Integrated Circuits, MOSFETs, OP-Amps and their Applications

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Lecture - 37
Experiment Introduction to Laboratory Equipment

Welcome. So, this particular set of modules that we are going to show it to you are regarding how to use your theoretical knowledge in practical applications. So, until unless whatever you learn in theory in books in lectures, you do not apply according to me it is useless. So, particularly when you are talking about linear integrated circuits or op amps or MOSFET's and their applications what are the applications.

So, what we will do today? We have divided these particular modules into several sections so that this student can understand what are each equipment. Now, before we go to the equipment, like I said in my first lecture, I have shown you few integrated circuits, isn't it? And I also shown you the passive and active components.

So, let us see passive and active components I will just bring it all the way here. So, if you can just little bit zoom in yeah.

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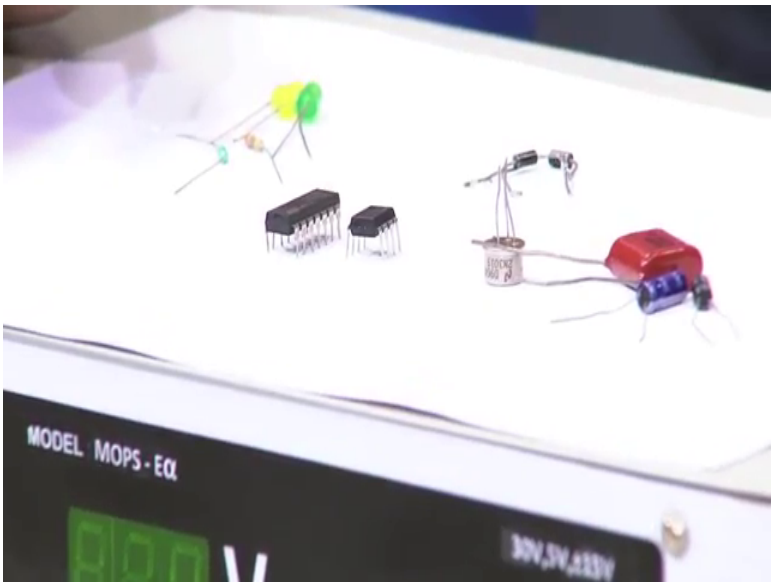

So, we start with the capacitors. So, you see there are several kind of capacitors here, this three that I am keeping in front not consider this three all these are capacitors right. So,

what are capacitors like we discussed last time, they are two parallel plates conducting plates separated by a dielectric material or air.

So, how we can measure this capacitor? What is the capacitance value, we can always see on the capacitor the 63 volts 10 micro farad ok? But if I want to measure it whether it is 63 volts or 10 microfarad or not, how would I know? So, we will also see how what is the equipment used to measure this capacitor, there is the capacitance of this particular device.

Now, capacitor as we know it is a passive component, right? Now let us see the another one which is right in front of me, again if we can little bit focus on this component yes. So, this is a pn junction diode, you can see there is a this is a diode, which I am holding in my hand right, yes. And you will see a black and if you focus right here where my nail is there right here, there is a silver ring. There is a cathode is easy way of identifying diode which is anode, which is cathode which is p which is n. So, when you say p n n; that means, that you have two semiconductors. One is p, then one is n; that means, we will see how we can measure the diode also.

So, what is equipment to measure this particular diode? And we will also see several kind of diodes, if you if you really understand semiconductor devices then there are several kind of diodes tunnel diode, where vector diode 8 pn junction diode short key diode so, but this is the pn junction diode. It is simple easy, but we have to also understand how we can measure right, which is anode which is cathode not just by looking at it, but also by using the equipment.

Now, let us see another one. And why I am kind of showing it to you I am sure that you all know what are the components, what are the active components, what are the passive components. But it is always good to take all the students together, unidirectional growth is not good we should grow together, and that is why people who do not know how components looks like, right? Generally, lot of universities they have the facility; however, unfortunately few of the universities we do not have the experimental facility, and that is why the students may or may not know what are the active and passive components.

