Some Analogy between Negative Shunt Conductance in a Distributed Parameter Line Equivalent to Parametrically Amplifying Traveling-wave Antenna and Negative Resistance in an Equivalent Lumped Circuit of Esaki Diode

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Structure of parametrically amplifying traveling-wave antenna is a wire above a semiconducting or lossy dielectric base-plate [1] and its eigen-mode becomes a fast wave for a certain high frequency range where the shunt conductance of its equivalent distributed parameter line becomes negative [2]. This new result of identity of a negative shunt conductance and a fast wave-mode is most remarkable and is a necessary condition for the present antenna to operate.

On the other hand, the Esaki diode is characterized by a negative resistance of an equivalent lumped circuit and plays a significant role as a semiconductor device based on quantum-mechanical tunnel effects as is well known [3].

An induced wave current of the present antenna is a fast wave. Therefore, when it is illuminated by an incident plane wave and its front velocity along the line is adjusted to be equal to the phase velocity of the induced line wave, parametrical amplification of the induced wave current along the line could be expected as a result of synchronization of both waves, thus the part of incident wave energy being transferred to the induced wave. In this way, the present antenna holds a high gain and a high directivity.

At low frequencies, however, the shunt conductance becomes positive, virtually being reduced to the conventional Beverage antenna. This corresponds to a positive resistance in the diffusion-dominant region in the Esaki diode.

Comparison of the present antenna and the Esaki diode is made illustratively in terms of voltage-current characteristics and their causing effects and mechanisms: attenuation and phase characteristics for the present antenna and energy-level diagram for the Esaki diode.

REFERENCES

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