Advances in UHV Transmission and Distribution
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Lecture – 37
Introduction to digital recorders, measurement

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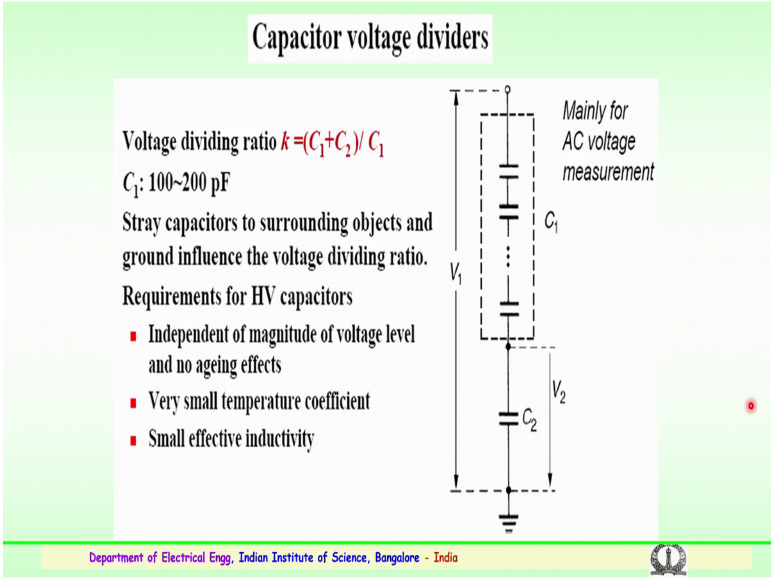

So, capacitor divider similar to the resistive type of dividers; again the ratio we have discussed is equal to number of units which are here as C 1 and C 2 being the capacitance which is of wire reading. So, C 1 plus C 2 by C 1 will give you the value of the measuring across the C 2. So, in case the voltage V 1 is applied, the divided value could be obtained by suitably the ratio into the V 2 which is obtained

So, here the capacitance could be anywhere between C 1 100 to 200 pF, example the stray capacitor to surrounding the objects that is near the objects and the influence of the ground should be kept in mind for the voltage dividing ratio. The requirements for the high voltage capacitors are it should be independent of the magnitude of voltage level and over a period the aging of the capacitor should not happen. So, no aging effect should be seen other value will change in case of the aging if the capacitance value changes over a period. So, this is very important and very small temperature coefficient, and small effective inductivity is permitted. So, not a lead inductance here it is reduced because of these of capacitance (Refer Time: 01:36).

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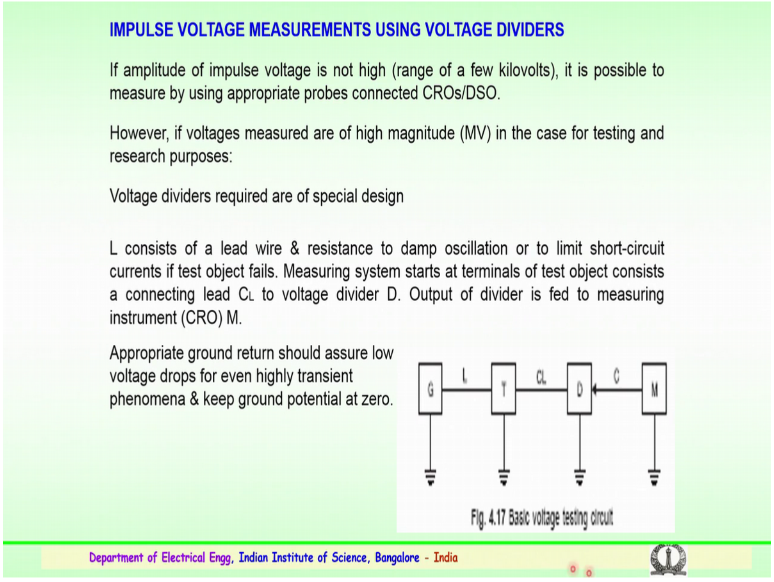

So, impulse voltage measurements using voltage dividers, in case of amplitude of impulse voltage is a not very high if it is range of few kilovolts there is a possible for measurement of using appropriately by the probes or using connecting to the digital storage oscilloscope or cathode ray oscilloscopes. Probes are available where few kilovolts could be measured up to nowadays a probes of 25 to 30 kilovolts are available for measurements for AC and DC. However, if voltages measured or to be of a very high magnitude more than 50 kilovolts to millions of volts in the case of a testing and for a maybe for research purposes and then suitable voltage dividers are to be used as discussed. And this voltages dividers could be of capacitive inductive or a resistive type have been discussed.

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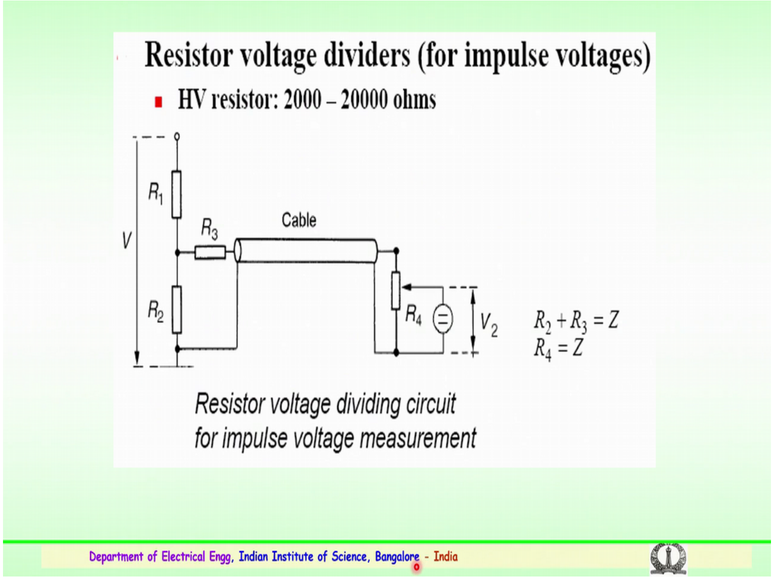

So, resistive voltage divider, how the resistive voltage dividers particularly for the impulse of voltages are connected or shown here, example R 1 is a higher voltage arm of the resister R 2 being the low voltage arm of the resister

So, suitably this value depending upon the cable impedance proper termination has to be employed by using suitable resister R 3 and R 4 and with the protection arrangement to measure the value. So, here again R 2 and R 3 should be equivalent to the value which is a Z impedance and R 4 the value should be equivalent to the impedance. So, suitable terminations have to be used depending upon the cable which is being used for the measurement. So, where the measuring impulse voltages the compensation or the cable which is being used have to be properly used with the terminations and suitable terminating resisters or impedances.

