabit per second. The USB serial bus so basically, these buses means, all these cards can come in these different architectures. And a USB is a plug-and-play architecture. And it has also a fairly high amount of data transfer rate that is 480 megabit per second. So, right now today we are using about Firewire and USB. There used to be the PCMCIA particularly, in the laptops, etcetera.

And of course, now, about a decade earlier, ISA, EISA, etcetera, they were very popular; but they have much much slower rate of data transfer. So, I need to have a high rate of data transfer and this is done through USB and Firewire at present concisely, regarding the communications, ok. So, as and when I go to the market to buy an A to D card because my objective is to transfer my real world machinery signal data which has been measured by a transducer in digital form quickly to my computer.

So, I would have done and my very nice conversion, but if I cannot transfer it to my PC, it is no good.

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And then, we have this PCI which is either 32 or 64-bit data, at a clock speed of 33 megahertz and this has been, this has replaced the ISA and EISA bus.

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Ethernet

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- Widely used for networks
- For communication between instruments and Computers
- Common transfer rates- 10 Mbits/s and 100 Mbits/s.
- CAT 5 cable for connecting devices upto 100 m.
- Wireless ethernet, IEEE 802.11 (54 Mbit/s within 20m)

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Of course, nowadays, the Ethernet are also being used for digital data communication between instruments, between networks, for communication. And they have the common transfer rates between 10 megabits per second to about 100 megabits per second. But there is a limitation by which we can have the data transfer at such high rates.

Particularly, if I am using this CAT 5 cable for connecting devices, we can have a maximum of 100 meters. But nowadays the technology is such that once this digital data has been captured at maybe a server location it needs to be transferred wirelessly. And the present limitations of wireless Ethernet are about 54 m megabit per second and within only 20 meters.

And beyond that the speed drastically decreases. So, I cannot have high data transfer, I mean, by data I mean digital data transfer at speeds higher than 54 megabits per second when I am doing an wireless Ethernet. So, this is a challenge which we have in computer aided data acquisition to transfer the data over the wireless at high speeds because the call of the day is to use, have wireless remote monitoring of machines. And this is where we are in the present state of the art.

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Network based data acquisition

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- Client/server model
- Local Area Network (LAN)
- HTML (Hypertext markup language)- to generate static web report
- FTP – To access large databases

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So, lots of network based data acquisitions are also available. The client-server model, local area network and all this data could be captured locally, put up an HTML base web based. And then people from the different client locations can access your server. Either to access the data on the databases; the data sizes are large; we have to have an FTP protocol to access these large databases.

So, the idea behind this computer aided data acquisition is not just to acquire the data at the machine and but also give it to the various clients. They could be sitting all over the world, over the internet, over the wireless and so on ok. Thank you.