Design Practice - 2

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Lecture – 40

Hello and welcome to this final design practice 2 module 40 you may have recalled perhaps that in this particular week we started with an introduction to McCann mechatronics lecture followed by a lab level demonstration of a very simple process of control of temperature on a small microchip using national instrument Labview. The purpose of doing this in this particular course was that you should be aware of some of the tools which are very commonly used for you know developing a man-machine interface.

And that can be translated very well into some of the principles of mechatronics at least on a prototyping level on a first hand you know maybe the first version level. Obviously more of embedment and integratability to controllers comes at stage 2 which may really not be in the scope of this particular course. But the idea was to enable you to sort of get to know about how you could interact you know with real systems real world systems by building up an interface through a machine a computer and you know you can rapidly through some programmable logic be able to operate you know on such a system.

So, today we will actually continue process ahead of this whole you know introduction to mechatronics lecture and delve a little more into the aspects of sensors, transducers I think we had had a very good description of sensors while doing the MEMS part of the modules but this particular illustration would be again sort of a recap of a little bit of recap about sensors but with more focus or emphasis to some real-life sensors which are being utilized more analogous and more again related to the macro world.

What we did there was more related to the microsensors and then a few slides of this whole idea of intelligent product designing and how it can be integrated with mechatronics ok. So, let us start this particular modules we were talking about sensors.

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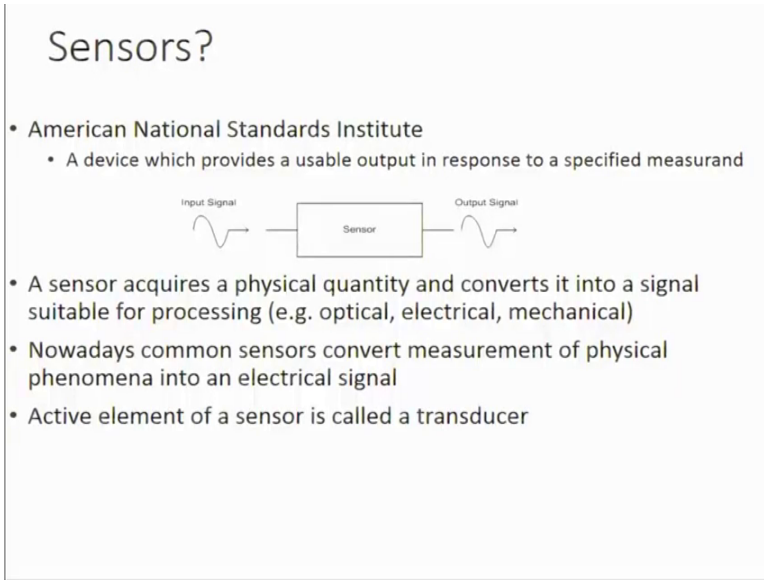

So, if I looked at and saw the definitions are set by the again the ANSI the American national standard institute, sensor is something it is a device that provides an usable output and this output is in response to a specified quantity which can be measured, we call this measure end. So, if this is an analyte it is a chemical analyte it gives you some kind of a signal which is transduced into machine-readable signal maybe electrical or optical.

And eventually can be digitized or eventually can be made into a readable response you know through machines. So, that is what the standard definition is now a sensor may acquire physical quantity and convert it into a signal suitable for processing our signals could be optical electrical mechanical you learnt some things about transduction which is about this conversion. Now very commonly because we are talking about you know computer assistants on one side and that you know the enablement of digitizing everything.

So, therefore it is quite common these days that sensors being degraded to physical phenomena which generates an eventual electrical signal ok. So, this becomes more integrated to the existing platforms you could read them you could you know work out measure them and you could actually give some decisions based on their levels ok which would eventually mean the presence or absence of a certain signal.

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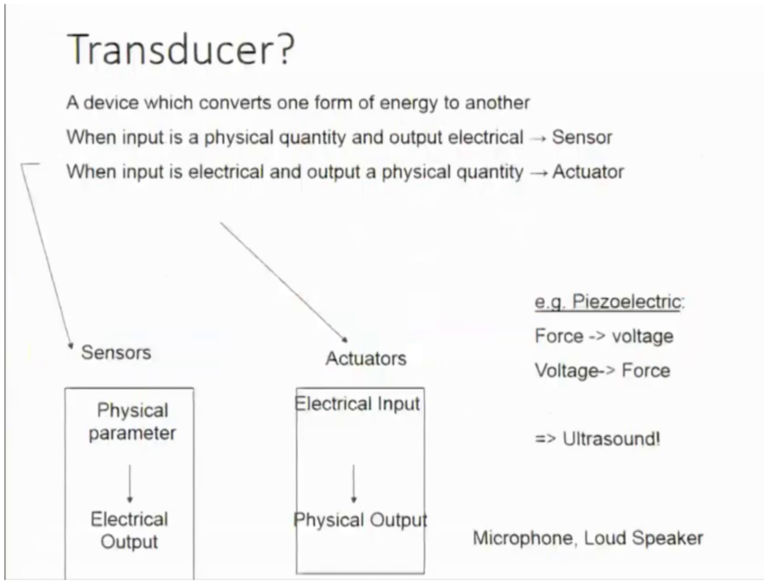

So, the active element of a sensor that is there is called transducer again which would measure or convert this into the corresponding electrical signal and what really is a transducer it basically again converts one form of energy to another. The input to a transducer could be a physical quantity the output could be like electrical signal okay coming out of the sensor. If supposing we are talking about a sensor typically all the inputs are in the physical domain the outputs are in the electrical domain.

But it could be the other way around as well if it is an actuator then basically there is another conversion that you give it an electrical or maybe a optical signal and the output is always a physical quantity in terms of a motion in terms of you know displacement a relative displacement so on so forth. So, that is in principle the conversion process of one form into another. A very common example could be for example the piezoelectric sensor or the piezoelectric stage which could be used for a small displacement.

So, in the piezoelectric sensor for example we could sense a force and produce a voltage. So, if there is a force which is in the in the shear direction or maybe in the lateral direction it would produce sort of a response based on the piece of coefficients in these various directions. Alternately it could be the other way around that if you provide a voltage signal to a piezo across its two plates it may result in some kind of a motion it could be a vibration motion if the signal is alternating current signal so on so forth.

So, you are producing motion okay by at the cost of some energy input okay which is in an electrical form. So, this again is a piezoelectric so in one case this acts as a sensor when a force is converted into a electrical response and in the second case it acts as an actuator when actually the electrical response is converted into a mechanical you know parameter. Other examples could be microphone or loudspeakers which convert the; you know the voice of a particular speaker into electrical signals from one end.

And in case of a loudspeaker the vice versa that is the electrical signal which is much more amplified in between to the eventually a very loud sound which is audible to a lot of people so in one case this guy acts more like a actuator where so the microphone acts as a as a sensor where a typically a set of compression and rarefaction is converted into some displacement of a membrane through which you know piezo of voltage can be generated.

The other end the loudspeaker act is like more like a actuator where there is an electrical signal which is in place and you know is able to assist the movement of the bass and the Twitter as normally is present in a loudspeaker to create a high level you know acoustic energy which can be perceived by many.

