Advances in UHV Transmission and Distribution
Prof. B Subba Reddy
Department of High Voltage Engg (Electrical Engineering)
Indian Institute of Science, Bangalore

Lecture – 33
Importance of Generation of HVDC in the laboratory

So we have discussed about the high voltage importance of high voltage transmission system and how the high voltage technology is being used in the country and elsewhere; the main importance of the high voltage a technology was developed originally mainly to cater the needs and also to transfer of the large quantities of electrical energy economically at a very high voltages.

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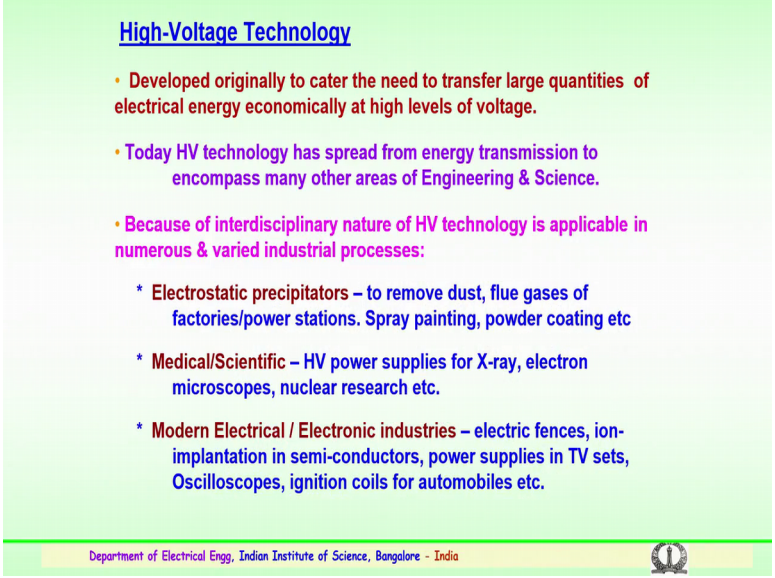

Today high voltage technology has spread not only from the energy transmission it encompasses a many other areas of engineering science, engineering and science because of this high voltage technologies of interdisciplinary in nature. The usage of the technology is being done for various industrial purposes and other numerous applications.

So, in the industry the high voltage technology is being used for the electrostatic precipitators, mainly to remove the dust particles, exhaust dust particles. The flue gasses emitting from the factories or the thermal stations, the technology is being used in the spray painting and for the powder coating by the electrostatic applications. The high

voltage technology is used in medical and also scientific applications, where the power supplies particular the high voltage power supplies are used for the x ray, the electron microscopes, the nuclear research purposes etcetera, and modern day gadgets of electrical and electronic industries are also using the electrical technology, once such example is about the electrical fences which are used guard the main buildings and designated companies or the government buildings where electric fences are being used and in ion implementation in plantation particle in some conductors industry it is used and you know that the power supplies in the television sets which uses the high voltage technology.

This high voltage power supplies are again used in oscilloscopes the ignition coils for our motor bikes, or the automobiles also use the basic high voltage technology.

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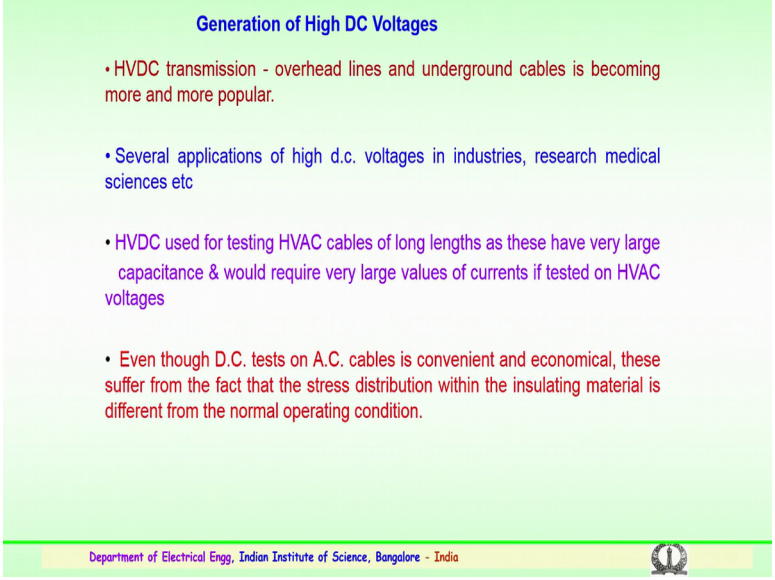

