Mechatronics
Prof. Pushparaj Mani Pathak
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 15
Data Presentation Systems

I welcome you all to today's NPTEL online certification course on Mechatronics. Today, we are going to talk about Data Presentation Systems. There are various ways in which data can be presented and it is important in the sense that we need to know that what is happening in the system. So, it is some sort of value of the parameters or variables which is in the form of a display.

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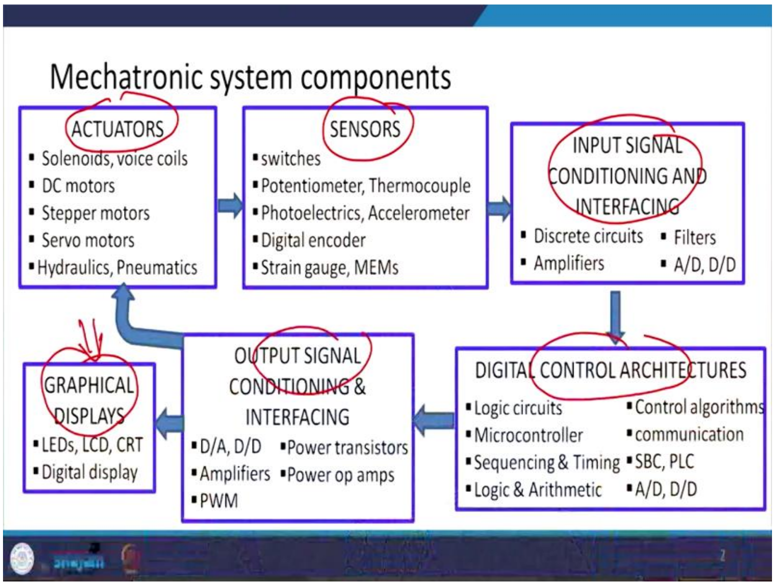

So, here are the essential components of the mechatronic system as I have been discussing with you that is actuators, sensors, sensor signal being conditioned here, then sent to the digital control architecture and the output signal conditioning, and here are the graphical displays. So, I am going to talk about this today in this lecture. So, here, it could be LEDs, LCDs, CRTs, or any other type of display device.

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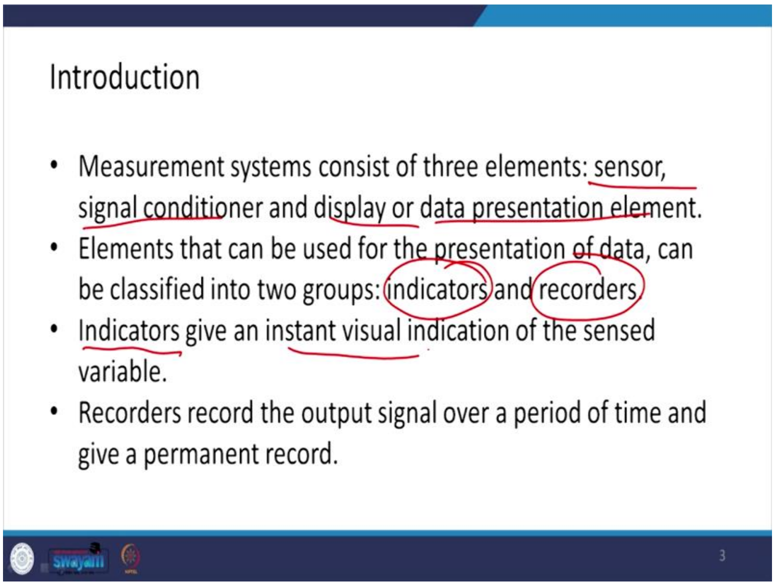

Measurement system usually consists of three elements; sensors, then the signal conditioners, and the display or what we call the data presentation elements and these elements can be used for the presentation of data and they can be classified into two types, one as the indicators and the other as the recorders. Indicators give you the instant visual indication of the sensed variable whereas, the recorder is used to record the output signal over a period of time and give you a permanent record.

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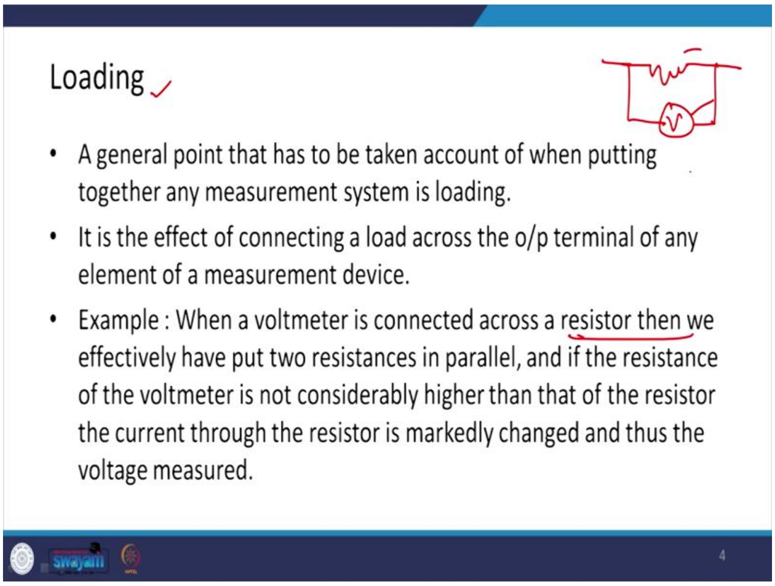

Now, before we proceed, now let us have a small discussion on the effect of measuring elements on the rest of the system and this is what we call the loading. So, a general point that has to be taken into account, when putting together any measurement system is the loading and it is the effect of connecting a load across the output terminal of any element of a major system.

So, this is what is going to have is it is the effect whenever I am going to connect a measuring device into a system, it is going to affect or it is going to load the system, means a very common example which many of you may be aware of is that of a voltmeter. When a voltmeter is connected across a resistor, then we effectively have to put 2 resistors in parallel. Lets, I have a resistor and I put a voltmeter over here so, this is what means that I am putting the two resistors in parallel and if the resistance of the voltmeter is not considerably higher than that of the resistor, the current through the resistor is markedly changed and thus the voltage measurement changes.

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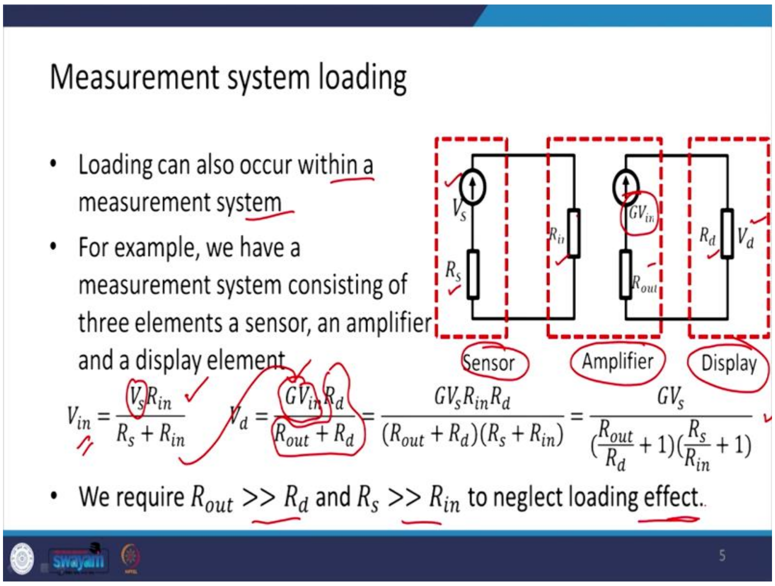

Now, let us look at this measurement system loading a little more in the detail and loading can also occur within a measurement system or and suppose I have got a measurement system which consists of saying a sensor, an amplifier, and a display device. So, here, if I look at this figure. So, suppose I have got voltage source and I have the resistance of the sensor is there and say this is the resistance of the input here that is amplifier input is there.