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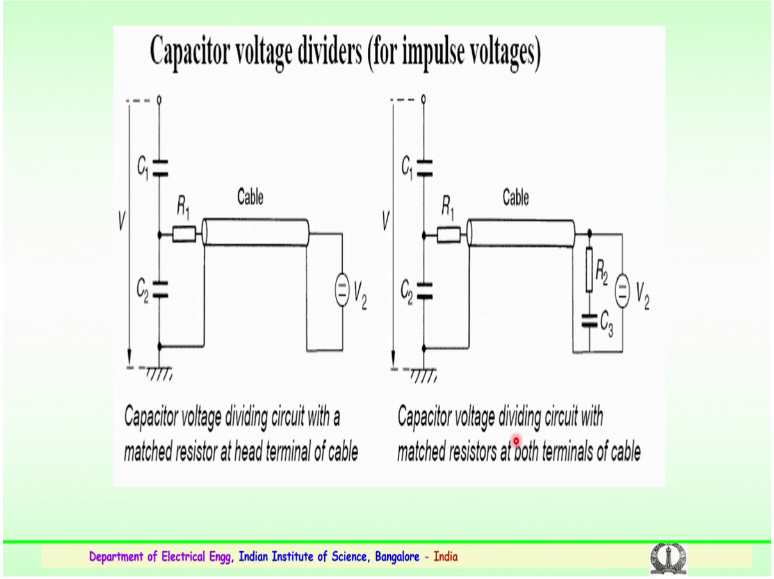

For capacitor voltages again for impulse voltages here as discussed C 1 and C 2 we used resistor R 1 at the beginning of the cable for the measurement, and how the voltage is obtain. So, this again suitable termination depending upon the impedance of the cable or is being employed. Here this is the capacitor voltage divide circuit with a matched resistor at the head of the terminal of the cable. And this shows the capacitor voltage dividing circuit with the matched resisters at both terminals of the cable. So, you can see here a suitable matching impedance of the cable is used at the beginning that is a R 1 and also at the R 2 with capacitor C 3 which could be obtained here for this could be use your filtering.

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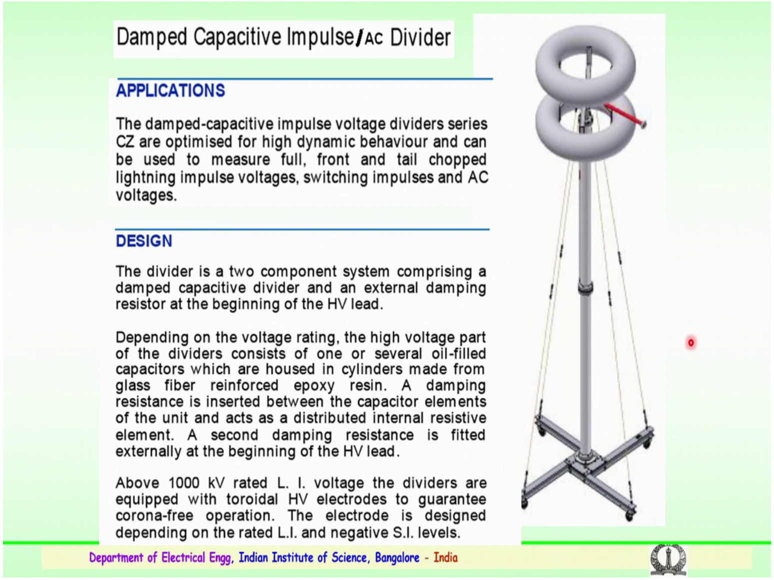

So, damped capacitive divider we have discussed about this, which is used for the AC and impulse.

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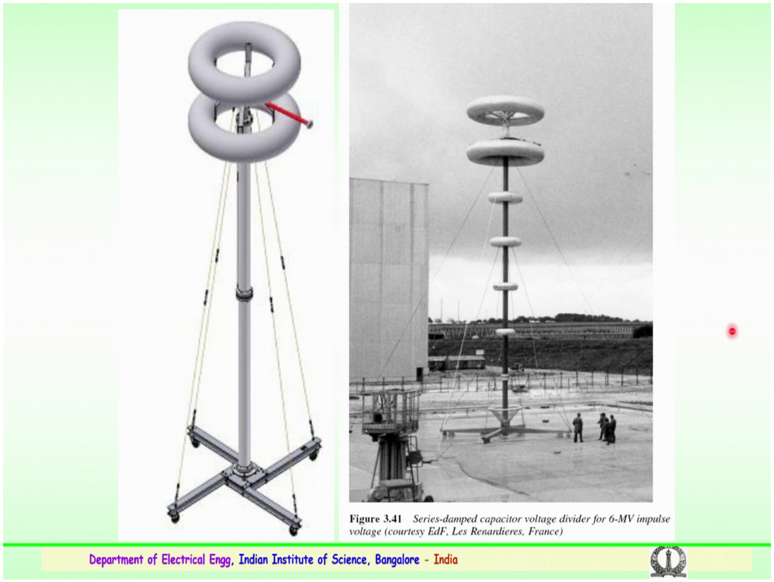

These are typical damped capacitive divider which is used in the lab. And one of the example of a series a damped capacitive divider for a 6 million volt impulse voltage measurement this is being used in France laboratory high voltage laboratory.