So, for those students who do not know this is what I am showing it to you for those students who already know it is kind of refreshed. So, it is always good to refresh whatever we know or brush-up whatever we know so that we do not forget ok.

So now let us take the another one this beautiful it is very easy to understand, and this looks extremely beautiful in terms of other components. What are these things? It is right you have guessed is correct, what is this light emitting diode. One is yellow right, one is green, we can have red, we can have bright field or bright we can also have UV, LEDS; however, we again do not do not about the functioning of this particular devices, because that is not scope of our particular series.

The understanding about this particular series is what are the components and what are the equipment that we can use to understand how this components would be can be used can be used, right. So, this is light emitting diode, again it has a anode it has a cathode when you talk about diode two ends one is anode one is cathode, all right? Both has anode both has cathode.

Now, there is another way or easy way of identifying anode, and cathode, but let us not go in that particular way of crude way of understanding. Which is anode which is cathode we will see in terms of how to understand, which is anode which is cathode in terms of a diode whether is pn junction diode whether is led we can always use a equipment called multimeter. So, we will see about multimeter in a while.

Let us see another component or another device, which is this one now let us keep this separate, what you see here? What you see here? These are resistors, these are resistors. Now, what is the value of this resistor right? So, there is a chart to understand what is the value of the resistor; whether it is 100-ohm 1 kilo ohm 2 kilo ohm 100 mega ohms, but there is another way of measuring the resistance and that is using the multimeter.

So, we will see how we can use the multimeter to understand what kind of what is our what is a resistance value of this particular resistors all right. So, resistors another concept in DC is resistance right, but if you understand AC then the resistance is not any more valid and we have to understand the impedance. Again do not worry about impedance right now, the idea of this particular series is not to confuse you or not to make the life more complex, life is very easy. Same way any understanding of any

devices understanding of any subject can we make easier when we connect it to a real-life problem, all right.

So, resistor resistors so now, we will see what is the value of each resistor ok, this is the idea that we see how we can measure the resistance or resistors and what is the value of these registers. Now, let us go to the next one, I show you transistor. So, I will put it like this. So, you can you can see there are three leads right, one transistor is NPN another one is PNP, right.

So, we will see which is NPN, which is PNP based on beta which is current gain. again we have to understand how we can measure the transistors, how we can understand whether this is PNP transistor is the NPN transistor. So, this is again I see metal can. So, it is a packaged it is a packaged. So, transistor is within this all right transistor is within this particular metal can all right within the metal can. So, you can all it is if you open this can, if you open this can, you will find a small chip which is your transistor.

Let me again say that you know recently when we talk about integrated circuits BJTs or by junction transistors are not anymore useful. we are not using it what we are using it, we are using the MOSFET's. MOSFET's are metal oxide semiconductor field effect transistors.

So, when we talk about BJTs these are all digital components, all the things that I have shown it to you until now are called discrete components, all right. So, let us see one more transistor, and this is the power transistor. So, let us start from the smaller one, this is the power transistor, can you see a power transistor, right?

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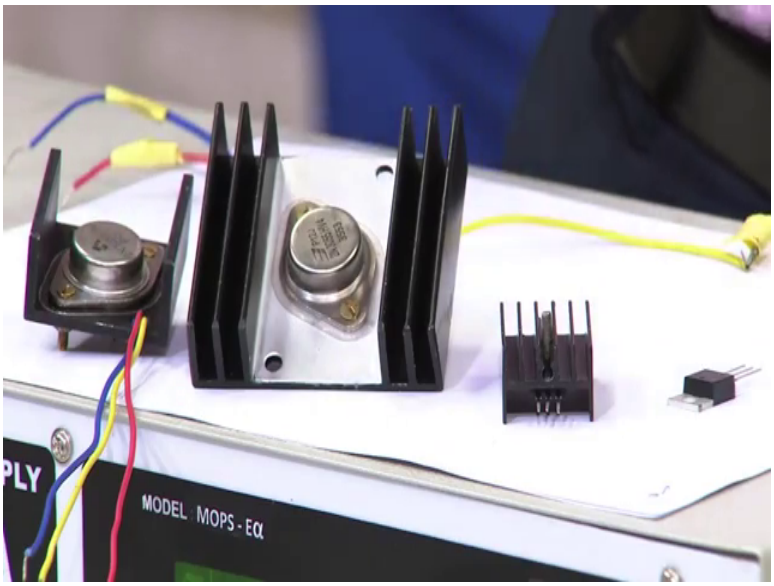