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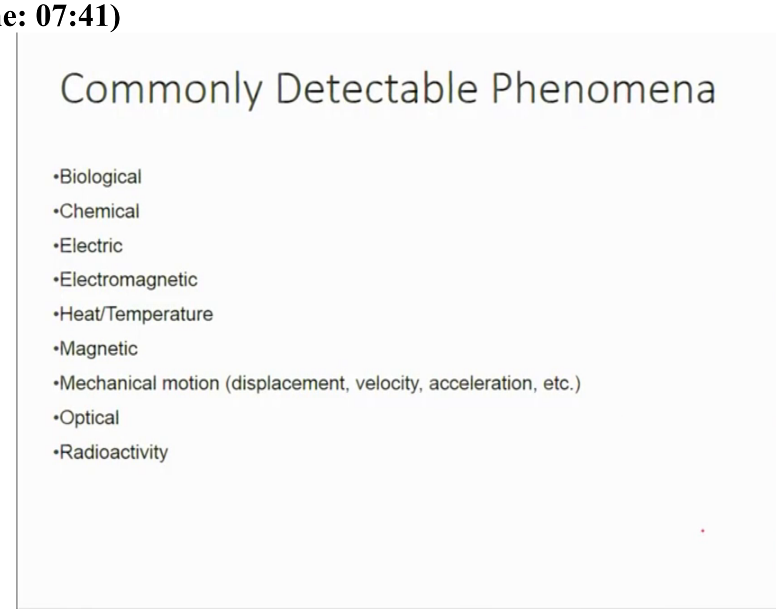

So, I think we have made this definitely very clear again if you look about sensing what you know and what are the typical detectable phenomena which exists where sensing is needed there are biological phenomena, chemical, electrical, electromagnetic phenomena heating temperature related phenomena, magnetic phenomena and then there are mechanical motion for example displacement velocity acceleration etc this optical phenomena or radioactivity all of them are detectable or detectable in the sense that they generate a stimulus which could be actually sensed by a sensor and reading output can be deciphered from the sensor.

So, that based on the output a corrective decision can be taken beat Diagnostics or beat you know related to motion or magnetic field or even radioactivity etcetera.

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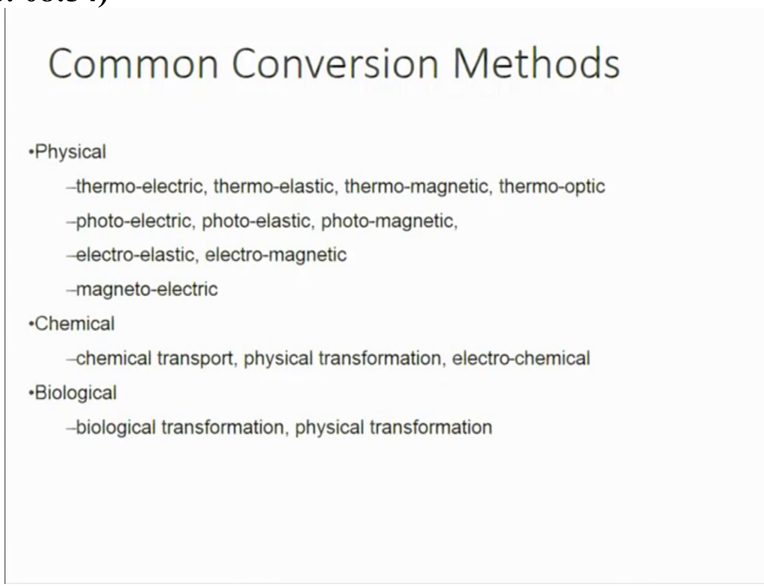

So, the common conversion methods are classified again based on what you are converting as you know the principal source of the measurement. So, the measurement is physical in nature it would cover lot of domains like thermoelectric, thermoelastic, thermal magnetic, thermo optic again photoelectric for elastic for the magnetic electro elastic magnetic electric electromagnetic so on so forth. So, these are all weather measurements are physical in nature okay and you are converting them into signals which either magnetic or light based or again electric in nature.

When we talk about chemical sensing we are typically referring to chemical transport physical transformations of molecules talking about electro mechanical electrochemical sensing so on so forth where the measurements happen to be in mostly chemical domains. If the source of the analyte happens to be biological where the measurement actually is a some kind of a biological transformation process or a physical transformation process that we are studying then the sensor actually falls in the biological sensors domain.

So, I think we had very clearly Illustrated when we had talked about MEMS about all these three physical chemical and biological sensing systems.

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Commonly Measured Quantities

Stimulus	Quantity
Acoustic	Wave (amplitude, phase, polarization), Spectrum, Wave Velocity
Biological & Chemical	Fluid Concentrations (Gas or Liquid)
Electric	Charge, Voltage, Current, Electric Field (amplitude, phase, polarization), Conductivity, Permittivity
Magnetic	Magnetic Field (amplitude, phase, polarization), Flux, Permeability
Optical	Refractive Index, Reflectivity, Absorption
Thermal	Temperature, Flux, Specific Heat, Thermal Conductivity
Mechanical	Position, Velocity, Acceleration, Force, Strain, Stress, Pressure, Torque

So, if we look at commonly measured quantities using some of these sensors we have acoustic sensors which typically work on measurement of the whole acoustic wave, wave means amplitude you know phase of the wave polarization aspects of a wave so on so forth. It talks about wave velocity talks about the frequency spectrum. When we talk about biological and chemical stimulus the commonly measurable qualities are the concentrations, concentrations of various substances which are either in gaseous or liquid forms.

When we talk about electrical stimulus this could be in terms of a charge, a voltage you know some kind of current, electric field, field could have again amplitude phase or polarization aspects you could talk about conductivity permittivity so on so forth. When we again mention magnetic in the quantities that we are measuring is typically the amplitude and polarization of the magnetic field or the permeability of the material of the medium or even the magnetic flux sometimes.

In case of optical stimulus we are referring to mostly change in refractive index reflected with the absorption spectra so on so forth. In case of thermal you know measurements we are referring to temperature of flux specific heat thermal conductivity mechanical measurements it would include position velocity acceleration force strain stress pressure torque so on so forth so. These are the commonly measured quantities by different sensors.

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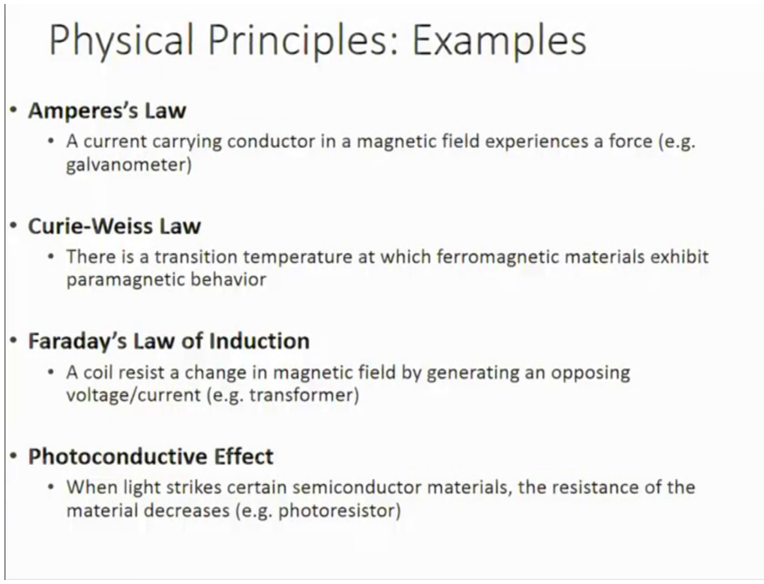

We do use many physical principles which account for most of these conversions between or transactions between one form of energy to the other. One of the very commonly used physical principles is the Amperes's law which talks about the magnetic effects to a current carrying conductor. So, when a current carrying conductor is placed in a magnetic field it experiences a force a very common example is the galvanometer which is based on the principle you know of the Amperes's law.

