Ferroelectric Transformer using High Frequency Electric field for switching polarization to get multiple levels of DC voltage and for fault protection [1]

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Abstarct: The fundamental understanding of negative capacitance is not fully complete. Ferroelectrics are like ferromagnetics in that the different areas of ferroelectrics get polarized in different directions based on the charge density and finally the net charge of the material, as a whole gives the resultant polarization in a particular direction. The negative permitivity results in opposite polarization and it can be further explained in multidomain ferroelectrics.The application model as a static DC transformer based on magnetic capacitor model is discussed here.

Introduction:

Relation between Polarization Vector(P),DisplacementVector(D) and Electric Field(E):

Polarization is the result of effect of effect on dielctric placed in an electric field and there will be further electric field due to polarized charges.There will be both applied electric field (E) and due to polarization-Ep with dielectric constant ofthe insulator as *εr.*

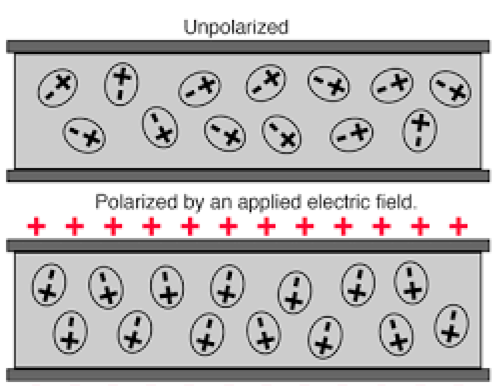


Fig. 1. Electric polarization

$$E = \sigma / \varepsilon 0 \ (1)$$
$$Ep = \sigma p / \varepsilon 0 \ \varepsilon r \ (2)$$

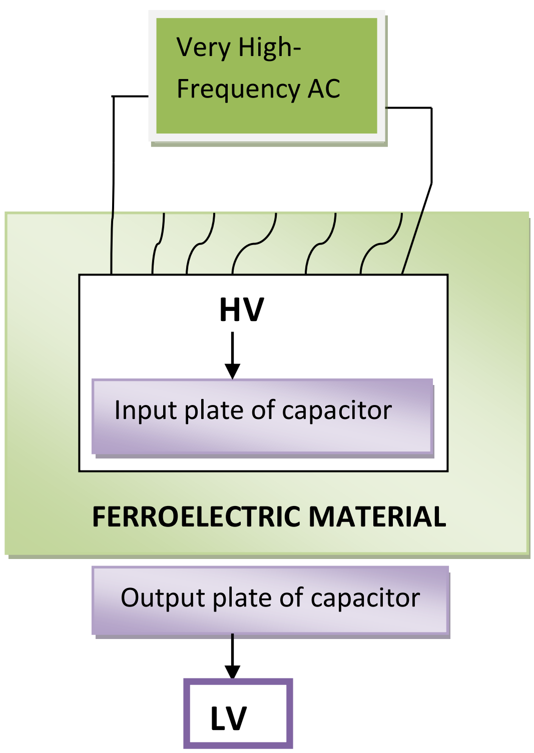
Where σ is the electric charge density.

The resultant electric field ER due to Dispalcement field(D) and Polarization field(P) is given by:

$$E_R = E - Ep \ (3)$$

$$\varepsilon 0 E_R = D - P / \varepsilon r \ (4)$$

Ferroelectric Transformer



As cited vide references, ferroelectric capacitors have the capability of doing DC voltage amplification locally.It is verified by Argonne National Lab,USA by designing a steady state negative capacitor. [3]

The opposite polarization of ferroelectrics is the underlying concept behind DC voltage amplification. The opposite polarization due to negative permittivity can be tuned by applying electric field at varying frequencies through the coil wound around the ferroelectric material as shown in figure.

If it is normal polarization, there is voltage decrease and if it is opposite polarization, it is voltage increase.

The amount of DC voltage that can be stepped up or stepped down depends on the permittivity of the ferroelectric material which is controlled by high-frequency signal, the charge distribution or polarization in the material and capacitance of the setup based on geometrical considerations.

Essentiality of the Model:

In order to achieve sustainability in power generation, HVDC transmission is very essential. The DC type transmission is not commonly used mainly due to the absence of step-up or step-down transformers which are easily available for AC transmission.If a proper solution is found out to solve this problem, the HVDC transmission and protection methods will be easy.

Advantage regarding fault analysis in Power Transmission Systems:

During normal fault, the fault current is being supplied by the transformer. In this case, the DC transformer wont supply the fault current and during fault ,the voltage drops to zero.

There will be no fault parameters for damaging the equipments or network. This transformer simply provides isolation during fault conditions too .All the fault currents will flow towards the earth not reflected in transformer neutral.

References

1. Deepalskhmi Chandrasekaran,"Underlying Physics behind negative capacitance," https://nanohub.org/resources/36716 (2022)

2. https://eepower.com/news/negative-capacitance-could-improve-efficiency-in-computers-and-solar-cells/#

3. https://doi.org/10.22214/ijraset.2022.40455

4. Deepalakshmi Chandrasekaran (2023),"A New Perspective of Capacitive-Inductive Transition in Ferroelectrics," https://nanohub.org/resources/36781