So, several applications of high voltage a technology exist. So, very important not only for the transmission and distribution and also for the regular applications; so, it is very important to know and have a basic information about how this high voltages could be generated in the laboratory level, and how this high voltage ac or DC could be used for the testing or verification of the equipments, which are used in the transmission at distribution or in the above a mentioned industrial applications, were these have to be properly verified and they have to be monitored they have to be tested.

So, for such applications it is required to generate high DC as well as high ac and laboratories provide these facilities for the testing aspects. So, we will briefly look into the generation of high voltage a DC initially, then we will also look into the generation of high ac voltages and generation of surges in the laboratory, how these are being used the equipment or being used for the testing of the accessories insulator strings or the other high voltage equipment in the transmission system very important information which has to be known.

So, first we will discuss about the simplest way of generating the DC high voltages, further we will see how the DC high voltages could be used for the generation of high voltage a dc. So, DC transmission or a high voltage DC transmission is known that we are employing for over a transmission lines and also for underground cables, this is becoming more and more popular in the recent days, apart from the transmission and distribution several applications of high voltage a DC voltages particularly in industries as discussed, research the medical sciences etcetera are being done.

So, the high voltage DC used for testing high voltage ac cables particularly of long lengths as these have a very large capacitance and would require very large values of currents, in case if there tested on a HVAC voltages. Even though DC test on AC cables is a convenient and economical, but suffer from the fact that stress distribution within the insulating materials is different from the normal operating conditions.

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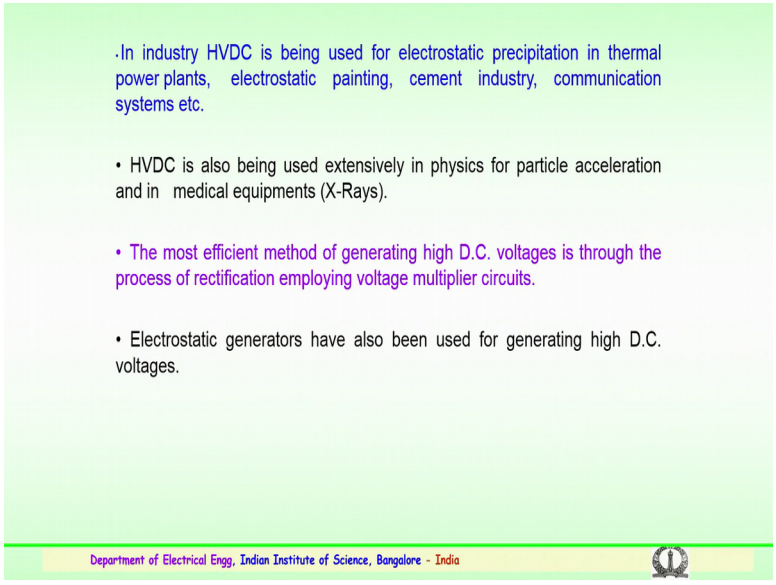

In industry high voltage DC as mentioned earlier is being used for electrostatic precipitation, particularly in thermal power plants for electrostatic painting in cement industry and communication systems.

So, high voltage DC is also being used extensively in a physics for the study of particle acceleration and in a medical equipments. The most efficient method for generating high DC voltages is through the process of rectification which we have already known and this simple rectification idea is being used here for further improvement and the generation of higher voltage are DC is by using suitable a voltage multiplier or voltage a doubler circuits depending upon the voltage requirement.

So, the electrostatic generators have also been used for generating high a DC voltages, wherever a suitable generation of this voltages are required.