Now, this power transistor this black thing, what is this black thing? What is a use for this particular socket or black thing? The use of this particular thing is called heat sink to sink, the heat what is sink that will take away the heat or dissipate the heat. So, the heat generated by this power transistor is dissipated using this heat sink, this is for 2 watts to watts. But if it is a higher wattage or it is 5 watt, then we have a bigger heat sink.

You can see again it is a heat sink, right? This black thing is heat sink this is a power transistor, all right. So, this is also transistor, this is also transistor, this is also transistor, this is also transistor. So, do not get confused when we when we when somebody shows you these are transistor, these transistors both are transistors. The application is different, this cannot be used in power applications, this can be used in power applications. When there is a high power there is a high energy lot of a heat, and heat we need to dissipate, otherwise it will cause difficulties in other the other electronic circuits.

So, now I hope that we know most of the components are discrete components. What we have seen we will also see your favourite and part of this particular lecture and the part of this particular course is the MOSFET, right? So, you see this is the IC. This is the integrated circuit, right? And again, there is a this for the heat sink, if you want to connect the heat sink, then you can connect it using this particular part. You see here this one you can screw this, and connect to a heat sink there are 3 here, right? Gate, source, drain, gate, source and drain.

Source is internally connected to the substrate. So, we do not have a separate connection for the substrate. Similarly, but if you want to use the MOSFET again, we can connect it to heat sink. Like I said this particular thing we can connect to heat sink you can see here it is connected through a screw it is connected through a screw to a heat sink heat sink looks like this, right? We have seen heat sink looks like this, this thing right heat sink looks like this, all right? This all black thing there all heat sinks, all right? Got it?

So, whenever we see anything we should be able to identify, until we cannot speak what is that very difficult to ask a question. So, once you know that this is heat sink what is the use of heat sink right, but if you do not know what is this thing then it is very difficult to ask. So, understand the terminologies understand what are the components around in the circuit and then you can have lot of questions out of your curiosity your interest right

So, let us see the thing that we have already seen in the last class, and which is your integrated circuit, right? I have shown you this integrated circuit, isn't it? So, this is integrated circuit, how about this? Is this integrated circuit? Yes, it is also integrated circuit. Only difference is the number of pins. So, what is the difference between this and this particular IC here? This is opamp which is single opamp; this is a quad op amp. Quad opamp is 4, 4 op amps into one integrated circuit quad op amp right. So, instead of using 4 ICs which is single op amp, you can use one single IC which are all 4 opamps integrated into one single IC.

So, the advantage of using this is it will require lesser space compared to single op amps right. So, this is about the operation amplifier, we will see in detail what are the parameters operation amplifier, and we will correlate with lot of experiments, that what is a use what is the application of this particular operation amplifier. So, for understanding the applications for understanding the experiments, we should first know what are the indicator circuits, what are the resistors, what are capacitors, right? What are diodes, right? And then we should also know what are the DC power supply.

How the power supply comes into picture, right? How we can give biasing to this op amp, we have not seen we will see in the class number 2, or we have seen the class number 2 or 3 if I correctly remember, that when we use an operational amplifier, we have to give a bias voltage. This bias voltage is a DC voltage this DC voltage is given using a power supply it is a DC power supply. We will see in this set of experiments,

how the DC power supply looks like and how we can use DC power supply. What are the newer version of DC power supply, what are the older version of DC power supply, it is variable not variable we will see this kind of things anyway.

So, how we will let us say we do not have this integrated circuits? We do not have integrated circuits. And what we have is, we have all the discrete components. We have discrete components that is your transistors, we have discrete components, that is your resistor, we have discrete component, that is your diode we have discrete component that is your capacitor, right? So, you have transistors resistor, diode, capacitor, you have light emitting diode, isn't it? Now and you have a MOSFET.