Again we have the Curie-Weiss law which talks about the you know the paramagnetic behavior being exhibited by some ferromagnetic materials at a certain you know range of temperature otherwise known as the transition temperature or we can talk about Faraday's laws of induction where a coil always this a change in magnetic field by generating an opposite voltage or current when placed in such a magnetic field.

So, we could also talk about the physical principles behind photo conducting effect which is quite commonly used to outlay some of the sensors and actuator principles. In this particular effect the concern is about light strikes to a semiconductor surface okay semiconductor material surface which changes the resistance of the material typically decreases example in the case of a photoresistor.

So, therefore there can be an intensity measurement performed of the incident light by looking at such delta RS or change in resistance you know of the material.

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Choosing a Sensor

Environmental Factors	Economic Factors	Sensor Characteristics
Temperature range	Cost	Sensitivity
Humidity effects	Availability	Range
Corrosion	Lifetime	Stability
Size		Repeatability
Overrange protection		Linearity
Susceptibility to EM interferences		Error
Ruggedness		Response time
Power consumption		Frequency response
Self-test capability		

So, that is the photo conductive effect how to choose the most appropriate sensor so you base your choices on many factors for example principle consideration is again the environmental factors. These are the most important in choosing sensors because the you know the sensors would have a life you know based on the operating conditions. For example some of the commonly used operating conditions could be the temperature range over which the sensor needs to be used or the effect of humidity, effect of corrosion, size over range protection, susceptibility to electromagnetic interferences.

You could talk about power consumption you could talk about self test capabilities or ruggedness these are all the environmentally assisted factors which would be the first choosing guidelines for what kind of sensor needs to be deployed or sensors need to be somehow graded to some of these environmental conditions where we can ensure that even though some of these fluctuate very rapidly the sensor will still have its normal performance.

There is also a set of factors about the economic viability or feasibility of the choice that you are making terms of a sensor it could be in terms of cost, availability lifetime of the sensor there are also characteristic based choices for example what sensitivity is needed by the sensor? What is the range across which it needs to operate? What is the stability in the; what is the necessary stability for the output you know how repeatable would be the sensor or what is the linearity that the sensor must provide? Is this linearity in a certain range example in temperature sensors.

This is very widely made observation that as linearity proceeds across different ranges of temperatures. There may be a possibility that towards the higher range linearity may not maintain itself because of changing physics with the concern material which is in question okay. Again you can even choose sensors based on the errors that are permissible in the system where the sensor needs to be integrated.

You can also base it on the basis of response time in gas sensors this is a very critical domain information that how much time would typically be needed for a sensor to respond and recondition itself for the next measurement. Again the frequency response also happens to be a very important characteristic for choosing a sensor.

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So, these are some of the criteria's for choosing such sensors the need for sensors are quite pervasive they today in you know if you look at all around you there are so many different aspects in which sensors are needed sensors are within human bodies they are within all automotives intelligent systems, airplanes for example cellular phones, radios, chemical plants industrial plants. If you look at the domain it is so vast that it is almost countless you know there is a need for sensors are almost all steps to safeguard to protect you know to make sure that you know systems are within control.

And typically we can we can call this or we can make this statement saying that without the use of such sensors you know which actually is able to monitor and feedback the signal. There will be virtually no automation possible so sensors do form a very, very important aspect of almost all mechatronic systems intelligent systems what we are discussing in this particular module.

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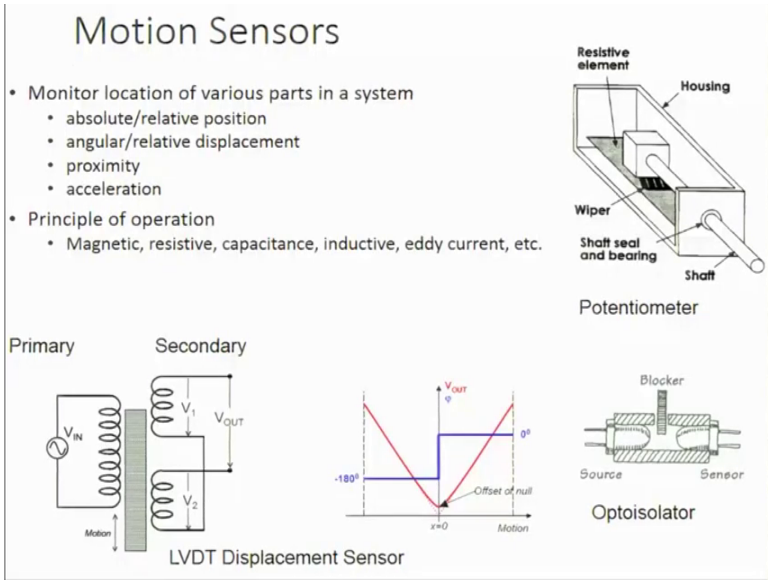

Let us look at some of the interesting sensors which are very commonly available which used mostly in day to day life. The first example that comes to our mind is motion sensors you must be quite aware of such you know sensors in almost all engineering systems which has a relative motion between its components. So, such a sensor would typically read the absolute or the relative position or the angular or relative displacement or even the proximity or sometimes the acceleration of moving parts.

The principles of operations are many fold for example there can be magnetic motion sensors there can be resistive sensors capacitive sensors inductive sensors, eddy current based variety of other methodologies for doing sensing here are some examples this is the very commonly used potentiometer which is represented through this wiper which wipes on this lower stage which is a resistive element.

There is a motion associated a forward motion associated with this shaft you know across the shaft and sealed bearing shaft seal and bearing in the forward manner okay through this element right here which forms a part of the circuit. So, the idea is that if this wiper goes ahead with forward motion from this you know block shaft assembly there is an inclusion of more amount of resistance okay as a function of motion.

So, as the resistance changes we could we could see that motion is being executed. So, if supposing a linear motion provider which is needed to be sensed is coupled to this system which helps to propel the shaft in the forward direction along with the block it will show up you know if I connected this to a voltage divider circuit and assume that motion gets executed means the resistive change is there.

So, you know in a very simple manner you could see you could look at the resistance per at length and actually compute the velocity of motion of an object connected to the shaft right here okay by looking at what is the Delta R as a function of time. So, this is one of the very simple motion sensors on the other very commonly used is this linear variable displacement transducer. We commonly call this as LVDT so the LVDT or the linear variable differential transformer is based on actually a AC transformer with a primary coil and a secondary coil.