So, in this case, we can see that it is this resistance acts as a voltage divider so, the voltage across this one is going to be,

$$V_{in} = \frac{V_s R_{in}}{R_s + R_{in}}$$

Now, you see this voltage is getting amplified with the help of an amplifier and we get,

$$V_d = \frac{G R_d V_{in}}{R_s + R_{out}}$$

So, if I substitute back V_{in} over here and simplify this, this is what we get,

$$V_d = \frac{G V_s}{\left(\frac{R_s}{R_{in}} + 1\right)\left(\frac{R_{out}}{R_d} + 1\right)}$$

we require R_{out} to be very large than R_d and R_s to be very large than R_{in} order to neglect the loading effect.

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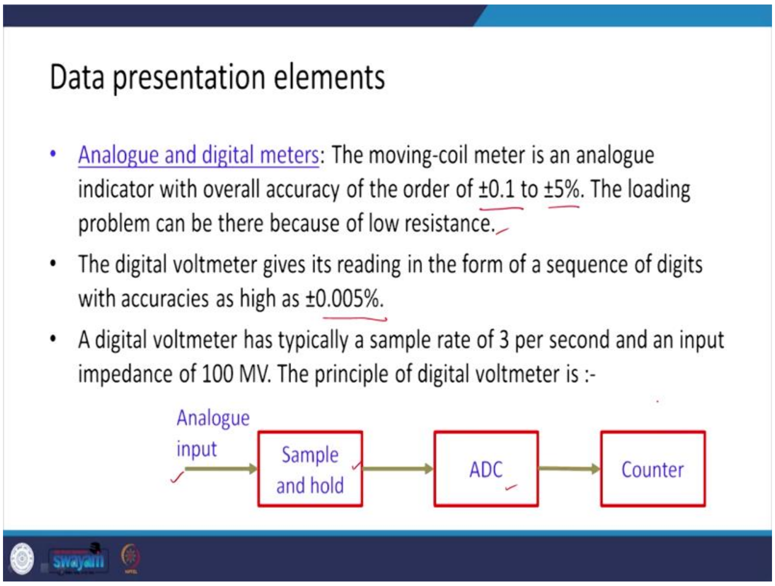

Next, let us look at the data presentation elements. Analog and digital meter, so the moving-coil meter is an analog indicator with an overall accuracy of the order of $\pm 0.1\ to\ \pm 0.5\%$. The loading problem can be there because of the low resistance. The digital voltmeter gives its reading in the form of a sequence of digits with accuracies as high as $\pm 0.005\%$.

A digital voltmeter has typically a sample rate of 3 per second and an input impedance of 100 megavolts. The principle of the digital voltmeter is that you have the analog input and there is going to be a sample and hold and you are going to have the analog to digital converter after the sample and hold and of course, then you are going to have the counter so, that is going to be there.

Next, is the cathode ray oscilloscope, or what we call in short the CRO. The cathode ray oscilloscope is a voltage measuring instrument that is capable of displaying extremely high-frequency signals.

A double beam oscilloscope has two separate traces to be observed simultaneously on the screen and in the storage of type of oscilloscope that traces to remain on the screen after the input signal has seized out and the digital storage oscilloscope digitizes the input signal and store the digital signal in a memory.

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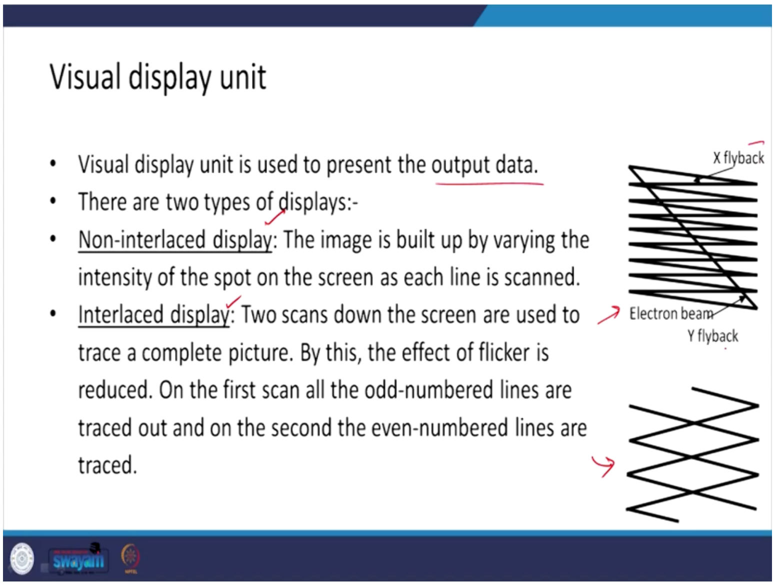

Then, let us look at the visual display unit or the VDU which it is called in short. So, the visual display unit is used to present the output data and these are two types of displays; one is the non-interlaced display and another is the interlaced display.

In the non-interlaced display, the image is built by varying the intensity of the spot on the screen as each line is scanned. Whereas in the case of interlaced display, the two scans down the screen are used to trace a complete picture and by this, the effect of flicker is considerably reduced and on the first scan, all the odd number lines are traced out whereas, in the second scan all the even lines numbers are traced out.

So, here is how it is shown the interlaced display and this is that non-interlaced display. So, you have an electron beam over here, there is X flyback and there is Y flyback.

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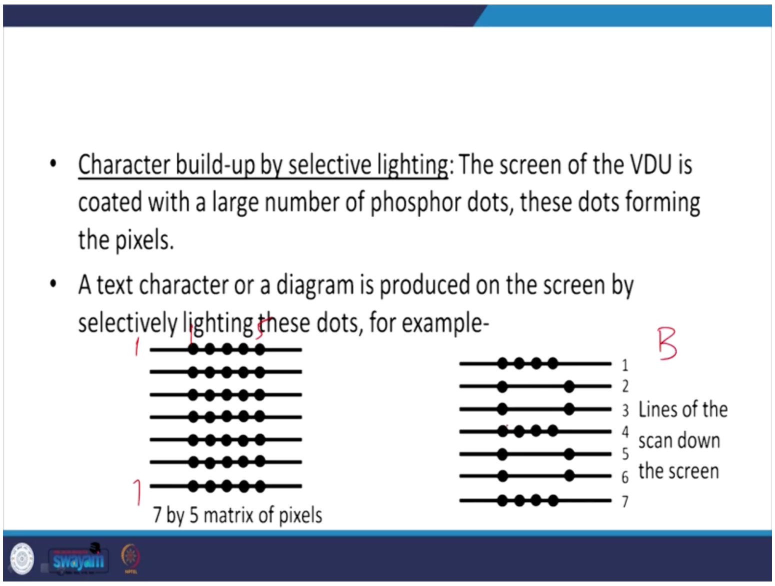

The next let us look at the buildup of characters by selective lighting. So, the screen of the visual display unit is coated with a large number of phosphor dots, and this dot forms the pixel and a text character or a diagram is produced on the screen by selectively lighting these dots. For example, here say we have the 7 by 5 matrix of pixels so, I have 1 to 7 rows and 1 to 5 columns over here. So, I can get the character here as you can see that by lighting the different pixels, I can get character B over here.

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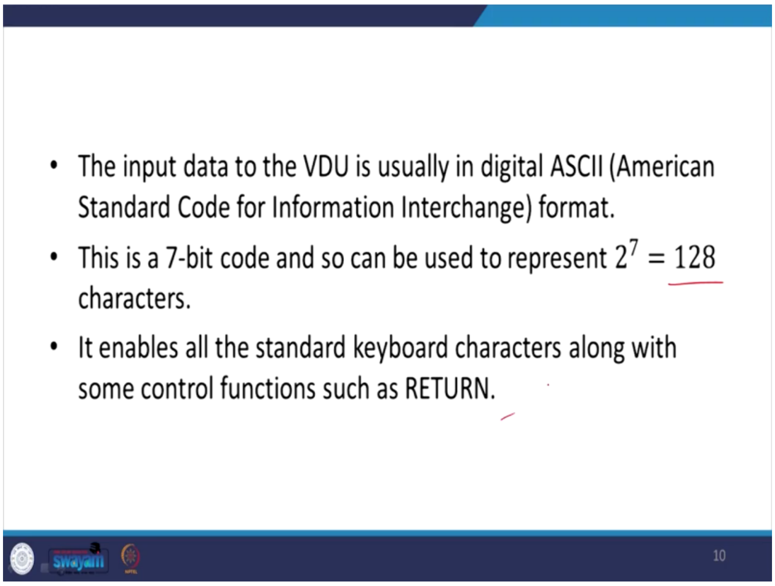

The input data to the visual display unit is usually in digital ASCII format. ASCII is a short form for the American Standard Code for Information Interchange. For example, a 7-bit code and can be used to represent 2 to the power 7 that is 128 characters, and with the help of these 128 characters, we can write that is all the standard keyboard characters can be incorporated along with some control functions such as RETURN. So, these things can be represented.