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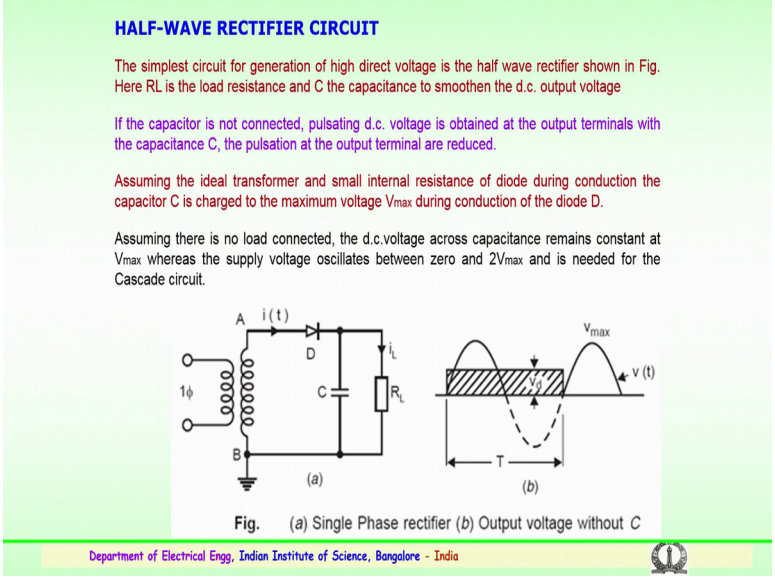

So, now we will discuss the simplest half wave rectifier a circuit which is used for the generation of the DC voltages, and how this could be used further for the high DC. So, the simplest a circuit for generating high DC voltages is the half wave rectifier a circuit which is shown here. This is a single phase rectifier circuit, single phase a transformer connecting the output of the transformer is connector to the diode D disconnected to the capacitors C and the load RL. So, the current flowing through that diode is i of t for a known time and iL is the load current flows through the resister.

So, this is the simplest half wave rectifier where RL is a load resistance and c the capacitance which is used to smooth and the DC output voltage. So, in case if it is assumed or if you assume that the capacitor which is shown here is not connected then there could be a pulsating DC, there could be a pulsating DC in case capacitors absents there could be a pulsating DC voltage which could be obtained at the output terminals here to the capacitance. So, the pulsations of the output terminals are reduced with the help of this capacitance that is one point.

So, assuming that this transformer which is shown is an ideal transformer, and has a very small internal resistance in it a small internal resistance and a sorry transformer is an ideal and small internal resistance of the diode this diode assuming it has a very small internal resistance particularly during conduction. So, the capacitor; see this capacitor gets charged to the maximum value through the diode. So, the flow of current will be in this way the capacitor gets charged to a voltage V max during the conduction of the diode. Assuming that now again if there is no load that is a there is no RL is connected.

So, the DC voltage which is seen here across the capacitance terminals that is between the capacitance terminal here and here, it remains constant at V max that is a it be it becomes V max here, where as this supply voltage we have considered that only one cycle. So, if the supply voltage oscillates because of the ac being the positive and negative. So, similarly this during the negative half cycle the plus V max will attain 2 V max. So, this is important. So, because of the oscillation or the supply voltage oscillation we see the voltage appear in across the capacitor in both positive and negative cycle, will be the 2 V max and this is required for further needed for the cascade circuit to generate a very high a DC voltages.

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When high d.c. voltages are to be generated, voltage doubler or cascaded voltage multiplier circuits are used. One of most popular doubler circuit is Greinacher is shown

Working of Voltage Doubler Circuit

Suppose B is more positive with respect to A, the diode D_1 conducts thus charging the capacitor C1 to V_{max} with polarity as shown in Fig.

During next half cycle terminal A of capacitor C_1 rises to V_{max} and hence terminal M attains a potential of $2V_{max}$. Thus, capacitor C_2 is charged to $2V_{max}$ through D_2.

Normally voltage across the load will be less than $2V_{max}$ depending upon the time constant of the circuit C_2R_L.