You know as you can see here in this layout and a core which is magnetic in nature and is capable of moving up and down. So, the idea is that if the core moves in a bottom-up manner and covers more of the secondary coil there is a change in the output which is measured between these secondaries the two secondary coils you know as you can see here okay laid out here. So, any small motion would be very sensitively detected through this particular mechanism.

You can see that at X = 0 there is an a certain output response which is there which actually changes if X you know oscillates to either end of 0. So, if it goes down there is a signal okay with change phase if there is a motion you know bottom up there is again a change in the output with the change in phase across the zero. So, this our LVDT works are not the very critical motion sensor is you up to isolator which is again used to sense angular or relative displacement you know relative angular displacement motion.

So, here you can see a sensor and a source of light which is being cleaved through a small blocker and the idea here is that the blocker can either move in this direction or a blocker could be some kind of a rotor which can actually chop the signals coming from the source to the sensor ok. So, the light signal get chopped off you have certain response which will indicate which will basically try to account for the angular rotation of the linear motion. So that is how you can use various principles to sense motion.

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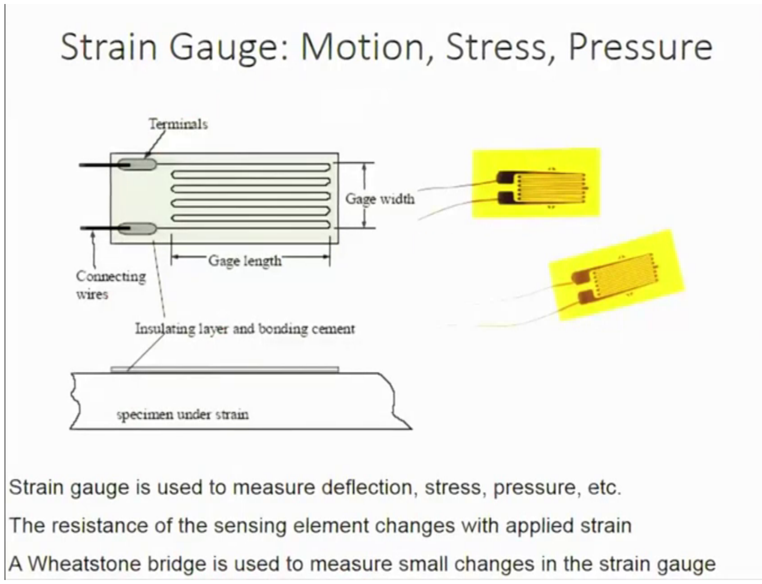

Now the very important you know sensor which is used in most of the times in all you know motion stress or pressure measurements is the very popular strain gauge okay. So, the strain gauge is typically used to measure deflection stress pressure and a bunch of different mechanical parameters. The idea here is that it is a simple element it is a simple resistor element whose resistance would change on different applied strains.

So, as this particular element is bent or deformed it will change the overall resistance and we can calibrate the extent of motion or the extent of deformation to in terms of the applied strain to the change in resistance for getting the strain induced in a real life system looking at that calibration data for different terms. So, typically the resistance range can be very commonly seen through a Wheatstone bridge so the bridge is used to measure small changes in the strain gauge.

The idea here is that when this element is pasted on the top of this mechanical member which is actually the specimen under the applied strain. The electrical signal coming out of this sensor would give you an idea of how much the mechanical member has compressed or expanded okay if there were an exiled strain given to the member.

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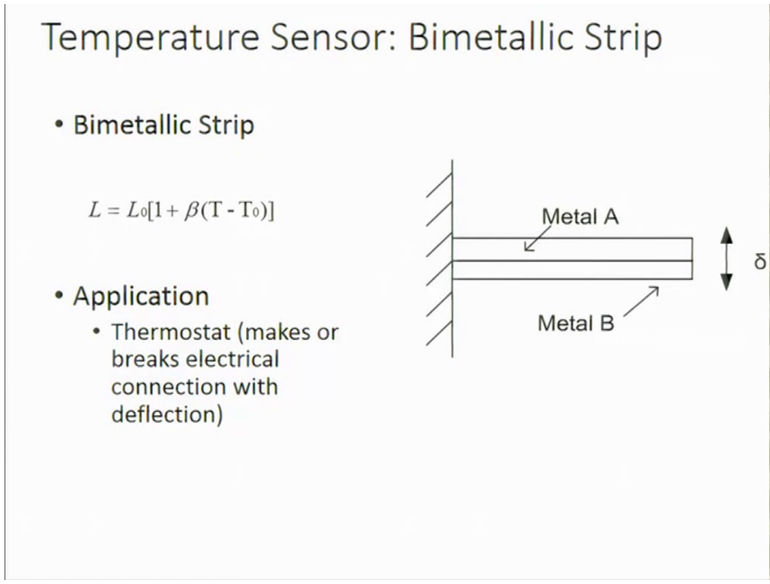

So, another very important sensor is temperature sensors and one of the most common variety of temperature sensors is bimetallic strip. So, the basic principle here is based on you know the temperature coefficient of expansion of metals particularly. In this particular case there are two different metals A and B which has a different beta value okay where a change in temperature would have instantly expand the length of a particular metal starting with length at room temperature being 0.

And at the room temperature being T0 actually so the idea is if there are two different expansivities thermal expand to be expensive these are the metals and they are stuck together. The only way to ensure that all these metals are still maintaining contact is if the metal assembly here or the metal stack here bends up or down. And such bending may lead to either D switching okay or lose of loss of contact Electrical breakdowns so on and so forth.

And it kind of gives you an idea of what is the temperature beyond which on the electrical breakdown should happen. So, typically all the fuses the electrical fuses where short-circuit executed has to be you know used as a call for circuit breakdown or ensure that there is no electric supply. This could be a very good alternative in fact to in the wind towards the very beginning these bimetallic strips were used for that purpose.

Later on of course there have been other modes of electronics being introduced into the design but there is a cut-off based on a certain gate voltage etc. And it leads to the on the circuit to break the electrical circuit to break.

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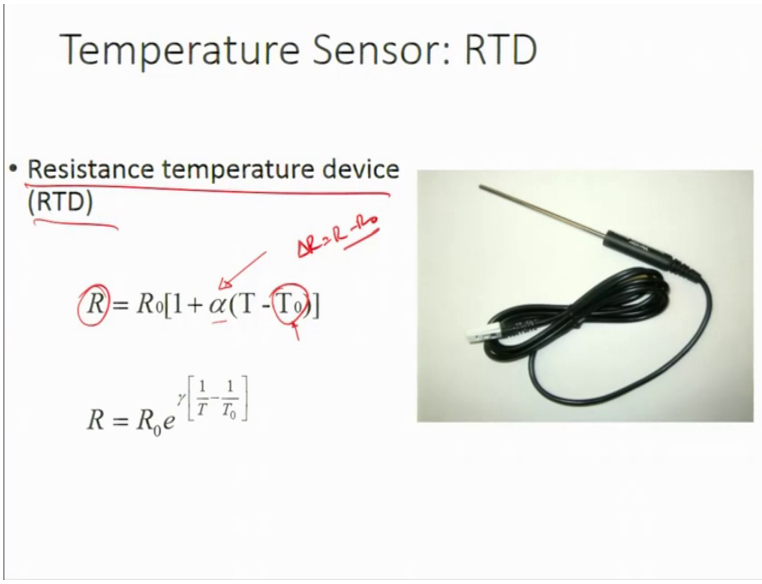

Another very useful temperature sensor is the resistance temperature device RTD we would basically again works on a principle of the change of resistance based on temperature. So, here in this particular case you know the metal is such either it is a metal which is actually which shows a you know linear change or a material where there is an exponential change of resistance with respect to a certain temperature over and above the room temperature.

