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Comparing Spice Model of STT based MTJ with Micromagnetic Simulations

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The development of compact Spice models is an important tool to explore all the potential of Spin-Transfer Torque Magnetoresistive Random Access Memory (STT-MRAM) in simulations. One of the biggest challenges is to accurately represent the Micromagnetic behavior of Magnetic Tunnel Junctions (MTJ), the basic device employed in STT-MRAM bitcells, with Spice simulations. In this work, we ported a Spice MTJ model implemented by University of Minnesota to the Cadence Spectre platform. This model was built on top of the Landau-Lifshitz-Gilbert Equation (LLG) formalism, which describes the Magnetization motion in nanometric ferromagnetic layers as a time-dependent function, using non-linear voltage and current sources. Using this port, we compared the performance and accuracy obtained with the compact model to the ones obtained with the mumax3 Micromagnetic Simulator. Micromagnetic simulations provide a golden standard in terms of accuracy, but their performance is orders of magnitude worse than electrical simulation. Since these models have different physical parameters, we established a set of rules to convert parameters between them. Then, we performed experiments setting the micromagnetic simulator to consider a single magnetic domain, representing the same physical problem solved by the Spice model. Through this method, we incorporate the same materials, precession, damping and STT constants in both models, such as the dimension, the Magnetization Saturation, the gyromagnetic ratio and the damping factor. The three Magnetization components produced by the LLG solution in both models present similar waveforms, even though the time scale does not match by two orders of magnitude. Further studies will be performed to determine the source of mismatch.