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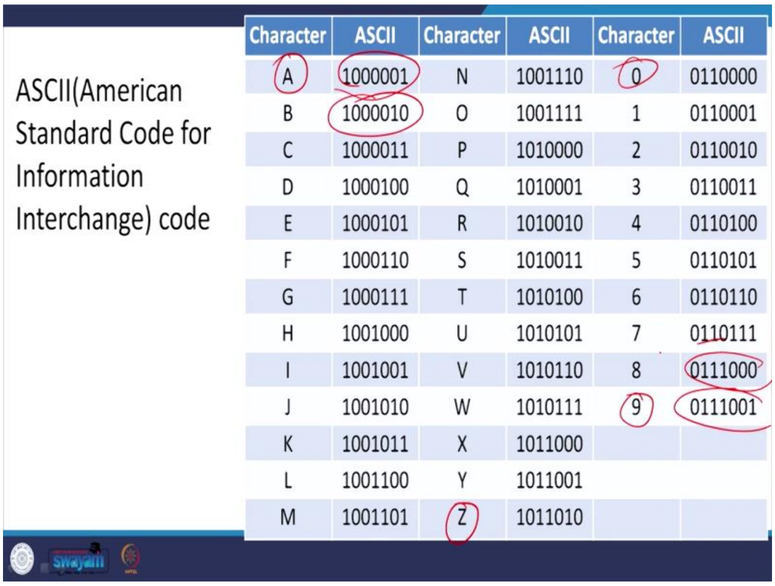

Character	ASCII	Character	ASCII	Character	ASCII
A	1000001	N	1001110	0	0110000
B	1000010	O	1001111	1	0110001
C	1000011	P	1010000	2	0110010
D	1000100	Q	1010001	3	0110011
E	1000101	R	1010010	4	0110100
F	1000110	S	1010011	5	0110101
G	1000111	T	1010100	6	0110110
H	1001000	U	1010101	7	0110111
I	1001001	V	1010110	8	0111000
J	1001010	W	1010111	9	0111001
K	1001011	X	1011000		
L	1001100	Y	1011001		
M	1001101	Z	1011010		

So, this is how the ASCII code for the different characters. You can see the alphabets that is A to Z and these are the ASCII code, a 7-bit ASCII code for the different alphabet character, and here is for the numbers. So, from 0 to 9, you have the 7-bit code over here to represent it.

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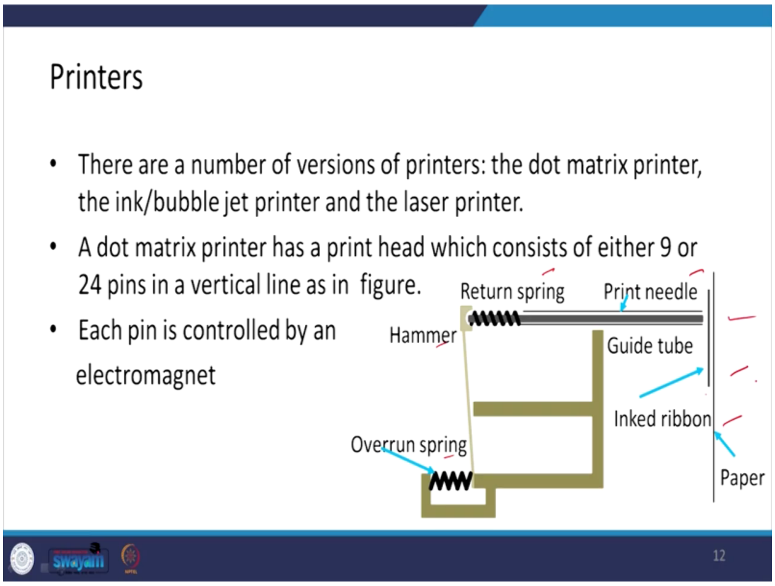

Now, let us look at another very popular output device that is the printer. So, there are a number of versions of printers that are commercially available, and these are dot matrix printers or inkjet or a bubble jet printer and the laser printer. A dot matrix printer has a print head that consists of either 9 or 24 pins in a vertical line as shown over in this figure and each pin is controlled by an electromagnet. We have the print needle over here, there is an ink ribbon, you put a paper over here, there is a return spring, hammer and there is an overrun spring. So, this way when this needle impinges on this inked ribbon, you get those characters in the paper.

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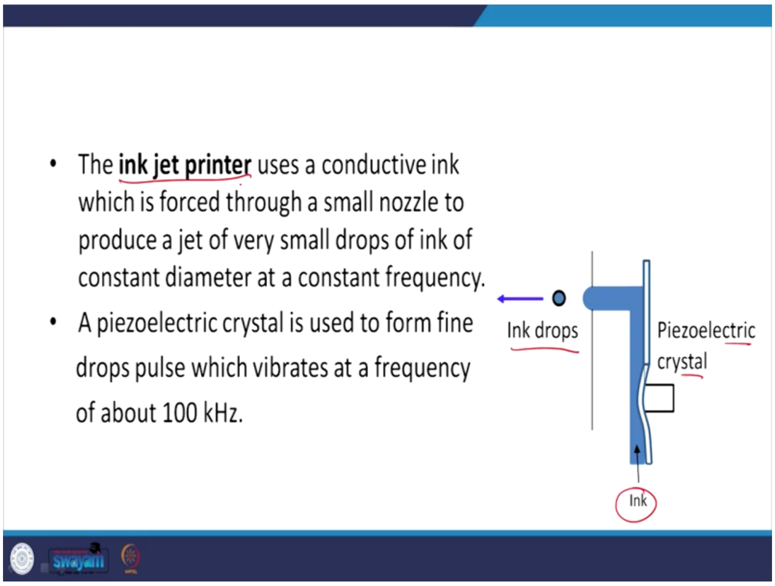

The inkjet printer uses a conductive ink which is forced through a small nozzle to produce a jet of a very small drop of ink of constant diameter or at a constant frequency and a piezoelectric crystal is used to form the drops pulse which vibrates as a frequency of around 100 kilohertz. You can see over here so, ink is passed from here, piezoelectric crystal is used to vibrate it and here, you get the drops the ink drops you get it from here and this is the principle for the inkjet printer.

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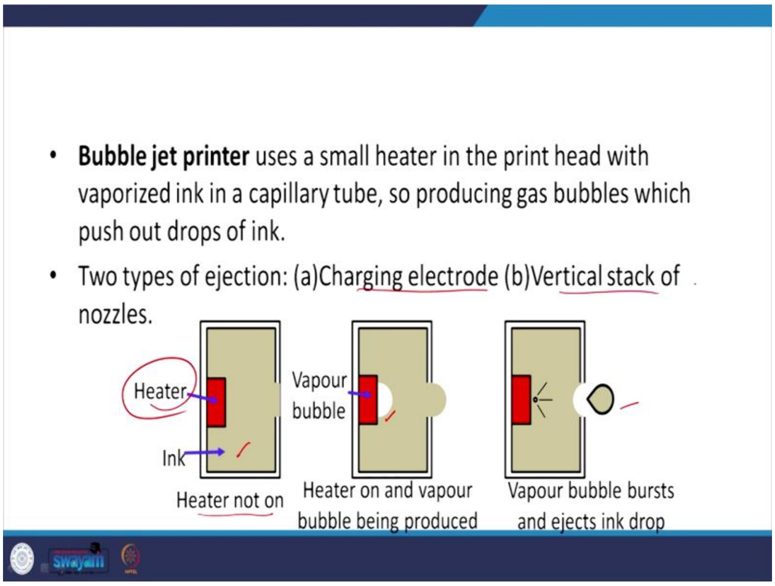

Then, in case of a bubble jet printer, the bubble jet printer uses a small heater as you can see over here in the print head with vaporized ink in a capillary tube so, producing a gas bubble that pushes out a drop of ink.