So, the idea is that as temperature of a certain small region is taken over this value T0 there is going to be a delta R where Delta R is known by R - R0 and this is a very important parameter to monitor you know once calibrated and all what is the temperature at any given point of time okay of particular devices where these IDs are mounted.

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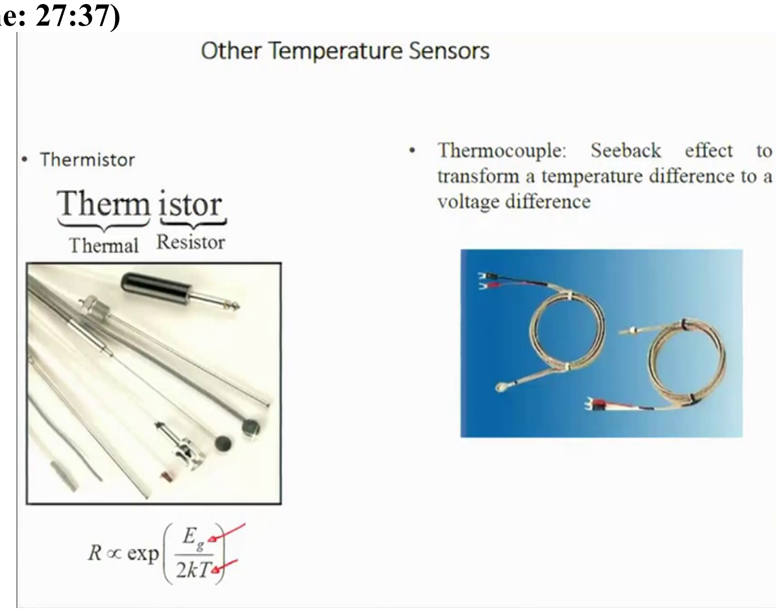

There are a variety of other temperature sensors one of the common sensors are thermistor for example which is a thermal resistor here with change in temperature there would be a change in resistance where this Eg is basically the bandgap particularly in housing sulphide and other semiconducting materials forming a certain kind of thermal resistors or thermistors. So, it basically depends on the temperature state that the electrons are in and the bandgap energy which is there in between the valence and conduction bands the material.

So, other form of temperature sensors are thermocouples based on Seebeck effect you know they transform either a temperature difference to a voltage difference.

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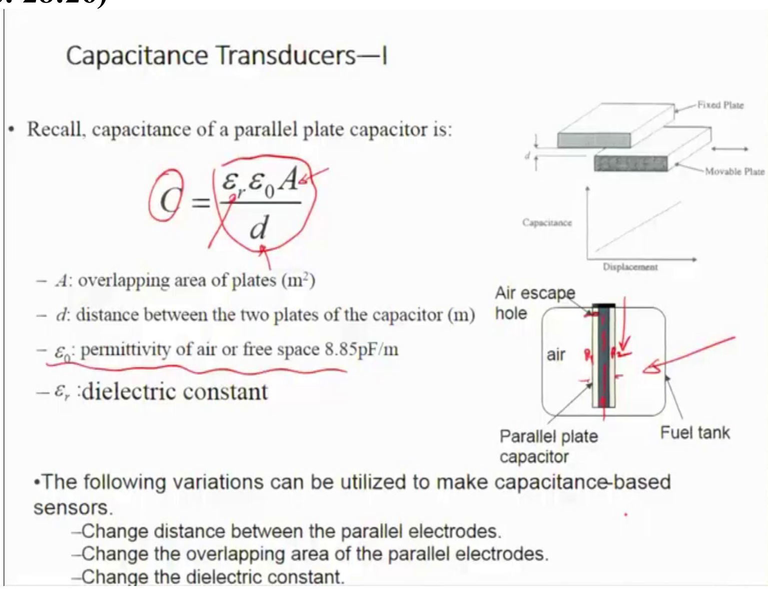

So, these are some of the commonplace temperature sensors available. There are also capacitance transducers which are used in a lot of different applications as sensors the basic principle is a change of any of these parameters you know on the basis of which capacitance between two plates could possibly get changed either there is a change in the dielectric constant of the there is a in the distance between two plates of a capacitor or an overlap area change so on so forth.

The permittivity of free space cannot change so this is our law only constant in the capacitance parameter. One such example could be some kind of a level sensor liquid level sensor where you know there is a capacitance with this air escape hole given for bringing out the air which is trapped in between. And tube across which two metal conductors are placed okay on both sides. The idea is that as a tube as this whole assembly is immersed into a tank.

Let us say a fuel tank sensor for example this petrol or diesel depending on the type of vehicle and when the liquid goes into this to you which changes the dielectric constant and therefore there is a change in the capacitive response coming between these two plates plate p1 and p2 shown by the two open areas. So, it could gauge the level up to which fuel is in a particular tank which is otherwise very which cannot be gauge because it soaked it is completely closed with only you know entry an entry for fuel and breathing out air.

So, the following variations can be utilized to make capacitance based sensors you could change distance between parallel electrodes could change possibly the overlapping area or parallel electrodes again change the dialectic constant okay. And that could give you change in capacitance responsive capacitance.

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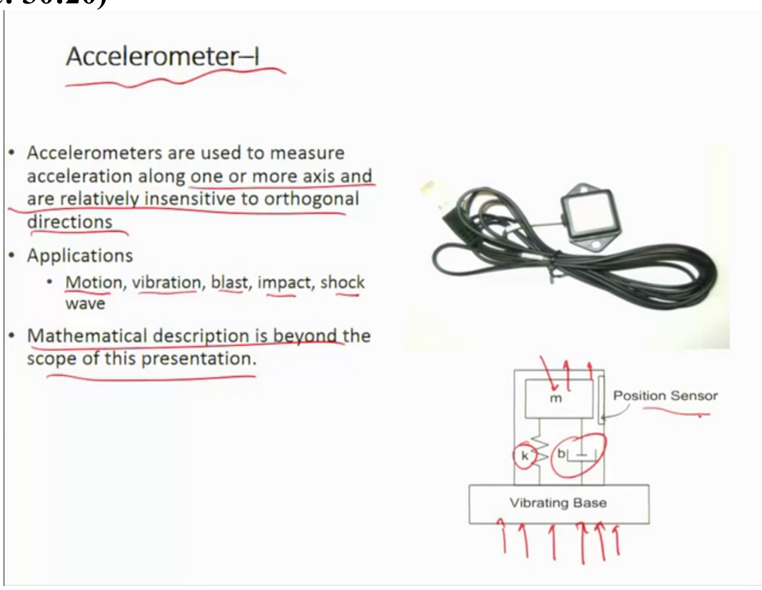

Some of the widely utilized you know capacitive sensors are for example accelerometers these are used to measure acceleration along one or more axis and are relatively insensitive to orthogonal directions. Applications could be in a variety of you know motion and vibration studies. You could actually measure motion measure vibrations blast impact shockwaves so on so forth. And the basic principle is again a vibrating mass with a base which actually transfers the vibrations from the source to this accelerometer.