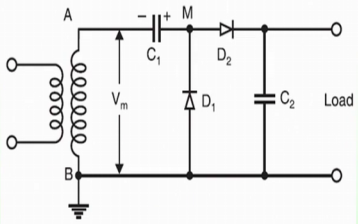

Fig. 2.2 Greinacher voltage doubler circuit

Department of Electrical Engg, Indian Institute of Science, Bangalore - India

So, when the requirement for high DC voltages are to be generated; a voltage doubler or a cascade voltage multiplier circuits are being used for the generation of high voltage DC, the one of the circuit the important circuit known as the Greinacher voltage doubler circuit is shown here.

So, the working of this circuit is as follows; suppose as mentioned earlier this is the transformer you have a capacitor C 1 you have a diode D 1, diode D 2 then C 2 is again a capacitor and a load. This is the general Greinacher voltage doubler circuit, how it functions suppose we take the B is positive more positive with respect to A the diode that is the diode D 1 conducts. D 1 conducts and hence the terminal M, this terminal M attains a potential of 2 V max.

So, because of positive and negative a polarity, initially iterance of V max sorry the terminal B is more positive with respect to terminal A, the diode D 1 conducts through the charging and the capacitor C1 to V max with the polarity as shown here that is the positive polarity. So, V max initially because of the D 1 during the next half cycle. The terminal A of the capacitor this terminal rises to V max and hence the terminal here. So, earlier there is a V max here, because of the positive polarity now due to the negative polarity. So, plus the V max plus the earlier positive polarity V max will rise the potential to 2 V max, and hence the terminal M attains a potential here to 2 V max and the capacitor C 2 this is the capacitor C 2 will be charged through this diode D 2 to 2 V max. So, that is very important.

So, normally the voltage a which is seen across the load this particular load will be slightly lesser then the 2 V max because this depends why less depends upon the time constant of the C 2 a capacitance and the load RL. So, depending upon the load and the C 2 there could be a small a reduction in the output voltage could be slightly lesser than the two V max. So, depends mainly on the factors C 2 and RL.

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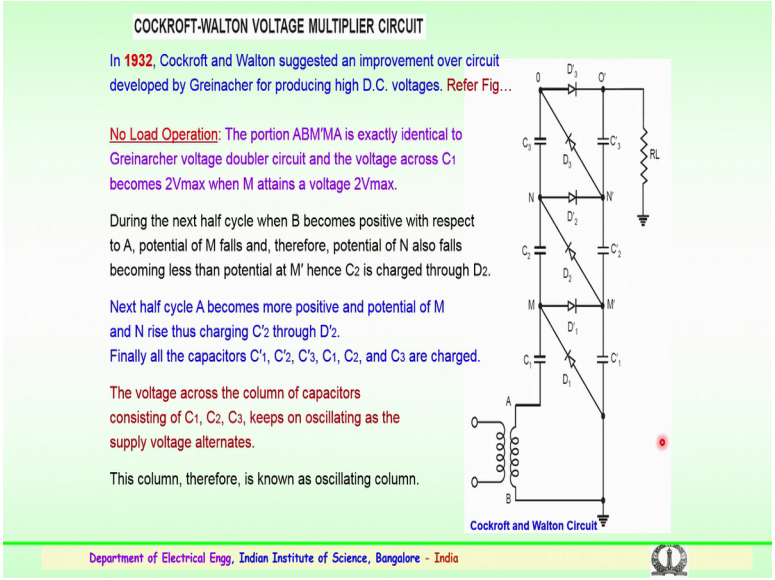

So, further in 1932 a Cockcroft and Walton suggested an important improvement over the circuit, which was a developed earlier which we discussed by the Greinacher for producing the DC voltages.

So, this is the Cockcroft Walton circuit for using for multiple stages are a multiplier circuit. So, where which several diodes and capacitor units are connected to the load and we could achieve more voltage that is the intension of generating the higher DC voltages. So, when you closely look the circuit here a various points have been mentioned here. So, during the no load operation, in case there is no operation load is not connected. So, the portion AB A B M and M dash. So, this is A B M dash and A. So, this loop A B M dash M and A this is the operation which is being exactly identical when you look this portion this is exactly identical to the previous circuit, that is a Greinacher voltage doubler circuit and the voltage across the C 1 here becomes 2 V max which we have discussed and this M will attain the voltage to 2 V max.