So, here you have a heater, you have ink when the heater is not on, this is the case and the when the heater is on, the bubble is produced as over here and this bubble is pushed into and the vapor bubble burst and ejects into a drop. So, the two types of ejections are there; one is the charging electrode and the other is the vertical stack of nozzles.

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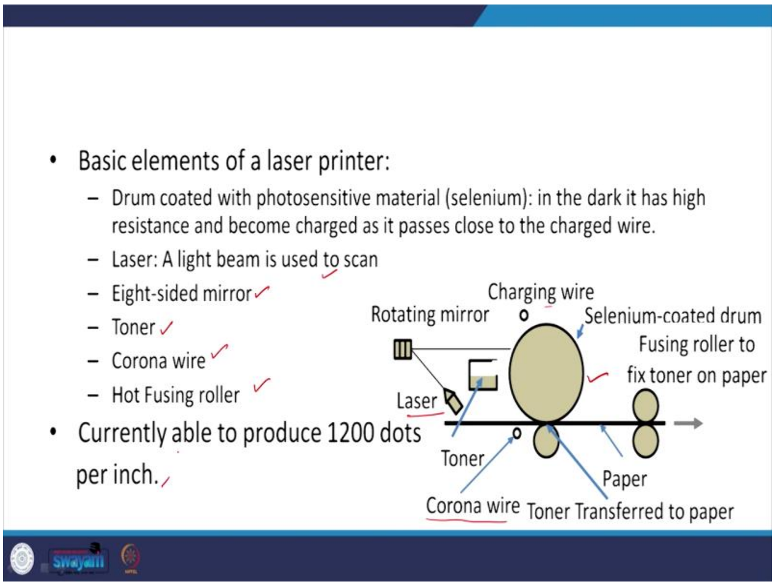

Next, let us look at the laser printer. So, the basic element of a laser printer is a drum this one is coated with a photosensitive material such as selenium, and in the dark, it has high resistance and becomes charged as it passes close to the charged wire. As it passes near the charging wire, it becomes charged. So, what happens a laser light is sent here, and it goes to the rotating mirror and it gets reflected from the rotating mirror, falls on this cylindrical drum, and wherever the light falls that portion of the drum gets discharged.

So, then what happens that this drum turns and there is a toner so, this toner is conductive so, the wherever it is charged so, that toner gets attracted over here, then there is a corona wire over here and this corona wire charges the paper and when it charges the paper, then this charged paper gets attracted to the inkjet and that ink gets into the paper and then, there is a fusing roller to fix the toner on the paper. A light beam is used to scan, there is an eight-sided mirror, there is a toner, there is a corona wire which is used for the charging of the paper and there is a hot fusing roller. So, currently, we are able to produce 1200 dots per inch this way.

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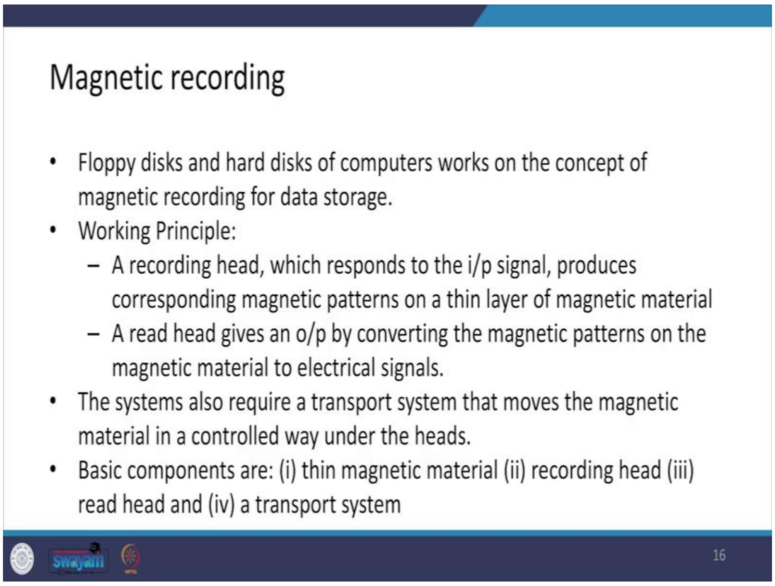

Now, let us look at the magnetic recording. This is again a type of recording device say floppy disk and hard disk of computer works on the concept of magnetic recording for the data storage. The working principle is, a recording head, which respond to the input signal, produces corresponding magnetic patterns on a thin layer of magnetic material, and then, there is a read head that gives output by converting the magnetic pattern on the magnetic material to the electrical signal. The system also requires a transportation system that moves the magnetic material in a controlled way under the heads and the basic components are a thin magnetic material, a recording head, a read head, and the transport system.

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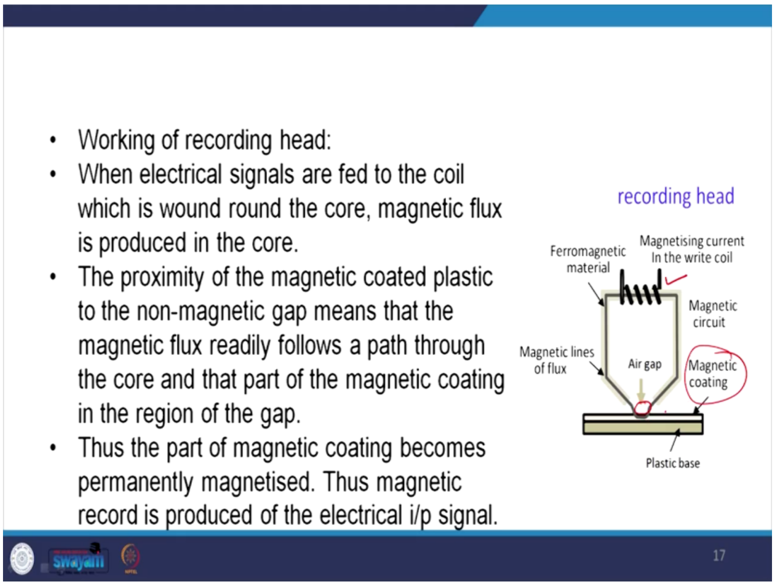

The working principle of the recording head has been explained. So, when the electrical signals are fed to the coil which is wound around the core, magnetic flux is produced in this core and the proximity of the magnetically coated plastic to the non-magnetic gap means that we have a magnetically coated plastic over here and there is a non-magnetic gap and so, when this is present here, it means that the path for the magnetic lines of flux exist through this way and that way it magnetizes the magnetic coating which is there, put in this gap. Thus, the part of the magnetic coating becomes permanently magnetized and the magnetic record is produced or It is rather due to the electrical input signal.