If I want to use these components, right? And I want to create a circuit to test the circuit. So, there are two ways, one is you make a PCB printed circuit board, you can see here in this one, right?

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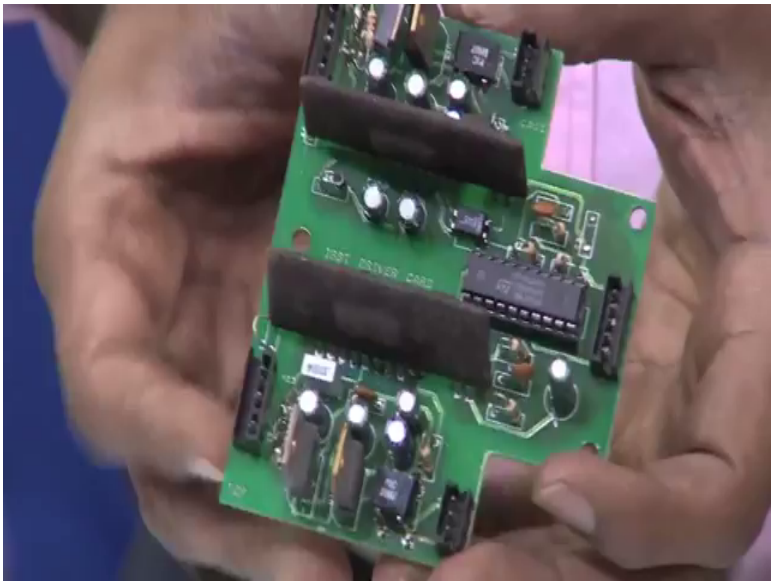

Printed circuit board on which you have mounted several components including your integrated circuit, where is it here, integrated circuit, right? You have capacitor where is capacitor now you guys should know, this is capacitor it looks like capacitor, right? What is matching to here? You see, this one, capacitor, then there are 2 capacitors here 4 actually 1 2 3 4 can identify yes, all right? Then you have capacitors here, here then you have then you have ICs right, you have indicator circuit, you have resistors can you see resistors, then this is also capacitor.

This one, this brown one, yes, this one, this is your paper capacitor it is a paper capacitor, all right? Resistors, capacitors and then your ICs everything mounted on single printed circuit board, how it is how it is connected is connected using a process called soldering.

It is called soldering, you can see here it is all soldered it is solder; that means, that once I have this PCB I solder the components if I test the component, and circuit may not work or it is not working. Then it is very difficult because we have to de solder it we have to remove the solder, then only we can plug this out that is plug the individual components out of the printed circuit board out of this circuit right.

So, what is the alternative to this is there a way that we can test it, and then we make this PCB. So, we do not have to alter these things again and again right. So, for this particular same way if you see this one right, it goes to many more complex layers. But you see this one right, is even more complex, even more complex right see.

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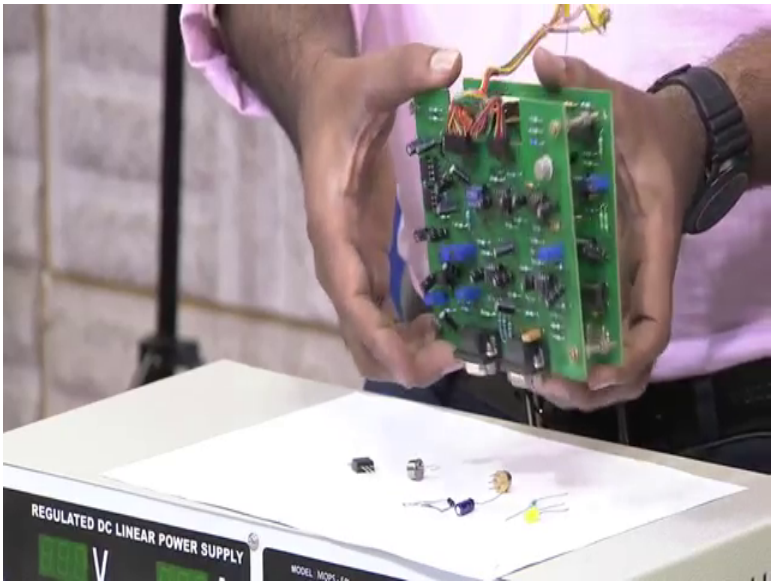

So, many components solder together see soldering solder together, now if something happens and then there is a fault it is, we have to first understand, where is the fault if you find out the fault let us say capacitor is faulty, your IC is faulty you have to de-solder it and you have to take it out.