So, during the next half cycle when B becomes positive with respect to A, the potential of M this is M falls and therefore, potential of N this N also falls becoming less then potential M dash. Hence this C 2 is charged through the D 2 this diode during the earlier stage, further next half cycle a becomes more positive and potential M and this point n raises thus charging these two capacitor that is C dash 2 through this diode that is D dash 2 through this it charges through D dash 2 and finally, the capacitors C dash 1, C dash 2 or C dash 3 and C 1, C 2 and C 3 are charged.

So, the voltage across here the column of capacitor consisting of C 1, C 2 C3 keeps on oscillating as the voltage alternates, and this column which is oscillating is also known as the oscillating column which is been known.

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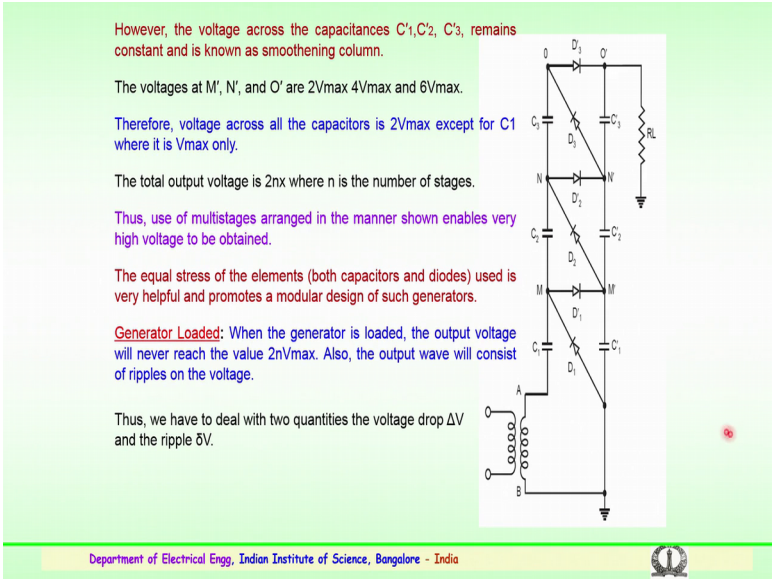

However, as the voltage across the C 1 dash C 2 dash and C 3 dash remains constant and this column is known as the smoothing column in the circuit. Now the voltage is at M dash and N dash that is M dash this point and N dash, and the output O dash are here it is 2 V max it is a 4 V max and it is 6 V max here.

So, therefore, the voltage across all the capacitors that is terminal here and here is 2 V max except for C 1, where it is V max only for here it is only V max all other points c the voltage of 2 V max. So, the design has to be made in such a way all the capacitors are rated for 2 V max except the C 1 which is at V max only. So, the total output voltage is 2 into N into x number of stages. So, here it is 3 stages the N could be any number of

stages depending upon the voltage requirement. Thus use of multi stage circuit arranged in a manner as shown here will enable to generate a high voltage which is necessary for the applications.

So, the equal stress of elements that is both the capacitors and the diodes used is very helpful and this promotes a modular design for such generators during load considering. So, when the load is added to the generator. So, the output voltage will never a reach two n into number of that V max. So, 2 n is the number of stages. So, V max here again because of the effect of other capacitance and the RL. So, as the output wave will consists also the ripple of the voltages. So, to reduce the ripple a suitable of arrangements have to be done by employing the suitable capacitance in the output side.

So, this ripple could be reduced depending upon the requirement of the DC output voltage. So, we have to deal with two quantities that is a voltage drop and the ripple of the voltages which have been seen. So, whether the ripple quantity have to be reduced a suitable capacitance could be employed and the ripple could be brought down for the testing aspect.

So, these are the basic idea of generating the high voltage DC

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And several high voltage DC sets are available across the country, one such example is the DC test setup which has a capability of 2000 kilo volts current rating of 10 amp

particularly for testing the power cables including a high voltage a resistor automatic grounding system and so on and this shows the photograph of high voltage DC set in a laboratory.