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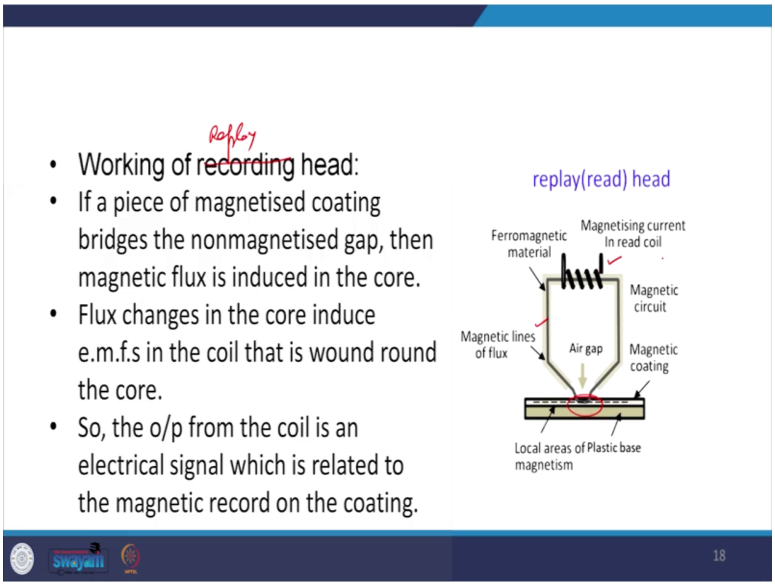

And if we talk about the replay head, the replay head uses the same mechanism, and what happens if we place the magnetized coating over here that is in the air gap, then the magnetic flux is induced in this core and this flux change in the core induces the e. m. f in it and the that is wound in the coil and so, in this coil, you have the e. m. f produced. So, the output from the coil is an electrical signal which is related to the magnetic record which is there on the coating. So, this way it is read.

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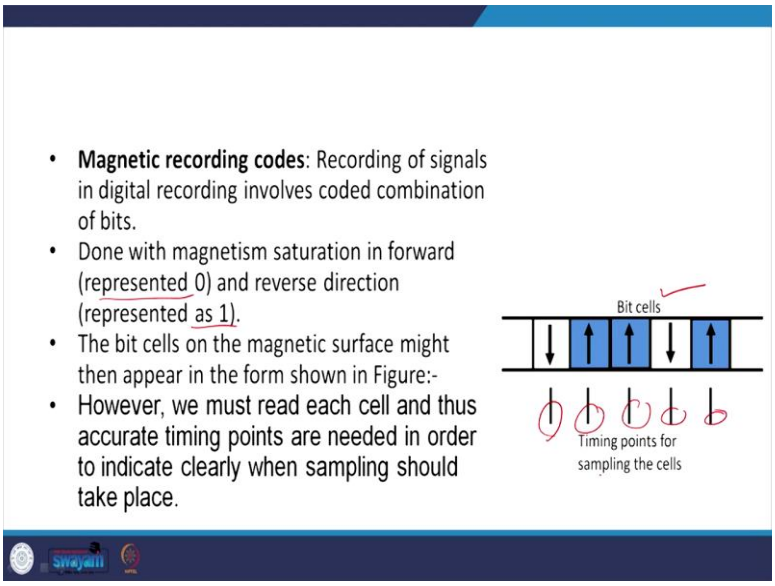

And this recording of signals in digital recording involves a coded combination of bits and it is done with magnetism saturation in forward represented by 0 and in the reverse direction which is represented by 1. The bit cell on a magnetic surface might appear as you can see over here, and however, we must read each cell, and thus accurate timing points are needed in order to indicate clearly when the sampling should take place. So, for reading each cell, we need to have the exact timing for carrying out the sampling.

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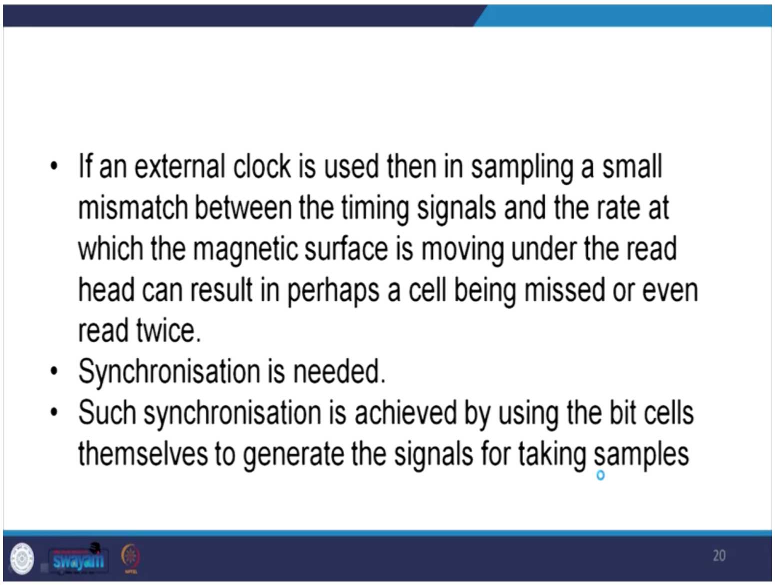

Now, if we are using an external clock for this purpose, then there may be a small mismatch between the timing signal and the rate at which the magnetic surface is moving under the read head and this can miss the information or this can result in the cell being missed or even read twice. So, we need to have a certain synchronization is needed between the time it is read and the time it is clogged and such synchronization is achieved by using the bit cell themselves to generate the signal for taking the samples.

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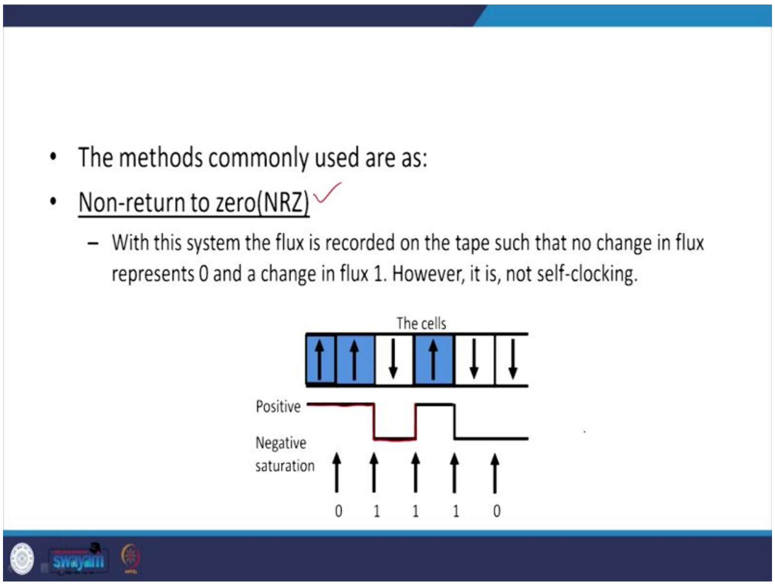

So, the method commonly used is I will be discussing a few of these methods and if you want to learn more, you can refer to Mechatronics by Bolton from where you will get sufficient information. So, the next, one way is the non-return to zero or what we call NRZ in short, and with this system, the flux is recorded on the tape such that no change in flux represents 0 and change in flux is represented by a 1. However, it is not self-clocking.

So, you can see that here there is a flux so, it is a constant. So, and here so, there is no change so, this is represented by 0 and here there is going to be a change so, it’s represented by 1. So, and this is magnetized and non-magnetized, this is what is represented over here. So, again this is a constant so, again this is 1 and again so, this remains over here and then, there is a change over here so, represented by 1. So, this way, it can be represented.

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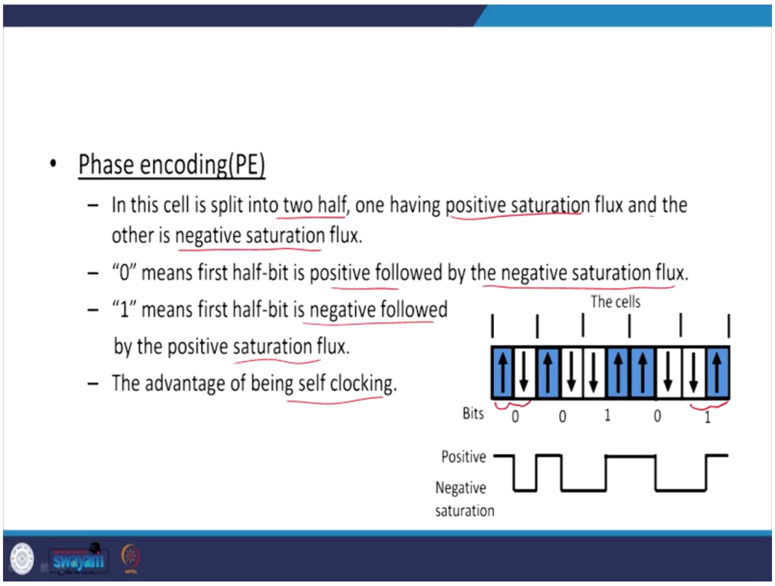

The next way is the phase encoding and in this method, the cell is split into two halves, one half positive saturation flux and the other half is called the negative saturation flux and 0 means the first half-bit is positive followed by the negative saturation flux and 1 means the first half-bit is negative followed by the positive saturation flux and this the advantage for this method is that it is self-clocking.