Now, doing this thing is a big pain and which is not ok. That is why what we can do we can test this component test this circuit before we do the soldering. So, where we can test

this circuit, right? There is the next question, how we can test? This circuit if I if I cannot shoulder it why is there an alternative arrangement to test the circuit. So, the answer is yes um.

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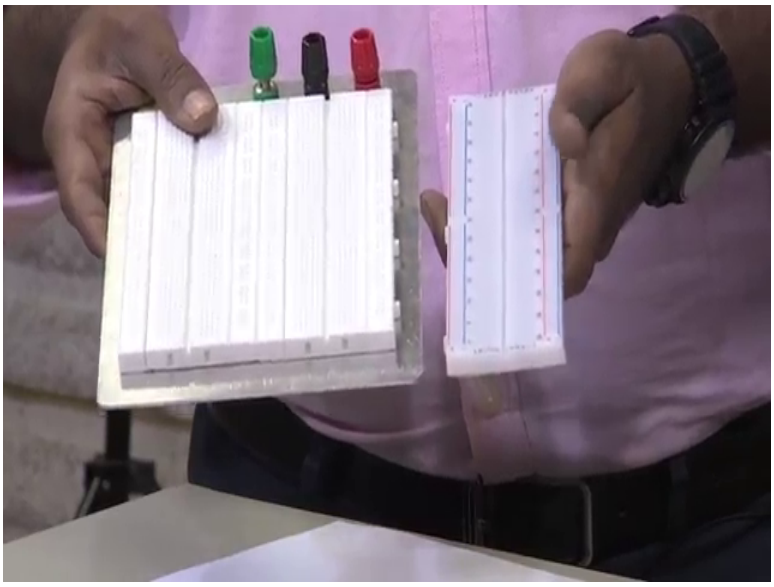

Answer is this beautiful thing in my hand here, right, maybe you cannot see because my of my pink shirt. now you can see it is zoom in. This is called breadboard, breadboard name is very interesting right. So, it was earlier used to actually cut the bread, it was a polished wood used to cut the bread, right.

And later in 1970's people have invented this particular board, and we call this a breadboard. It is also called as a, with a different name for us recently or in most of the universities or most of the instructors they will tell you use breadboard. This is breadboard; this is also breadboard, right? Easy, advantage here, you do not have to do any soldering. You do not have to do any soldering. The breadboard is integrated or internally it is connected internally it is connected.

Now, here you see, this line and this line right, there is rows and there is columns. So, you can use either positive see near newer board breadboard comes with this sign. So, it is easier here this in positive plus you see minus right plus minus or here plus minus. So, you can connect the positive terminal to plus ground to minus right, and then you have rows and columns. So, I can again connect the resister I will just show it to you, this way, you see? Easy to connect, right?

So, if I make the entire circuit on the breadboard entire circuit. So now, again understand, this line that is let me show it to you with another resister. This particular line, this one, straight this is connected this is connected. The next one is not connected to second one. So, so let us focus here, let us focus here, all right? Yeah, this one is not connected with the next one, but this one, this one is connected to here.

This whole column if you consider this as a column my line is a column, whole column is connected. But the next one is not connected with the first one, all right? That is why I connected resisters like this, not resister like this. You see, anode kind of resister like this, is it correct? So, anyway the you will know and I am sure that you have used this breadboard the point that I am making is that you can use this breadboard to create entire circuit, which you are looking at here instead of this PCB, create the circuit on the breadboard, and then test the circuit. Once your circuit is ok, then you use this particular printed circuit board and solder your components, right.