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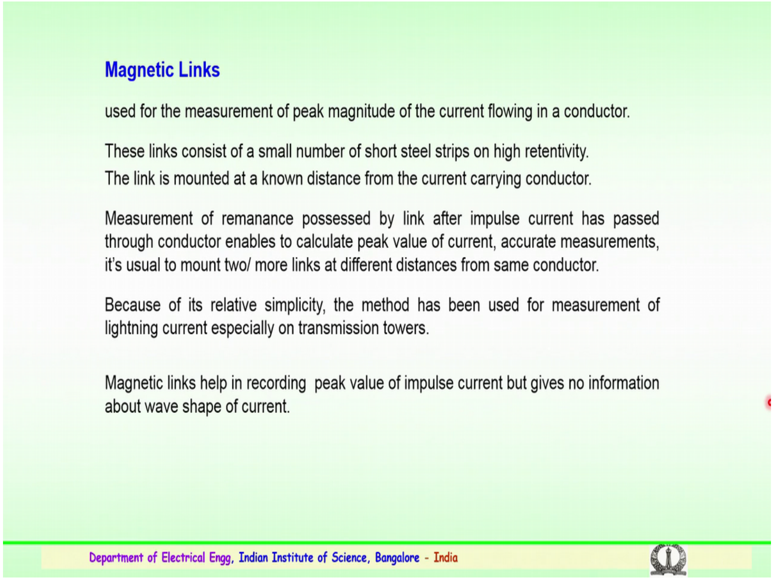

Next is the magnetic links. This magnetic links measurement is used for the peak magnitudes of the current flowing in a conductor. So, these magnetic links consist of a small number of short steel strips of very high retentivity and the link is generally mounted at a known distance from the current carrying conductor. So, the measurement of remanance which is possessed by the link after impulse current passed through the conductor will enable to calculate the peak value of current, accurate measurements, it is usual to mount two or more links at different distances from the same current carrying conductor.

So, because of its very simplicity or relative simplicity this method has been used for measurement of lightning current especially on transmission towers though. The magnetic links are provided on the transmission towers the magnetic link helps in recording the peak value of impulse current or surge current, but these give no information about the wave shape of the current, so that is importance.

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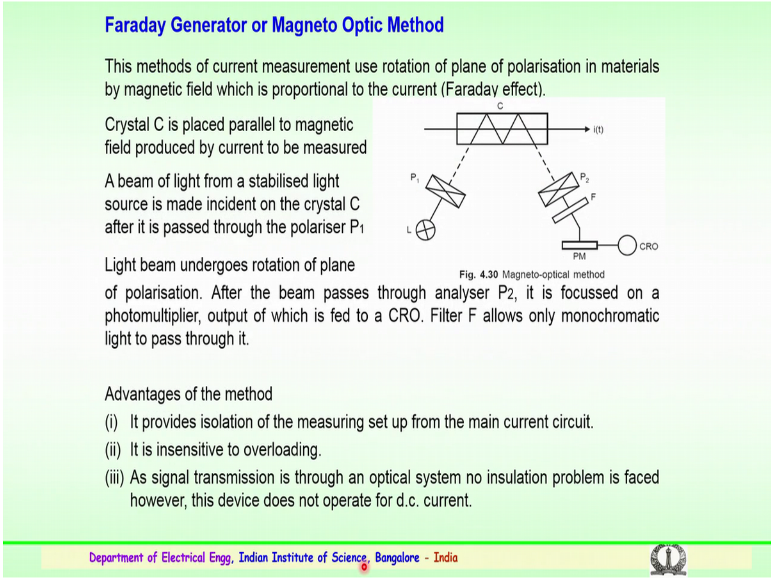

The second for the method for current measurements is a Faraday generator or the magneto optic method. This method of current measurement basically uses the rotation of a plane of a polarisation in materials particularly by the magnetic field which is general proportional to the current that is effect of a Faraday effect is considered here. So, the crystal C, you can see the crystal is showed here the crystal C is placed parallel to the magnetic field produced by a current as shown here i of t which is to be measured. So, a beam from here a beam of light from a stabilized source is made to incident on the crystal sees this light is made to incident on the crystal after passing through the polarizer P 1 is a polarizer here.

So, these light beam undergoes rotation in the plane of polarization as a shown here. After the beam passes through the analyzer, there is a second analyzer here is a polarizer P 1 and second P 2 is analyzer it passes through the analyzer P 2, this further focussed on the photo multiplier here F the output of which again is connect sorry photomultiplier is here filter and a photomultiplier here. So, this is further connected to a digital storage oscilloscope or as cathode rays oscilloscope and the filter F which is shown here allows only monochromatic light to pass through this a photomultiplier.

So, advantages of this method being it provides isolation of the measuring set up from the main current circuit, and it is insensitive to overloading this is the point to be considered. The third being the signal to the signal transmission is through an optical system, which we discussed. So, no insulation problem is faced; however, this device does not operate for DC currents that is important point to be known.