So, here as we can see that 0 means the first half-bit is positive followed by the negative. So, you have the positive, negative so, this is 0 and if it is negative followed by the positive so, that is represented by 1. So, as you can see that negative followed by positive so, that is represented by 1. So, this way, this can be done and the biggest thing is that this is a self-clocking.

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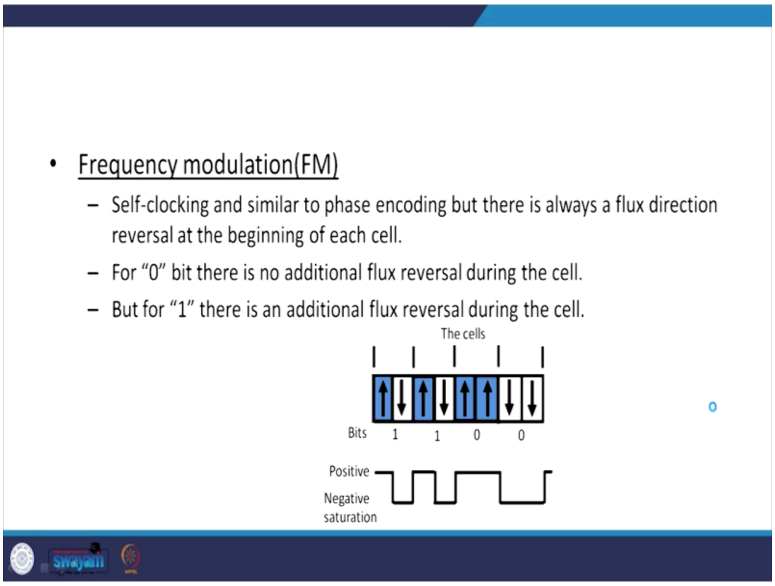

Next is frequency modulation. This is Self-clocking and similar to the phase encoding, but there is always a flux direction reversal at the beginning of each cell and for 0 bit, there is no additional flux reversal during the cell and, but for 1, there is an additional flux reversal during the cell.

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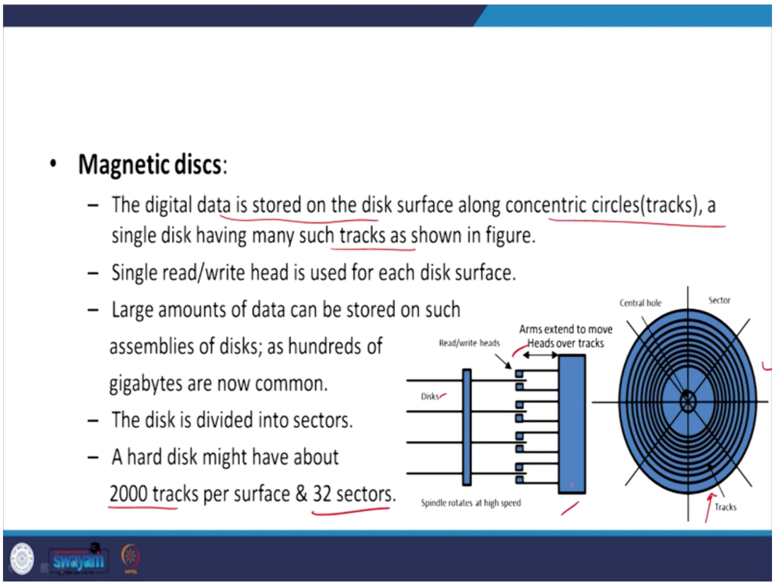

Then, we let us look at the magnetic disk. In a magnetic disk, the digital data is stored on the disk surface along a concentric circle as you can see over here, a single disk having many such tracks. So, you can see that a single disk has got many such tracks, and this is divided into the sectors and the single read, write head is used for each disk surface.

A large amount of data can be stored on such assemblies of the disk as hundreds of gigabytes are now common. The disk is divided into sectors and a hard disk might have about 2000 tracks per surface and around 32 sectors. So, this is how it could be. So, we have the disk read and write heads are there, extend to move heads over the track.

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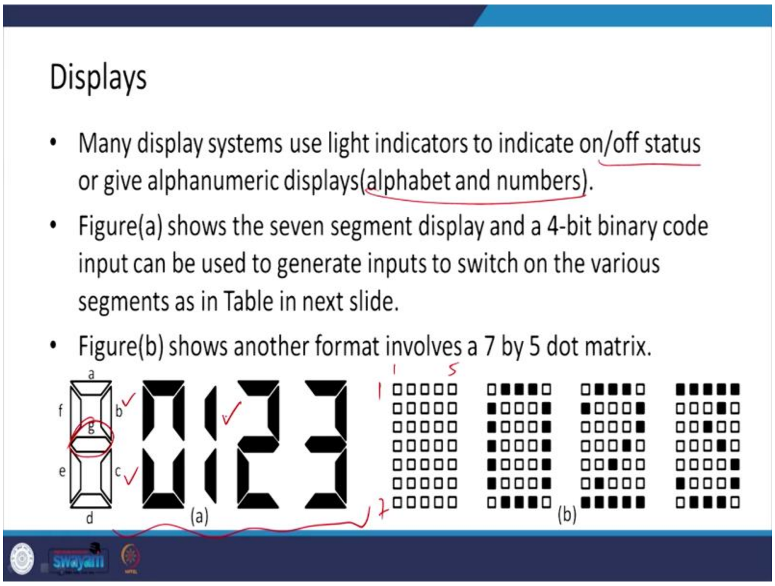

Then, let us come on the display devices. So, the many display systems use light indicators to indicate on, off status of or give the alphanumeric displays that are the alphabet and numbers. So, here as you can see this is the 7 segment display and there could be a 4-bit binary code input that can be used to generate input to switch on the various segment that I can explain in the next slide.

And we could also have another format where we could have a 7 by 5 dot matrix. So, we have 1 to 7 rows here and 1 to 5 columns here and by lighting the different elements in this one, we can generate the alphanumeric characters.

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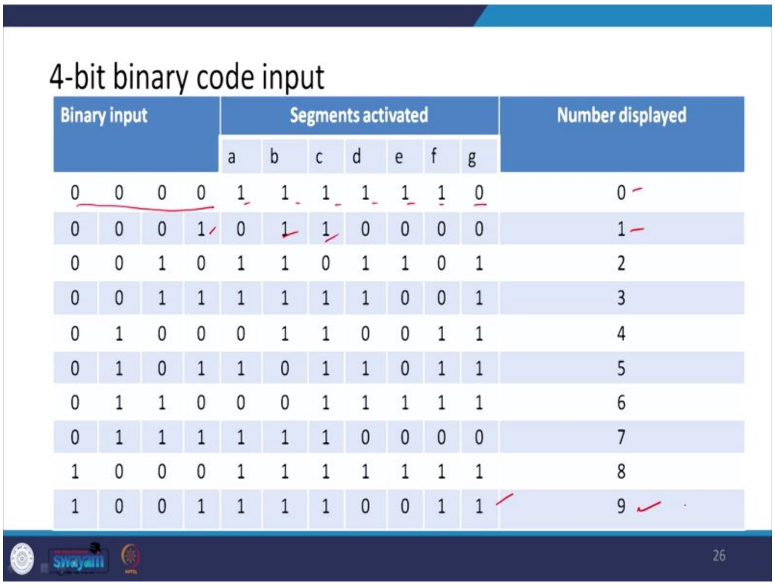

4-bit binary code input

Binary input				Segments activated							Number displayed
				a	b	c	d	e	f	g	
0	0	0	0	1	1	1	1	1	1	0	0
0	0	0	1	0	1	1	0	0	0	0	1
0	0	1	0	1	1	0	1	1	0	1	2
0	0	1	1	1	1	1	1	0	0	1	3
0	1	0	0	0	1	1	0	0	1	1	4
0	1	0	1	1	0	1	1	0	1	1	5
0	1	1	0	0	0	1	1	1	1	1	6
0	1	1	1	1	1	1	0	0	0	0	7
1	0	0	0	1	1	1	1	1	1	1	8
1	0	0	1	1	1	1	0	0	1	1	9

So, if we look at the 4-bit binary code input for that so, suppose the binary input is 0000, this we could get by segment activation of that is all the segments except the middle one that is g is 0 as we can see this is the g so, except the middle one this is there, we get a 0 number. Similarly, for binary input 0001 what we get is 2 to the power 0 which is 1, and this 1 we can get if the b and c are lightened. So, b and c are lightened means that this one and this one is lightened I can get the 1. This way, we can get the 7 segment display. For different types of binary inputs, the different segments can be activated in order to get the different numbers being displayed.