So, breadboard is an alternative approach is a is a is a better approach to fire to make the circuit, and test it and then we move on to the printed circuit board, all right? Now because there is lot of time, you know, this positive negative is here, but what about this particular breadboard. Can you see this particular breadboard? It does not have any sign; positive, negative; can you see any positive negative sign? There is no sign, right.

So, alternatively we can there is a connection given to this breadboard such that is the red one, this is the red is not actually connection. You can use any line as positive any line as negative by connecting this terminal. So, you do not have to use the pins, you do not have to use the wires to connect it here, you can use directly DC power supply you can give the ground to here positive to here and so and so forth. So, it is a easier way of using a breadboard, but this is a bigger size of the breadboard compared to this breadboard; that means, that you can you can have bigger circuit here, or you can have you can test multiple circuits on the single breadboard, right? Disadvantage of using a breadboard compared to the smaller breadboard.

Now, when we say that we are using the breadboard we are we are mounting the resisters we are mounting the capacitors we are mounting transistors. First thing is, that whether the resistor we are using ease of the value that we want. For example, if I say that we

want to use a resistor of 100 ohm. How you make sure that? The value is 100 ohm right. So, to understand this thing we have something called multimeter.

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You see, this is how it looks. I am sure again like I said earlier that lot of people a lot of you guys have already seen how a multimeter looks like. For those who do not know how multimeter looks like for them, this is the multimeter. And I will show it to you, the functions of the multimeter in actually actually ok, just now I am just showing it to you this is how a multimeter looks like, all right.

This is a multimeter, you can just focus it if you can. Same way, this is also a multimeter all right. Both are multimeters um, you can see digit, you if I turn it on you will see some digit, right. You I if I turn it on we see some kind of digits right, actually it is not connected so, it is showing 0 right.

So, these digits that is why it is a digital multimeter, digital right; when you can see this play you can see the readings right in terms of digits digital multimeter. Now, we will see what are the functions or what are the things that we can do with a multimeter, all right. So, one is on my hand, and it is easy to identify I can refer like it is yellow, right this is orange and gray, right.

Now, let us see the role of each digital multimeter, and how I can measure the components, all right? So, for now let us quickly understand that we have components,

we have resistors like components like active devices passive devices. And then we have a breadboard, and before we implement a circuit on the breadboard right, before the final implementation of the circuit on the PCB we have to use the breadboard, and before implementing on the breadboard, we should know what is the value of each component. To measure this value, we can use this particular equipment called a digital multimeter.

Now, the there are probes, these are called probes, all right? Which is in my hand probes you see, one is red, one is black easy. One is black, one is red right. So, black is ground or common right and you will see here, if I just take out this probes, you see here, what is written? Volt ohms right, see volt voltage and ohms resistance right, then this is common, common.

There is written here warning is a warning 1000 volts DC, 750 volts AC, 1000's-volt DC, 750 volts AC may means that you cannot operate this equipment at that particular voltage is. This too high, it will cause damage or it will damage the multimeter, you cannot go to that.

Now, if you want to measure current, right this voltage, and resistance, if you want measure the current, then we have this milliamperes and amperes you can see milliamperes ma amperes a capital a here, right? Now there are several functions on this multimeter, several functions all right; which we go from here, and then we actually measure the value of the components, all right.

The first thing, let us see, this is off. So, can you go to the display see display is off all right this is off, easy. Now we go towards, this side, this is AC voltage. Can you little bit focus? Yes, very good, 750 volts AC. Now, we go further 200 volts, AC maximum it can measure 200, if you give 350 volts, you cannot see anything. If you want to measure 350 volts, you have to convert back to 7 50, all right?

These are knobs 200, 20 2 right, 200 millivolts. Same way DC ampere right, 200 microampere to that range 2 milliampere, then you can go down right 200 milliampere 20 ampere similarly AC voltage here you see, 20 ampere 2 200 microampere, then we go to this particular section, which is called HFE, this is used for measuring the transistor. You can see here, it is very easy, right NPN transistor or PNP transistor, right NPN, PNP transistor.