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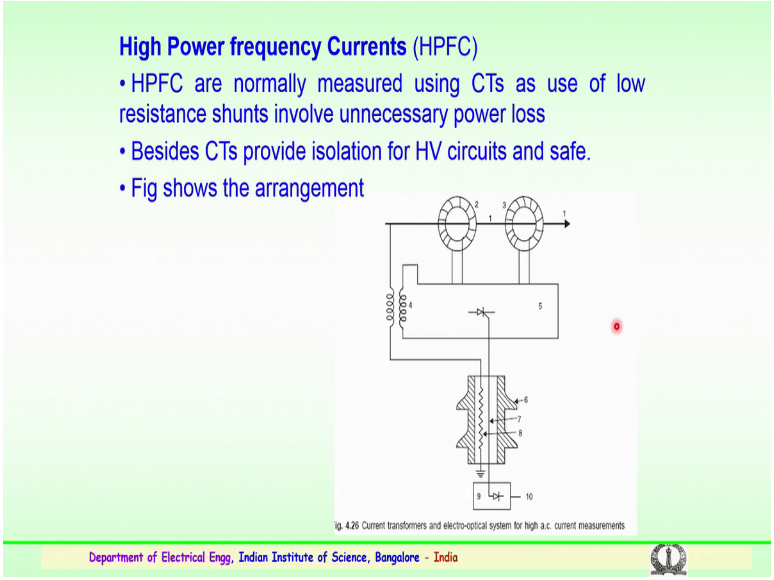

For measurement of a very high power frequency currents, the method which is used or the current transformers and an electro optical system are employed as shown in the circuit here. The high power frequency currents are normally measured using the CTs as a shown here current transformers as low as use of low resistance shunts involve unnecessary power loss that is a reason they going for current transformers. Besides these current transformers provide a isolation for a high voltage circuits. So, not directly connected to the circuit and they are safe. So, this arrangement is used for measurement of the high power frequency currents which this is a conductor which is being carrying the current.

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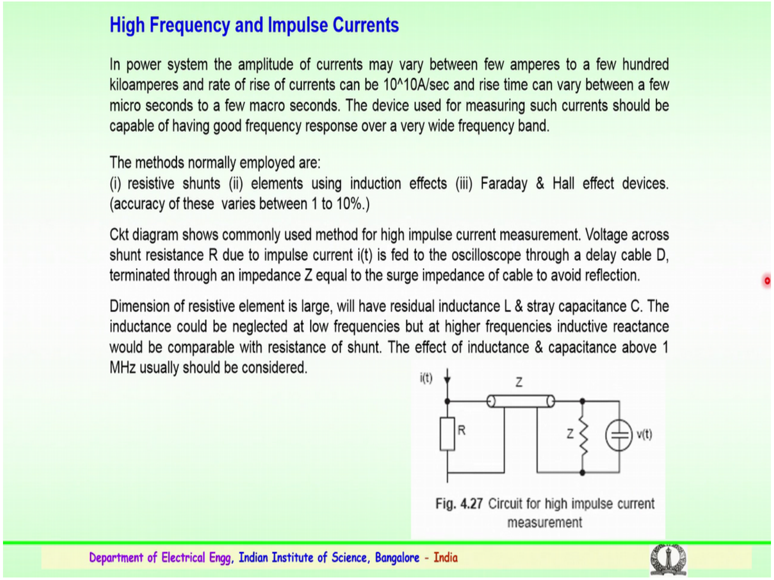

The high frequency and impulse currents, again impulse measurements you have a two important aspects one is the measurement using voltage divider, and the second is going in for the robot screw coil or the voltage divider again you call the current shunt here. So, these again is a resistive elements which are number of elements connected in parallel and it is used for the measurement. So, in power system, we know the amplitude of currents which are seen in the transmission network could vary between few amperes to few 100s of kilo amperes and here the rate of rise particularly of these currents can be between 10 to the power of 10 ampere second. So, and the rise time can vary anywhere between few microseconds to few macro seconds that is standard impulse currents could be 8 by 28 microseconds the front time and 20 being the 10 is typical example. So, these are devices used for a measuring such currents should be capable of having good frequency response very important over a wide frequency band.

So, general methods are used in the laboratories for the measurements of high frequency impulse currents are the resistive shunts, elements using inductive effects, third is a faraday and Hall Effect devices. So, these are accurate these between 1 to 10 percent depending upon the devices. So, this is a general circuit which is used for impulse current measurement with cable and again a terminating impedance. So, commonly used method for high current impulse. So, voltage across the shunt resistor R, this is the shunt resistor are due to an impulse current which is flowing through the object is fed to the oscilloscope using a suitable cable and through a delay cable in case required. And it is terminated across an impedance as Z which is shown here, which is equivalent to the surge impedance of the cable to avoid the reflection so very important. So, dimension of this resistive element is large. So, we will have residual inductance and a stray capacitance. So, this inductance could be neglected at low frequencies, but at higher frequencies, inductive resistances would be comparable with the resistance of the shunt. So, the effect of inductance and capacitance above 1 megahertz usually should be considered.

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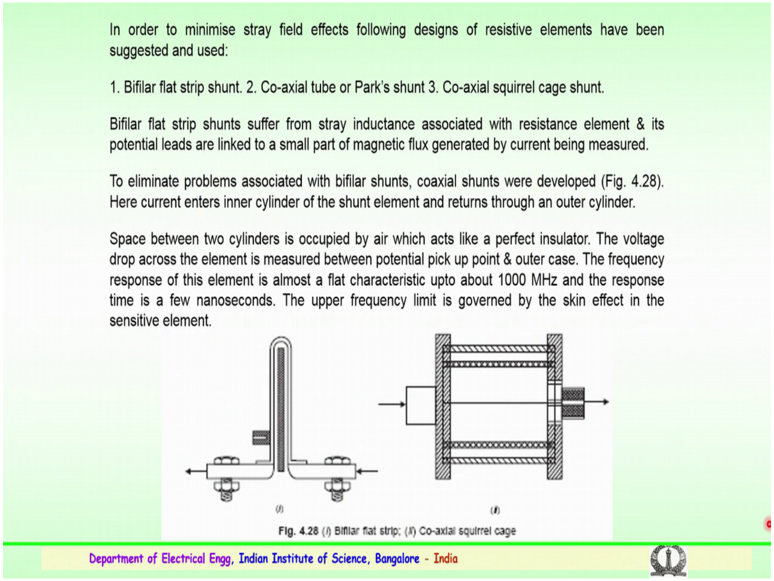

So, in order to minimize the stray field effects some of the designs are shown here. This is the bifilar flat type of strip. This is the coaxial type of arrangement or a squirrel cage arrangement is shown here. The designs are used as a resistive elements, there is a current shunts these are different shunts that is the bifilar type strip current shunt, coaxial tube or parks shunt or coaxial squirrel cage shunt. So, this bifilar strips suffer from stray inductance affects which are associated with the resistance elements which are used. And the potential leads are link to a small part of the magnetic flux which could be generated by the current being measured. So, to eliminate this problems of the magnetic flux which is generated and also the resistance or say inductance effects the bifilar shunts, so coaxial were developed as shown here.

