Circuit Analysis of Nested Current Element to Explain Ohmic Current Diffusion in Tokamak Plasmas

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A seemingly simple question sometimes is not that simple to answer in simple way. The direction of current diffusion in the tokamak is one example. The inductive Ohmic current when the central solenoid current is varying, we all know that the effects are start from outside to inside. The answer may given by the wave propagation and skin depth effect but if you compare the system size of the tokamak with the wave length caused by the central solenoid current variation, the answer should be given in a simpler way. The most simple and successful description of the start up of the tokamak operation is the circuit theory. The circuit theory does not miss any essential feature of the tokamak start up in this aspect. Therefore this question also should be able to be answered by circuit model. Each circuit comprised in the circuit model does not direct information of distance from the CS coils they just communicate each other through the mutual inductance. How do they know which one is higher rank? This work is inspired by the following statement:

At the very moment of CS coils current are varied the loop voltages applied on any closed paths surrounding the center stack are the same. Therefore all closed paths start to build current on their paths and at the same time they are screening the induced electric field or loop voltage each other by mutually interacting through the mutual inductance. They seem to be equal when we write down them in a circuit model.

We modeled the tokamak current consists of nested circuit elements conformal with the flux surface and we found that the matrix of mutual inductance of circuit model has specific symmetry. Intuitive explanation of this question and analysis of some of KSTAR Ohmic discharges are studied.