So, we will see how we can attach the transistor, and what kind of display we will see on the multimeter when we do the actual experiment. Now let us go to the next section, which is your what is this off, again it is off here one off is in the same. It is 180 degree, right if you consider 0, it is 180 all right.

Then next one is diode, next one is for understanding this short circuit is easy to understand if the if there is a continuous connection. Um that also we will see then we have this resistance you see there is a ohms, right, here we can see there is a symbol ohm ohm is for resistor. We start from 200, we go to 2 kilo ohm 20 kilo ohm 200 kilo ohm 2000 kilo ohm or you can say 20 mega ohm and 200 mega ohm, until 200 mega ohm it can measure, right.

Then we go to DC voltages, DC voltage starts from 200 millivolts 2 volts 20 volts 200 volts one 1000 volts, right? And we come back to our original point which is your off this is the function of this particular multimeter.

Now, can this multimeter measure frequency? No, there is no option of measuring the frequency. So, how about we see the another multimeter, right which is the orange one, let me switch it off always remember if you do not switch off the multimeter it will consume the battery. It will consume the power there is a battery here you can connect, you can open it and you can insert the battery, and the back side of the multimeter this operates on the generally 9-volt battery.

We see another multimeter, again in multimeter there are probes these are called probes right p r o b e s probes, all right? I will remove this one, remove this ok. Now, off you can now see anything correct, now what are the different things here one is towards here if I go towards this side right; that is, towards the in the in the anti-clock direction, if I go anti clock then I can see voltage, right? This correct?

And if I go in a clockwise direction, clockwise then I can see current you see 10 amperes AC and DC it can measure both AC and DC go to milliampere, go to micro ampere, right? If I go to anti-clockwise, I see voltage AC and DC you see if you still focus further if you can the single line straight line is DC, right? A sign wave kind of thing; you see here, sign wave kind of thing. This is your symbol for AC alternative voltage DC direct current or direct voltage ok.

So, next one, here what is that you can measure capacitor, you can measure diode. You can measure resistors, all three things you can measure, right? You can change the mode here you see there is a auto power off is a auto mode you can see here auto mode is there, right, you can change the mode from auto to capacitance mode or resistance mode, or the or you can change the value, suppose is a higher value of resistor you can again change the mode**.**

Now, next one would be your hertz. See, this function was not there in the earlier multimeter. Hertz is nothing but frequency right. So, we can measure the frequency using this multimeter, we cannot measure the frequency using the this particular multimeter. I am not telling that this multimeter is better than this multimeter. That is not the goal of this lecture series; so, do not worry about who manufactures it; that is not our idea of telling you by this multimeter by that multimeter.

Our idea is to understand if you get a multimeter or if you have the multimeter which what are the parameters within the multimeter that you can use it and you can operate it for measuring different components, or other parameters like DC voltage, AC voltage, DC current, AC current resistance capacitance frequency, right? you can also measure temperature, and with advancement of electronics like I said that, there is more analog electronics in a in a digital multimeter. If you see this multimeter if you really open it there is lot of analog components.

But anyway, the that the point that I am making here is, now we have one more thing which is your temperature. So, if you see here, this is on the temperature; that means, we can also measure temperature. So, what we can measure, we cannot only measure the resistance, we cannot only measure the capacitance, we cannot only measure the frequency we can also measure the temperature; that means, what is the room temperature right now, or what is the temperature of particular surface that we can measure.

For that we need a separate probe, all right? And this probe is here so, I will put this multimeter down because right now our function or our application is to measure the temperature.

Do not worry about the company like I said, you select a best thing for example, if somebody wants to buy multimeter, they will go for fluke, it is it is even more precise

more costly right, but we right now the goal is not to understand which is costly which is precise, goal is to understand if you have a multimeter, can you measure the resistors? Can you measure the capacitor? Can you measure the devices? Can you measure the components? That is the only goal all right.