So, here current enters between the cylinder of the shunt element and returns through the outer cylinder, so the space between the two cylinders is occupied by air which acts like a perfect insulator. So, the voltage drop across the element is measured between the potential pick up point and the outer case, this outer case. The frequency response of this element is almost a flat characteristics up to 1000 megahertz and the response time is few nanoseconds, so that is a reason these are being used. So, the upper frequency element is governed by the skin effect in the sensitive element.

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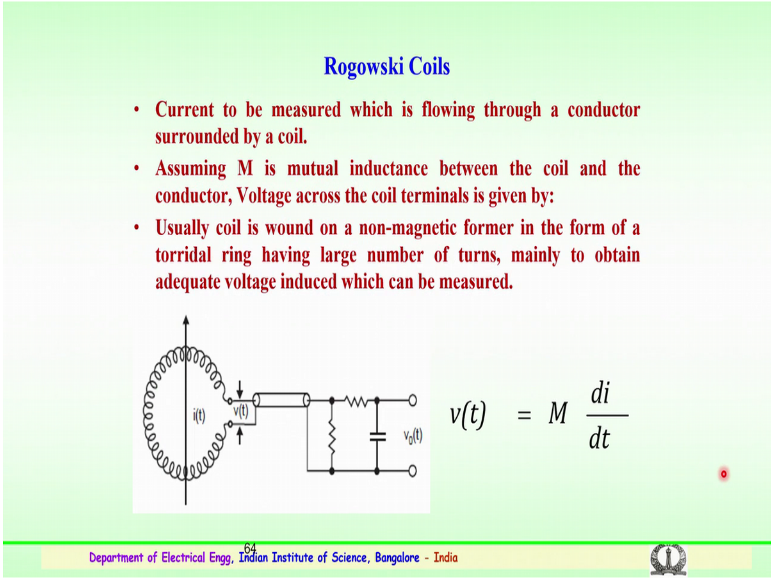

One of the important measurement used for high current is the Rogowski coil. Rogowski coil is used for the current measurements. The current to be measured which is flowing through a conductor surrounded. You can see the conductor which is surrounded by this coil the current which is flowing and this can be measured with the help of the Rogowski coil. So, in case assuming M is a mutual inductance between the coil and the conductor here. So, the voltage across the coil terminal is given by v t is equal to M the mutual inductance into di by dt. So, usually the coil is wound on a this coil is wound on a non-magnetic former in the form of a ring you can see the torridal ring having a large number of turns several turn or wound on this ring . So, mainly to obtain or adequate voltage which is induced because of the current which is passing in the conductor which can be measured that is very important.

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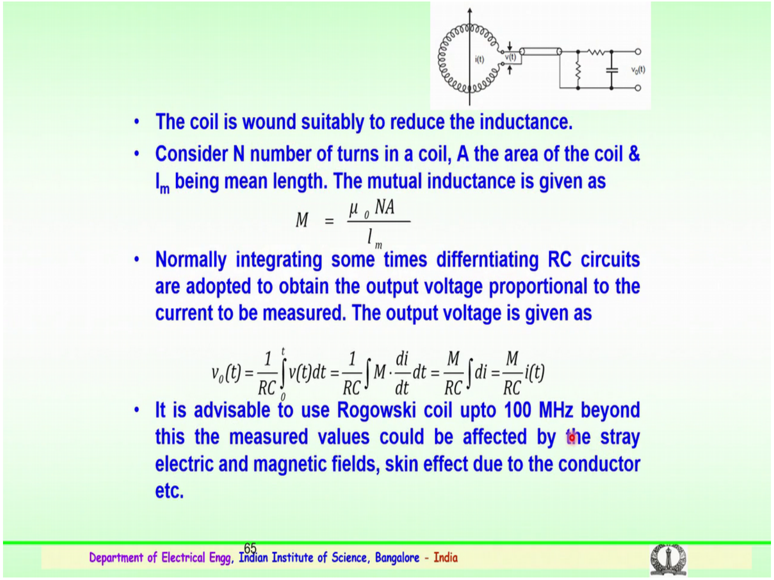

So, the coil is suitably wound basically to reduce the inductance. So, here the alternative layer the one which layer is starts here the other in the reverse direction is intentionally wounded. So, that to make it non-inductive type of arrangement. So, consider N number of turns in a coil, A being the area of the coil and I m being the mean length. So, the mutual inductance is given by M is equal to mu naught into NA by I m. So, normally integrating sometimes normally this coils are Rogowski coils could be of integrating or sometimes if it is required differentiating the type of a Rogowski coils.

So, here the circuits are adopted suitable circuits are adopted to obtain the output voltage which could be proportional to the current which is to be measured the output voltage is given us V naught is equal to V naught of t is a 1 by R C, the R and C which is used for measurement integral of V into dt. Where this is equivalent to M by R C into the current which is being flowing. So, it is advisable to use the Rogowski coil up to 100 megahertz beyond this the measured values could be affected by the stray electric and magnetic fields or the skin effect due to the conductor.