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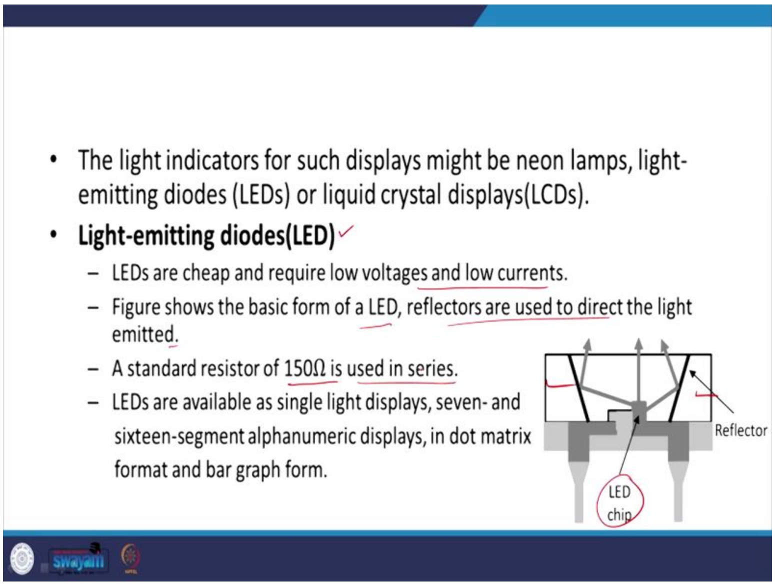

The light indicators for each display might be neon lamps or LEDs that are light-emitting diodes, or the liquid crystal displays which we call LCDs. Now, let us look at the light-emitting diode. I have discussed this thing during my introductory classes in the 1st week. So, you can refer to it over there also. The LEDs are cheap and require low voltage and low currents. Here, you can see the basic form of LED where reflectors are used to direct the light emitted, you can see the reflector over here and this is the LED chip, and they reflect the light. A standard resistor of 150 ohms is used in series and these LEDs are available as a single light display seven and sixteen segments alphanumeric display in dot matrix format and in the bar graph form.

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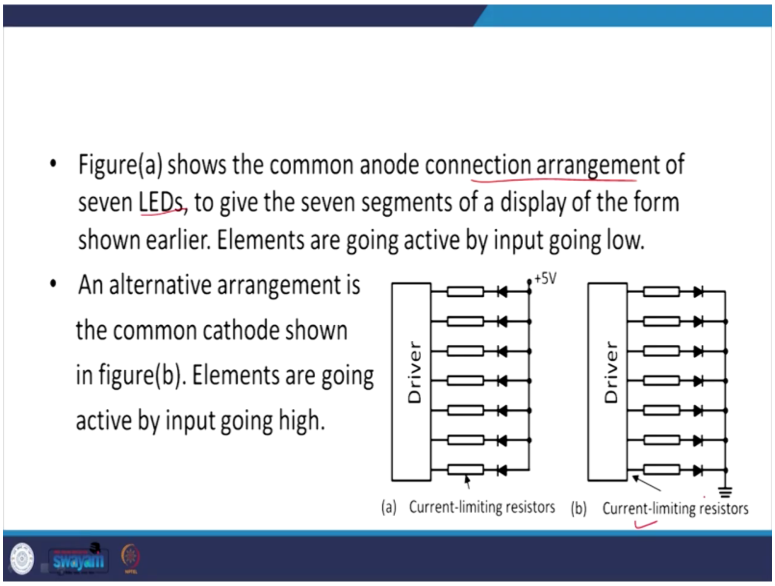

Here, we can show the common anode connection arrangement of the seven LEDs as you can see over here to give seven segments of a display of the form which I have shown previously and inputs are, elements are going active by an input going low and then, we can have the other arrangement where elements are going active by an input going high.

Often, the output from the driver is not in the normal binary form, but in the BCD form that is the binary coded decimal form. This is Input to the encoder. So, the driver output has to be decoded into the required format for the display.

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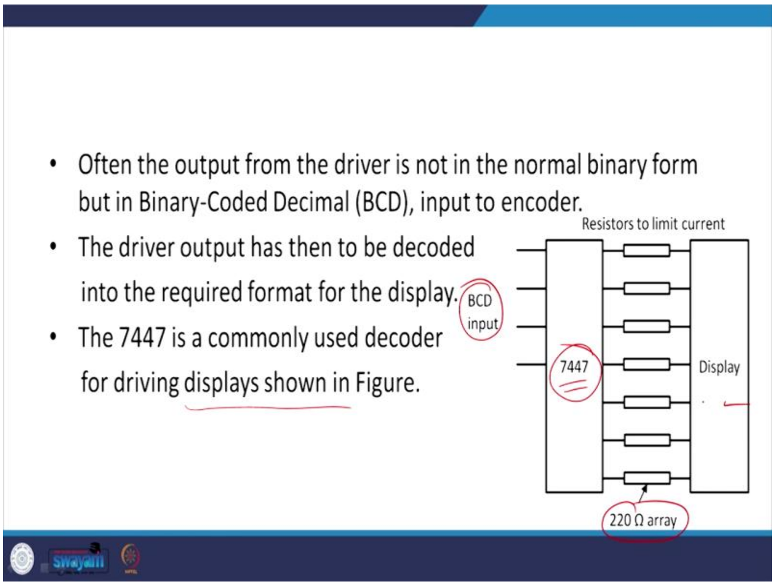

The 7447 is a commonly used decoder for driving display as you can see over here. So, you have the BCD input, and you can have the 7447 decoders to display and this is 220 array ohm array and then you have the display.

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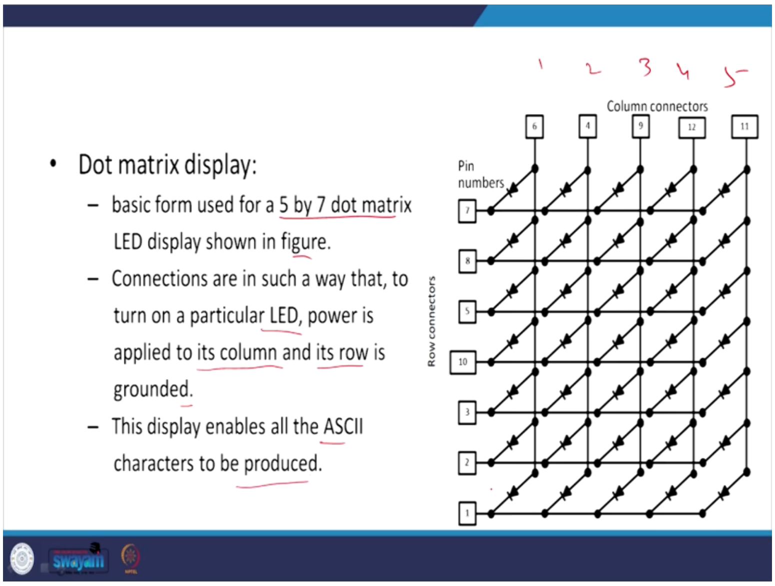

Then, dot matrix displays, the basic form used for a 5 by 7 dot matrix LED display is shown over here. So, here you can see 1, 2, 3, 4, 5 there are 5 columns, and you have the 7 rows over here and the connections are in such a way to turn a particular LED, power is applied to its column and its row is grounded. So, that is how it is done, and this display enables all the ASCII characters to be produced.

