Study of Magnetic Pickups for Electric Guitars

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ABSTRACT

Electric guitars use sensors to convert the string vibration into an electrical signal. The most common type of sensors is the magnetic pickup based on the principle of magnetic induction. These pickups are generally modeled using an equivalent Thevenin's generator whose electrical impedance is measured but whose voltage generator is not discussed. The aim of this work is to study Thevenin's generator of a single coil guitar pickup.

An experimental bench is carried out allowing to measure the response of the pickup to a harmonic motion of the guitar string for a single polarization. Several magnetic pickups are built in order to easily control each geometric and magnetic parameters. A parametric study is led and highlights the influence of several parameters on the induced voltage (frequency, material and section of the string, cinematic of the string, etc.).

A modeling of the output voltage is first proposed where the magnetic permanent field created by the magnet is supposed to be uniform. The approximation is rough but required to derive an analytical expression of the induced voltage where the influence of all parameters (coil, magnet, string) are explicit. Predictions of the modeling are compared to the experimental results: although the model succeeds to accurately predict the influence of some parameters, the assumption of uniform magnet field prevents the model to be fully satisfactory.

Consequently, in order to investigate the limitations due to the assumption of uniform magnet field , the model is compared to the numerical model proposed by Horton and Moore which takes into account the exact topology of the magnetic field created by a permanent magnet. The comparison between both models allows to clarify Horton's model and notably to establish the constant of proportionality between the magnetic field generated by the magnet and the one generated by the magnetized string. The comparison of the theoretical results with the experimental data leads to a discussion about the modeling of the string magnetization suggested by Horton's model.