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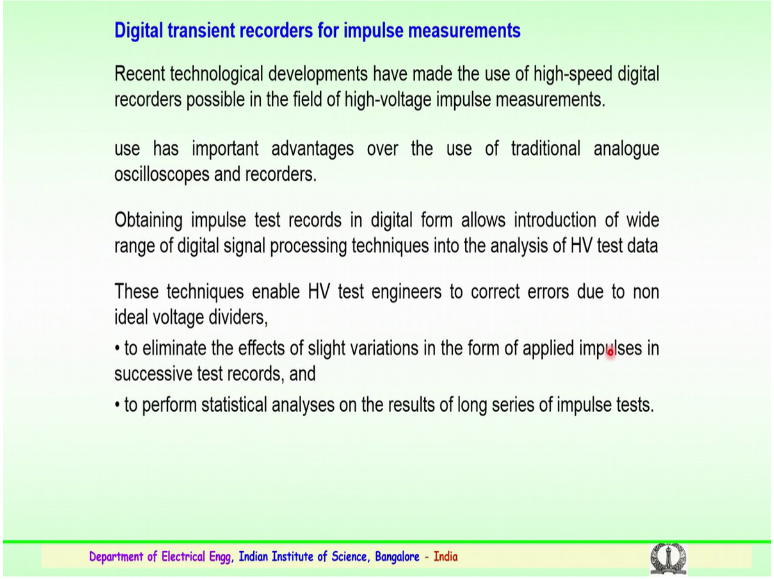

So, further to the measurements are recent advance or developments have been happening in the measurement of the high impulse or currents where digital transient recorders particularly for the impulse measurements are being used. Here the recent technological developments have made the use of high-speed digital recorders possibly in the field of high voltage impulse measurements. So, the use of important advantages over the use of traditional analogue oscilloscope or recorders is to obtain impulse test records in digital form. And this allows introduction of wide range of a digital signal processing techniques into the analysis of high voltage data which is being collected.

So, these digital transient recorders techniques enable high-voltage test engineers to make suitable correction to the errors due to the non ideal voltage dividers. So, to eliminate the effects of slight variation in the form of applied impulses in successive test records, and also to perform statistical analyses on the results for long series of impulse test which are conducted.

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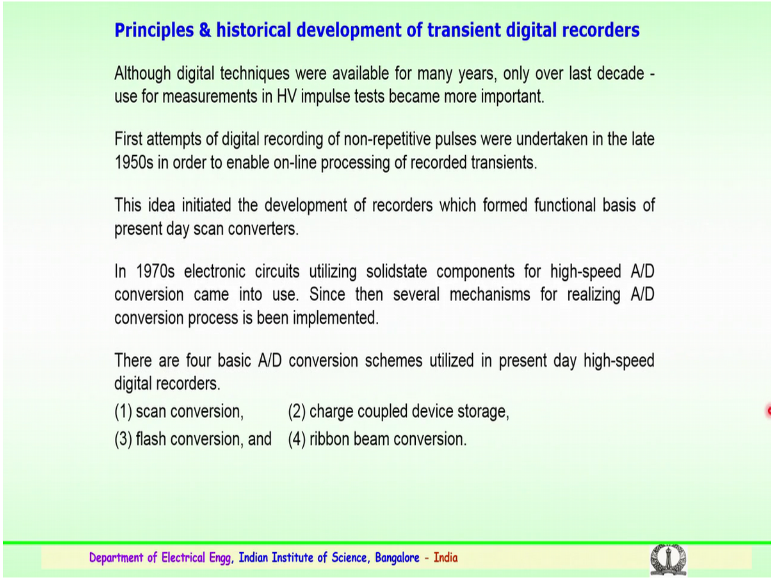

So, some of the principles and how the historical development of this transient digital recorders how evolved and it is important. We see that all though digital techniques where available for many years; only over last decade these are used for measurements of high voltage impulse test which have become more important and analysing the data and also the recording. So, the first attempt of a digital recording of non-repetitive pulse was undertaken in late 50s in order to enable online processing of the recording of the transients on the power system network. So, this idea initiated the development use of recorders which formed functional basis of the present day scan converters.

So, in somewhere in 1970s electronic circuits utilizing the solid state components of for the high-speed analogue to digital conversion came into use. So, since then several mechanisms for realizing the analogue to digital conversion process is being implemented. So, there are four basic analogue to digital conversion schemes which are utilized in the present day a high-speed digital recorders. So, one is the scan conversion, the second is a charge coupled device storage, the third is the flash conversion, and forth being the ribbon beam conversion.

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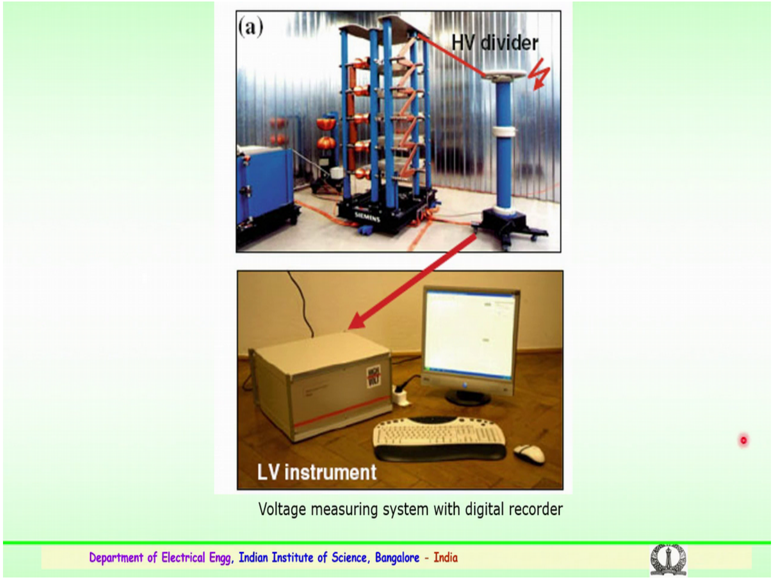

This is the one of the example of using the digital recorders for the measurement of the impulse voltage, this is a impulse generator, you have a divider, you have digital recording unit for the measurement of the impulse voltage. So, the data can be monitored carefully analysed and it could be used for the interpretation.