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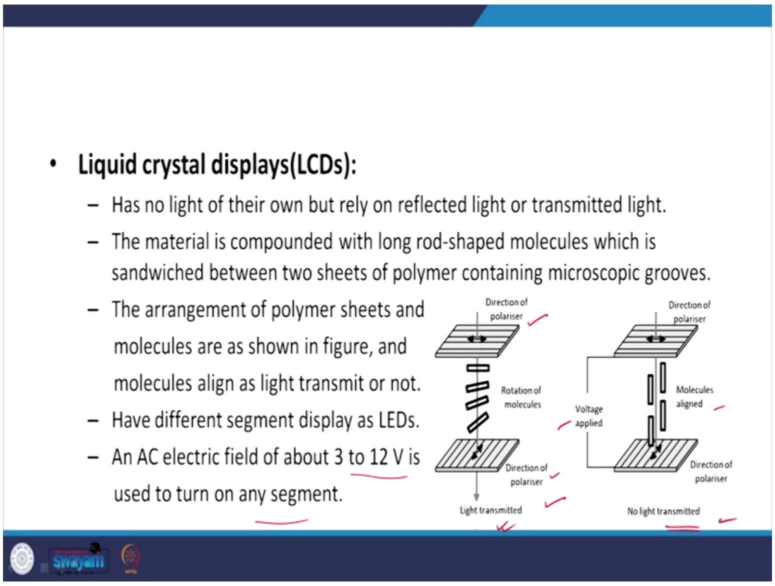

Then, the liquid crystal displays or the LCDs, it has no light of their own, but rely on reflected light or the transmitted light. The material is compounded with long rod-shaped molecules which are sandwiched between the two sheets of polymer containing microscopic grooves. The arrangement of polymer sheets and the molecules are here as you can see over here, and molecules align as the light transmits or not.

We have different segment displays as the LEDs and an AC electric field of about 3 to 12 volt is used to turn on any segment. Here as you can see that direction of polarized light and this is how the light is being the direction of polarizer so, light is getting transmitted over here, and here, when the voltage is applied, these molecules get aligned and you do not get the light transmitted.

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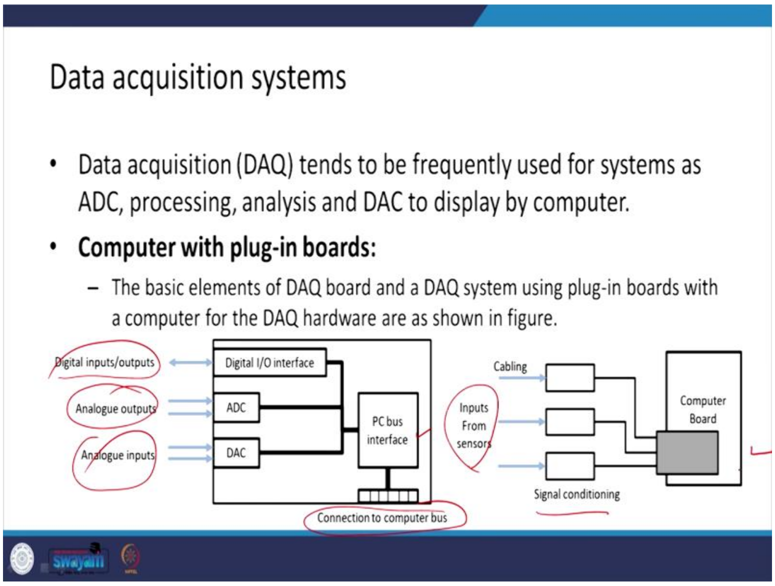

Now, let us look at the data acquisition system. The data acquisition system is used these days to get the input data. This tends to be frequently used as an analog to digital converter, processing, analysis, digital to analog converter to display by the computer. There is a computer with plug-in boards, the basic elements of the DAQ board and the DAQ system using plugging board with a computer for the hardware is like this you have a connection to a computer bus, PC bus interface is there so, you have the digital input-output, analog output and analog input ports are over here. You have the inputs from the sensor, there is signal conditioning and then you can put it on the computer board.

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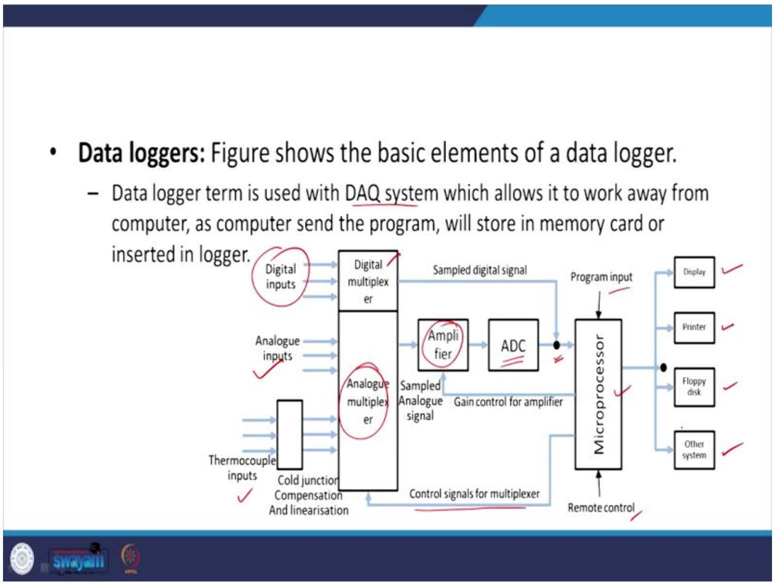

Data loggers is the term used in the DAQ system which allows it to work away from the computer, as the computer sends the program will store in the memory card are inserted in the logger. So, as you can see that you have the digital input so, the digital multiplexer is used to select the proper input. You may have the analog input also, for example, the thermocouple input and analog multiplexers are there and if you have the analog signals, then an amplifier has to be used and an analog to digital converter has to be used.

A sample digital signal is there, your sample analog signal which has been converted into the distance signal that is there and then, you can have these things going to the microprocessor where you have the program unit and you can have remote control of this microprocessor and from here, you can have the control signal for the multiplexer and here, from the microprocessor, you could have a connection for display printer, floppy disk, and the other systems.

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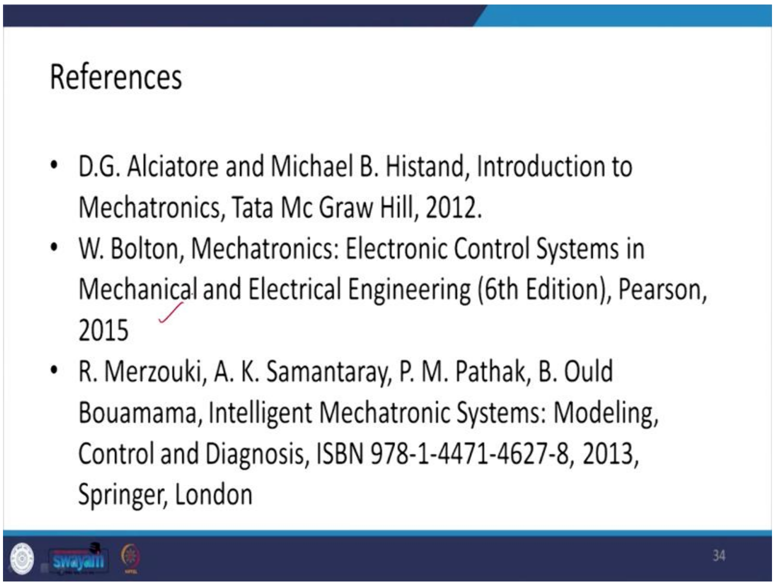

So, these are the references if you want to read further you can refer to these books specifically the Bolton, Mechatronics.

Thank you.