And the transfer happens through a parallel combination of a linear spring and a damper and based on the motion of the mass we are not actually getting into the mathematical description which is actually more like a UG level problem here it is an overview about how these sensors can be utilized into various products okay. So, there is a change of capacitance because of overlap area between the mass on one side and maybe a position sensor on the other side which would cause again a capacitive signal.

And now the signal is all well calibrated in advance so you could actually measure vibrations for example using such an orientation.

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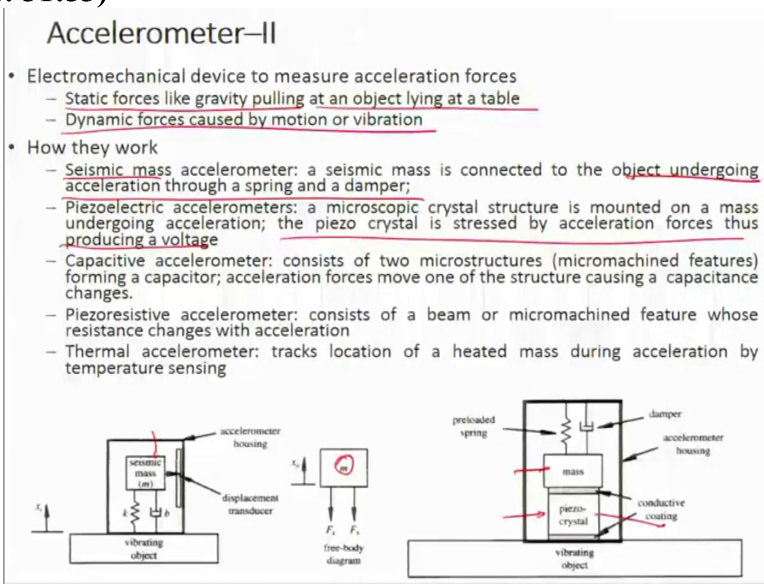

There could be other complex forms or accelerometers extra meters could be in electromechanical devices which would measure static forces like gravity pulling at an object lying at the table or dynamic forces caused by motion of vibration. How they work in one of the types of accelerometers there is the seismic mass I think I just mentioned this earlier is connected to an object undergoing acceleration through a spring and damper.

The other you know there is a mass which sits on a piezo crystal the piece of crystal is stressed by acceleration forces and it produces in turn a voltage output. So, the basic principle here is you know the in the motion analysis of this mass spring system what is the change in the frequency as a function of the applied load for example or you know through which you could actually get what is the magnitude of the load and also get a temporal response from the particular motion causing element.

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Now there are various applications to which extra meters could be used a lot of it is goes into automotives typically extra meters are used to monitor the vehicle tilt roll scaled impact vibration and is used to open clothes many safety devices for example you know stability control anti-lock braking systems, airbags they are all initiated extra you know actuated through accelerometers. And the purpose of all this is to give a comfortable ride feeling to the passenger.

There is a lot of use that accelerometers find in aerospace accelerometers find used in inertial navigation, smart ammunitions, unmanned vehicles the variety of other areas where these can be deployed and applied. So, you have sports and gaming a person electronics, security, industrial usages, robots so they in various capacities utilize some of these experiments accelerometers sensors.

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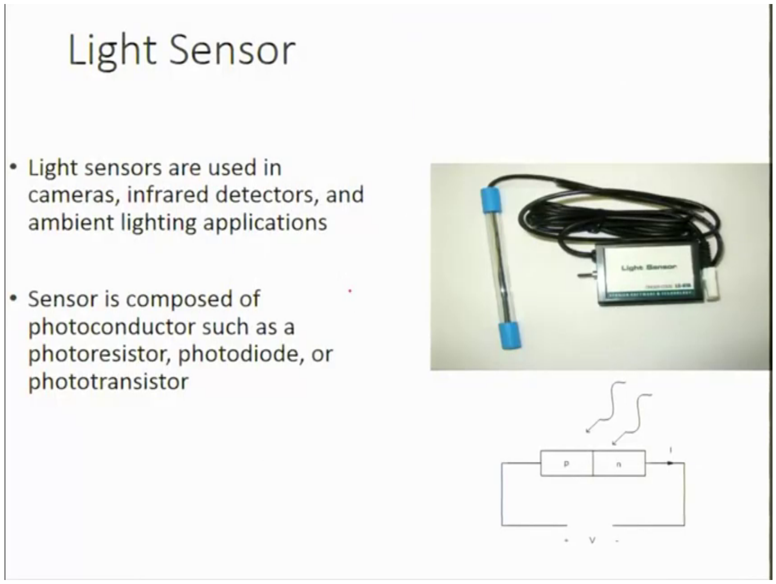

Sensors can also be utilized for various light devices or devices which get actuated with light for example cameras or infrared detectors here the sensor is composed of a photo conductor mostly something which gets you know actuated in terms of its conductivity through exposure to light. There could be a photo resistor or a photodiode or for the transistor all of these are a minimal this is the photodiode for example there is a light signal which is coming here this is H Nu and it changes the you know the electrical bandgap.

And so there is a change in the resistance of the device based on such an exposure to a certain light and so if you could calibrate the exact change in resistance with respect to the light that is falling in terms of its intensity or maybe wavelength that would give us a very good idea about what is the level at which the radiation is taking place and can be used very well as light sensors.

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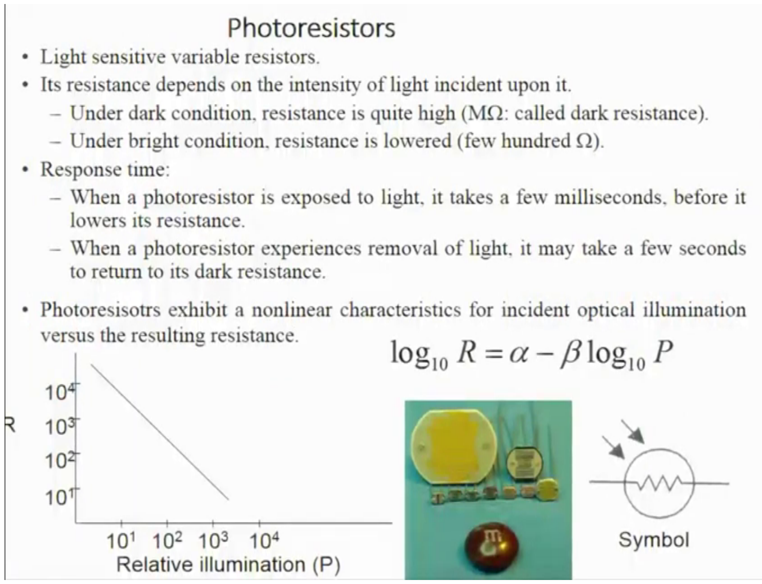

Another class of you know optical sensors could be photo resistors. These are light-sensitive variable resistors of the materials where the resistance depends on the intensity of light incident upon it for example under dark conditions the resistors typically would be very high okay this is called typically the dark resistance almost mega ohm range and as the intensity increases the radiation increases the resistance is lowered almost to a few 100 ohms. So, there is a large operation range of these photo resistors.