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So, this is again use of digital AC, DC peak voltmeter and a recorders for the impulse measurements, other type of digital recorders. So, there are mainly for the measurement of high voltage impulses, we have two important, one is the digital impulse analysing system and the second being hybrid impulse analysing system which are having a very good capability of a capturing the information from the impulse. And which will help in a proper analysing and the interpretation of the surges which are applied to the high voltage equipment.

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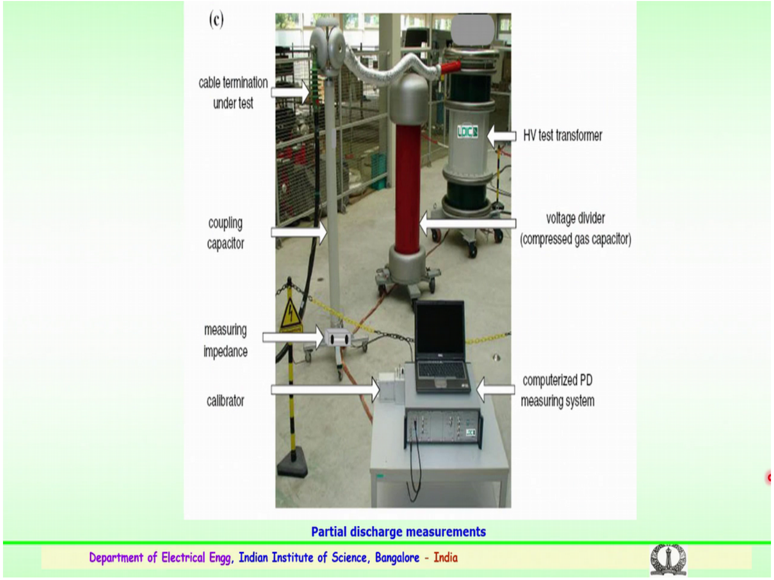

This is again one of the example which is being use the digital recorders, computerized measuring the systems being used for the measurement of partial discharge activity. So, you can see the digital recorders have come in a long way for the help particularly in the high-voltage measurements. So, this partial discharge from the divider and the coupling capacitor you have a measuring impedance here, the measuring impedance it is connected to a monitor of the digital recording system where a proper interpretation with the help of this measuring system could be done.

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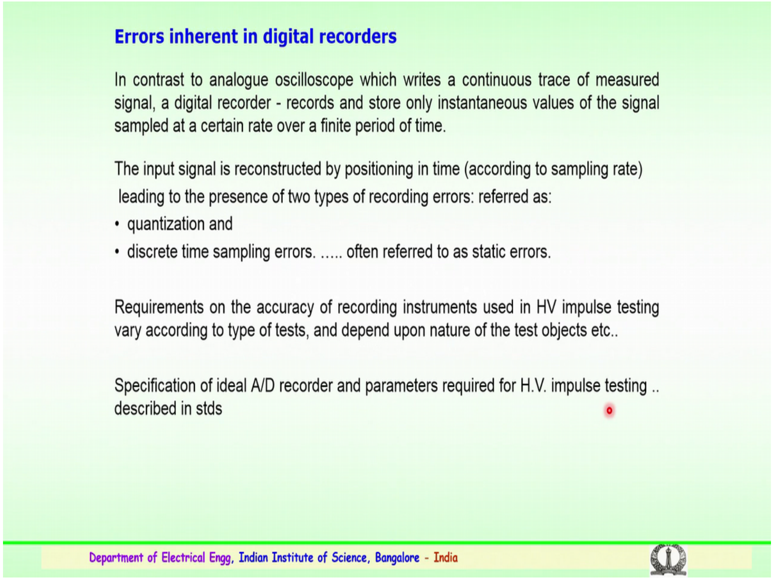

So, during the measurements, it is likely to have errors inherent in a digital recorders in contrast to the analogue oscilloscope with generally rights continues trace of measured signal in a digital recorder records the and stores only instantaneous values of the signal sampled at certain rate over a finite period of time. So, the input signal is reconstructed by positioning in time according to the sampling rate. So, this leads to the presence of a two types of a recording errors which are generally referred as the quantization and discrete time sampling errors. So, these are often referred to as static errors. So, the requirements of accuracy particularly using the digital recording instruments in the high voltage impulse testing could vary accordingly to the type of test and also depend upon the nature of test objects. The specifications of ideal analogue to digital recorders and the parameters required for impulse testing or in general available and are available and described in the relevant measuring standards for the high voltage test systems.

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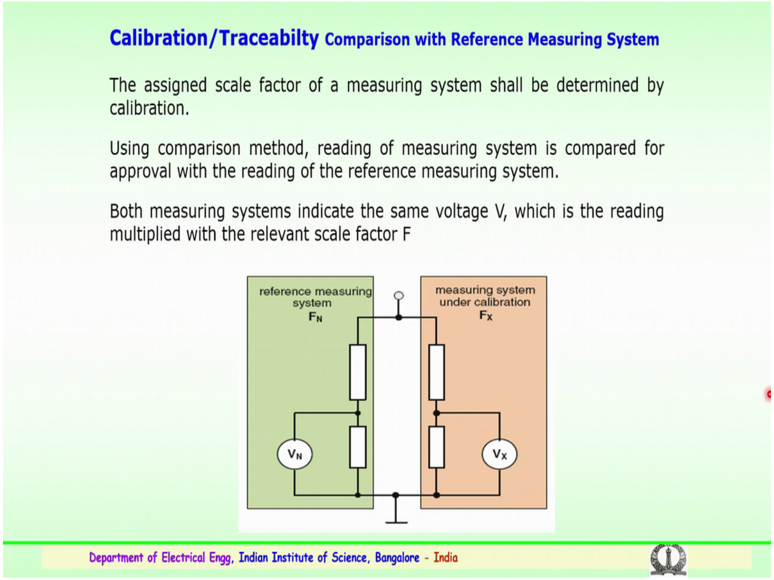

So, final important is the measurement you have to have a suitable calibration and the traceability. These are the important requirements and comparison with a reference measuring units. So, the assigned factor the scale factor of any measuring shall be determined by the calibration of it which is done. So, using comparison method, reading of measuring system is compared for approval with the reading of the reference measuring system. So, both measuring systems indicate the same voltage V which is reading multiplied with the relevant scale factor. So, this reference measuring system and this is the measuring system under calibration. So, this both have to be showing the same value then the equipment which could be used can be traceable to the main equipment and it can be the results which are obtained can be of accurate in nature. So, calibration and traceability are also equally important for any measuring devices which are used in high voltage laboratories.