So now we have this particular sensor, we have nothing but if you see the tip it a tip is so, let me show it to you so that you can see the tip, yes, yes, you can see the dot here right. And that tip is nothing but your thermocouple, you can see. You can see here, right. This tip, this one is your thermocouple, all right

So, we will see the function of thermocouple somewhere, sometime else, but understand that this is also kind of temperature sensor it can measure the temperature. Now, whatever temperature is measures is gives the output in terms of millivolts. So, if your if your electronic circuits already know that the millivolt obtained at the output of this particular sensor, and you have the values you can correlate it with respect to temperature.

So, here you will not be able to say millivolts, here you will be able to see degree centigrade, you see here degree centigrade. So, how to connect this probe to this particular multimeter, all right? So, here again you see here what is the 10? 10 ampere current, next common ground, right here see volt, resistance, temperature, hertz, milliampere, micro ampere means you can if you measure voltage, you can connect to this particular terminal.

You have to connect temperature, you have to connect between this and common, if you want measure frequency, you have to connect this and this if you want to measure milliampere microampere current you have to measure this with this. And this only when it goes to higher current higher current is 10 amperes ns in amperes, then you have to connect these particular terminals, all right?

So, what I will do is, I will open this right there is this thing. So, we open it, you see here and then we open the other one. Now, we will insert it now, it is very easy right black and red I said black and red. So, keep it like this, what I have done I will open it again to show it to you what I have done you see red goes here black is common right and we insert it, right.

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Now, if I keep it here it is in temperature, this is a thermocouple right. So, it will try to measure what is the temperature of the this particular room. And what you can see is it is around 22 degree centigrade, why 22 degree centigrade? Because air condition is on; so, is around 22 degree centigrade all right. So, it is kind of it is kind of easy way of utilizing multiple things within the same device, right. So many things you can do by having just a single device.

But if I touch this thermocouple, you will see the change in temperature, if I touch the thermocouple; you will see the change, because the heat here in my hand within to 2 fingers is more than the room temperature. You can immediately see the change in the in the temperature, that is degree centigrade right from 20 to 80 and to 29, 25 if I generate more heat by rubbing the hand it will even show more, but again the point that I am making is there is a provision of measuring a temperature, there is a provision of measuring frequency.

So, do not come under the impression that the multimeter cannot be used to measure frequency; the multimeter cannot be used to measure temperature, right. There are devices that we even do not know right, and there are there are equipment that we are we are not able to understand we are not able to utilize it we are not able to look at it in our undergrads, right.

Because we all come from universities, where they focus on theory, and they focused on certain set of experiments; but they may not have enough facility to give you all the components which are high end technology. That is absolutely correct, that absolutely fine no worries about that. What you should understand is, that given a given a set of equipment what is a use of those equipment, and can you use it for particular experiments, right?

So, the final goal is not to understand just the equipment or just the devices or just the integrated circuits final goal is to apply it. Until you apply, it again I am saying this again and again theory is very important, theory is extremely important. But if you do not apply into practical it is not useful.

So, use theory understand theory, I am talking about this particular lecture, again, right it depends on if you if you take a mathematics, right, again if you see mathematics also there is a lot of application of mathematics lot of application of physics lot of application of chemistry, right?

So, actually it until unless you translate it to experimental your theoretical knowledge you are not doing justice to your theoretical knowledge that is what I can say. So, let us see now what are the experiments that we will be performing in a course of time, actually before we move to the list of experiments that we will be performing in the course of time, first my idea is that you should know that what are the equipment.

So, we have now seen if I quickly repeat, we have seen this DC components, we have seen PCB, which is this one, this one, then we have seen the soldering. We have seen what is alternative to that which is your breadboard yes in this breadboard, right. Then we have seen multimeter; multimeter is a device that can be used to measure resistance, capacitance, right? It can be used to measure temperature it can be used to the frequency, it can be used to measure the diode, it can use to measure NPN and PNP transistors whether transistor is NPN whether transistor is PNP right and so and so forth; So, very important device.

Now, let us move to the next set of device one by one, and before we move to the next set of device first, let us see how multimeter is used for measuring the different components, all right. So, for this particular module, this is the end of this module, and the next module, we will look at the different values of the discrete components, all right.

Thank you and I will see you next model.