They have excellent response time it takes about a few milliseconds to lower the resistance at least comparing some of the mechanical devices this is on a much faster scale that you can have such changes. So, photo resistor exhibit nonlinear characteristics for incident optical lamination. So, therefore it is a log scale which could happen to have a linear characteristic as you can see and the plot right here. These are how some real devices look like photo resistor devices.

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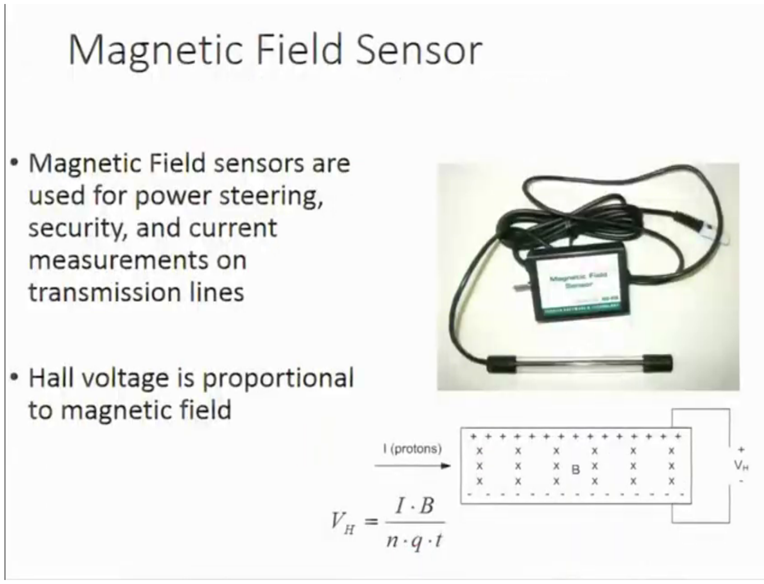

So, these are another class of light sensors there are sensing you know it's carried out for magnetic fields a variety of applications exist for magnetic field sensors in power steering security current measurements transmission lines so on so forth. So, the basic principle is the Hall effect which is the production of potential difference across an electrical conductor in this case you know you can see that there are a group of positive and negative charge layers which are accumulating on both sides.

And this happens particularly when a magnetic field is applied to a direction that is perpendicular to the flow of current. So, if there were a current flowing in a certain direction in which there is a perpendicular magnetic field there would be a voltage developed in both ends of the conductor which is otherwise known as a halt voltage. So, with this measurement we could actually calculate the impact that the B field of the magnetic field has the voltage is higher than the V the B is higher and so on so forth. And so magnetic field sensing can be done using such Hall sensor strategies.

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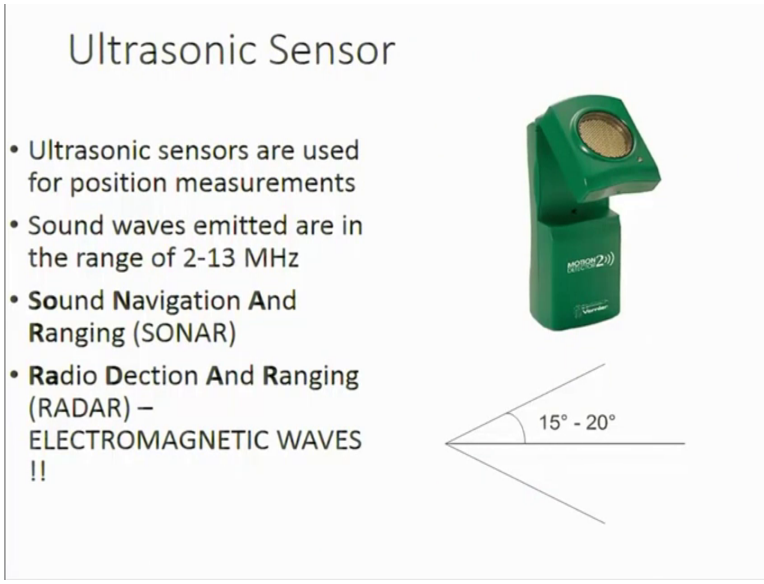

This is another very commonly available ultrasonic sensor so these are used for position measurements basically the idea here is that the device emits sound waves in the ultrasonic range 2 to 13 megahertz and whatever portion of it is reflected back and received is used for finding out the proximity of an object through which it is reflected. and so it is used in a variety of applications like the sonar the sound navigation in ranging very commonly used in you know naval applications or even in the ship navigation industry.

You can also use it as a radio detection and ranging radar application on the difference in this case is that the same principles are deployed through electromagnetic waves rather than sound waves. So, the basic principle in such sensors is that the distance of an object could be gauged by an assumption that the waves would get reflected back and come back in time and be received at the source emitting the particular signal. The signals could change in different frequencies or different types or natures.

So, I would now like to just you know change gears a little bit and go into a direction you have had a basic idea about mechatronics about interface building about some sensors which are used for a day-to-day purpose. Now I think we can look into the basic principles of how intelligent products are designed and maybe just give you an illustration through some examples of certain intelligent product designs like activities which have happened world over just to give you an idea of how you know you could make a product intelligent.

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So, the basic principle that is used in such a design you know experience is that you spend more time developing the intelligence rather than the interface okay. So, this is something that you must get a product a priori that you cannot just confuse the customer with too much of electronics too much of interface too much of control. But there will have something intelligently so that the customer is happy that this feature is very, very useful to a certain product that he or she is using.

So, do not build what happens offline build something that cannot happen offline okay. So, typically these are all real-time products I will show you some examples from case studies done earlier through some companies. There was a case where idea was launched a smartphone which would assist women for their exercise schedules and give them instructions so that they could perform outperform so on so forth.

So, in similar manner okay so everything which is real-time works out well if you are talking about intelligent products do not think obsessions think in relationships do not abstract success to digital metrics. If you think something only you service on to existing platforms rather than making new platforms which are more complex in nature and not user-friendly and so on so forth. And do not wait to be asked that can you do this okay if you have something in your mind where you think that the overall intelligence level of a product or a performance can go up just off right apply to a product which is existing in some nature building up an interface can come later on okay.

So, you could also adjust the service based on the customers behavior and context. So, let us look at some examples.

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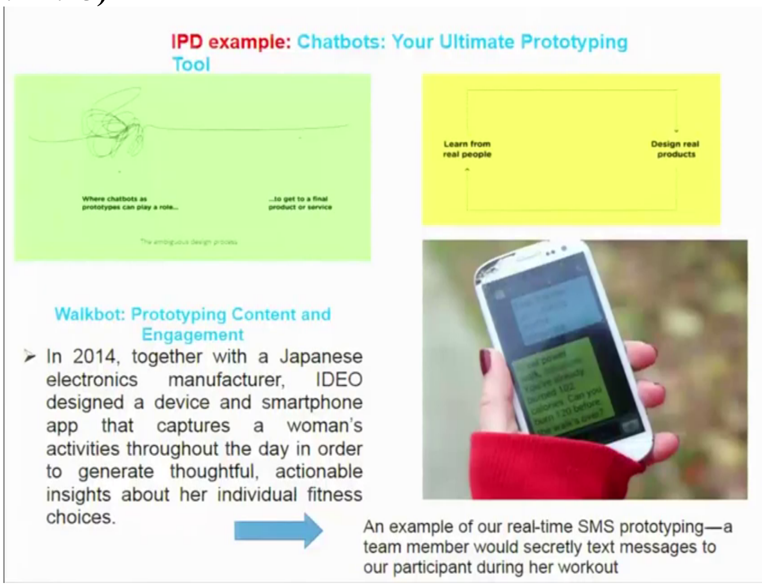

For example I was just talking a few minutes back about this you know the ideas tie up with a Japanese electronics manufacturer who designed a device and smartphone app that captured a woman's activities throughout the day okay. And the idea was to generate thoughtful actionable insight about her individual Fitness choices. This is an example you know an SMS coming out of the device says great power walk you have already 102 calories can you burn 120 before the walks over.