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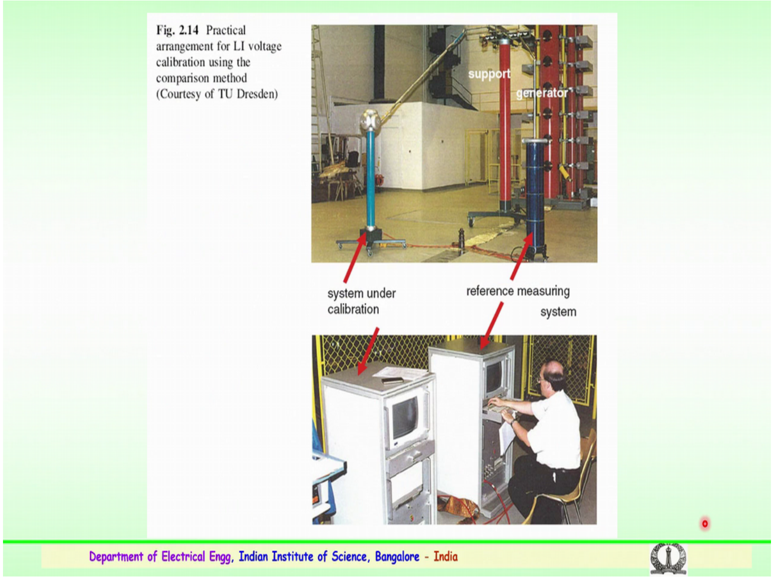

This is one of the example of conducting a calibration experimentation for the equipments with the reference measurement system. So, with reference or measuring system in case of a divider, this divider which is under calibration is done and suitable equivalence of the reference system is maintained and it is calibrated and certified. So, this is how importance is a calibration and also the comparison which is to be carried regular intervals of time where the with the traceability equipment which is situated at different regions of the country or the places which is available. So, the equipments have to be calibrated at regular intervals to check for the accuracy and proper functioning of this measuring device is very, very important.

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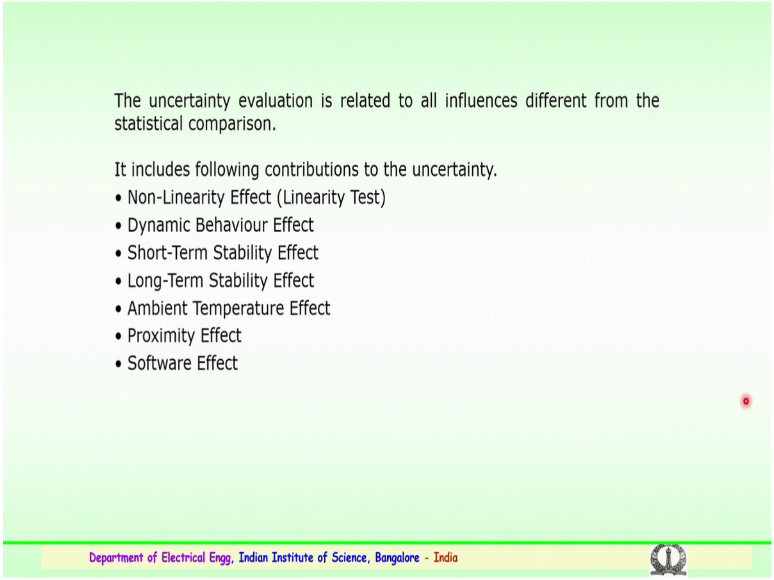

The uncertainty which evaluation could be related to the influences which are different from the statistical comparison. This could include contribution to the uncertainty that is the non-linear effect, linearity effect that is done by the linearity test. And dynamic behaviour effect. This short term stability effect, the long term stability effect and whether the ambient temperature effect for the measurements. The proximity effect the of the equipments which are being used and the software which is being used for the measuring. So, several of these things contribute to the uncertainty in the measurements.

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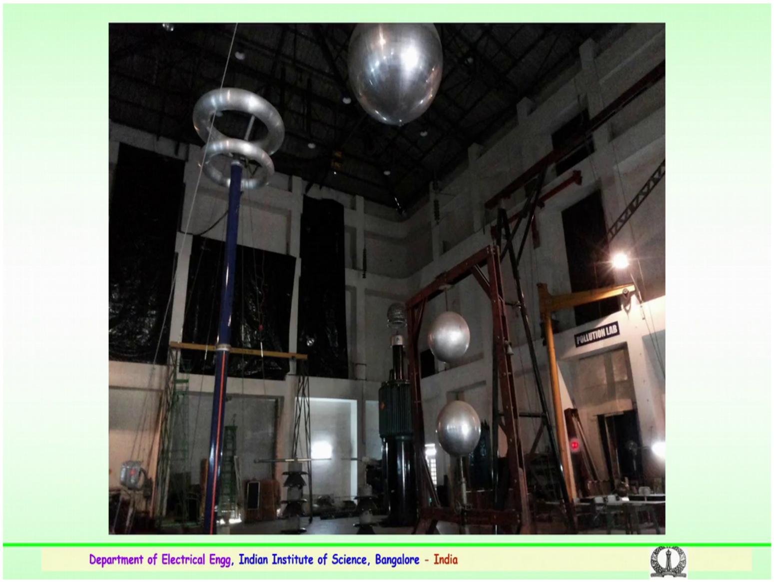

So, we will the stop here. We have discussed about the measurement aspects.

Thank you.