So, this is an example of a real-time interacting system on the ordinary cell phone which can only be possible through some kind of a web app. But the utility that it has is that once this app is on it can keep on giving you secret text messages okay to the participant during the workout session which can enable to perform and sometimes perform to the expectation of the targets set for the particular day.

So, this is kind of a real example of how you know intelligence can be delved into an existing platform or a product.

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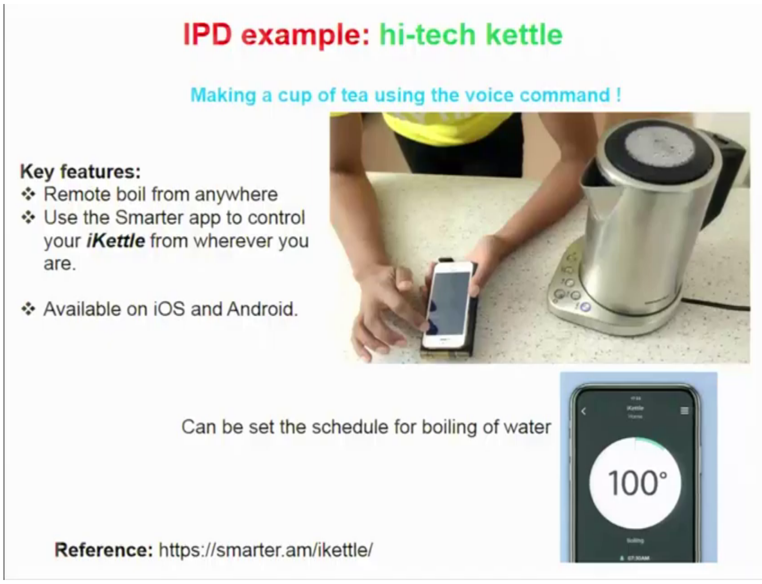

Another very good example is how to make a cup of tea using a voice command. So, the key features that you should have are you know you should be able to remotely assist the boiling process in a kettle from anywhere so use the smarter app to control your i-kettle from wherever you are. So, you could actually schedule you know for boiling of the water just before you hit the office or just before you supposing coming home you know.

So, at a distance mode through a small you know GPS system probably a GSM system probably you could use the cell phone network to send a voice command or maybe even a normal command so that a switch on this kettle gets executed and the boiling starts and by the time your home or by the time you are at office you get hot water. So, these kind of small intelligent thinking processes which could be integrated to the normal products in existence okay could actually make products become intelligent.

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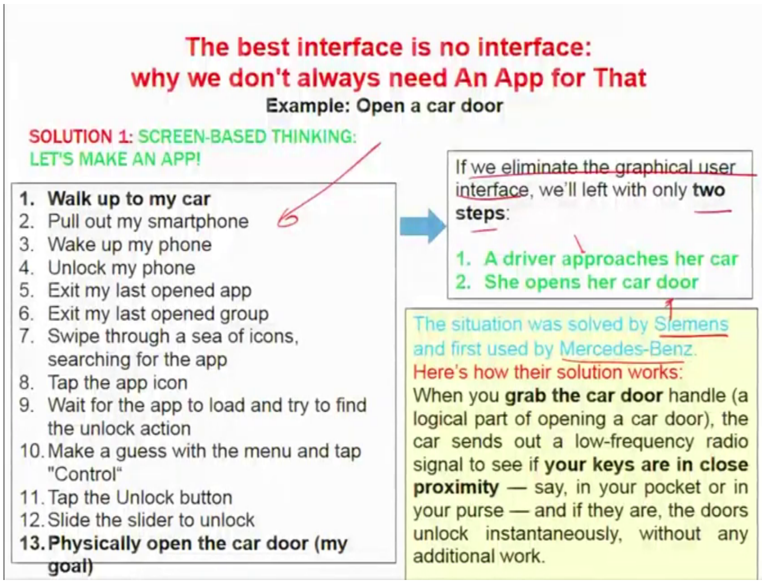

So, let us say we wanted to interface to open a car door and you know get a signal when you are carrying the car key or not carrying the car key. So, the interfaces no interface we do not always need an app for that let us say example one example could be you know the opening the car door so the solution one could be that you have a screen based thinking process to make an app where you know you walk up to a car.

Pull out the smartphone wake up the phone unlock the phone exists the last opened app exists my you know the last Open Group swipe through the sea of icons searching the app tap the app icon wait for the app to load and try to find the unlock action make it guess with the menu and tap control and tap the unlock button and then slide the slider to unlock and physically open the car door so this is not the goal okay.

So, this is like very complex solution which is in there. If you could eliminate the graphical interface into question where you are doing all these files Cannings etc to access an app through which you can open a door we only need two steps in the whole process which are of use to the user or the driver so one is that the driver approaches the car and then the driver opens the car door. So, one approach could be that and in fact this is a real approach real solution given by Siemens it was used by mercedes-benz in one of the models that they have.

So, when you grab the car door handle okay a logical part of opening the car door is basically grabbing the car door handle the car automatically sends out a very low frequency radio signal to see if your keys are in close proximity your keys do have that remote assisted remote resistance button which is like a small controller which is there in your key itself. Say in your key or in your purseif in your pocket or in your purse if there is the existence of the key you are carrying the key or the rightful owner there are automatically opens okay.

So, this is like you know building from a web of different applications and you know accessing the right area trying to open up the car door through the mobile phone that a person is carrying to a very, very simple situation where the car makes signal to gauge whether the key which is having a small controller is with the owner and the owner is the rightful owner and if the frequency matches the door automatically open.

So, this is how intelligent thinking has to be embedded within the design process. so, I think I am able to in whatever time we had this is of course the last module of this particular course create some kind of stimuli in all of you that to use whatever you have learned in the mechatronics and the sensing in the actuation in the electronic control and interface building area to the minimum possible extent to make us some simple and easy solution for a person and that is what intelligent product design is all about. I think I will close this module in the interest of time and thank you very much for patiently being with me through all this.

We have had a wonderful time going through different illustrations from principles of computer aided design to how you know you could do intelligent rapid prototyping or manufacturing some of the basic concepts into you know realizing a design. And then delving into the MEMS area and then finally into you know this mechatronics and controls and then building up intelligent products through all this. So, I hope you had a reasonably good time staying with this particular course thank you very much again and I will close this course now, thank you very much.