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Phase Diagram of Spin-Torque Oscillators with Dual Free Layer
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We theoretically study properties of spin torque oscillators that consist of two free layers with easy-plane magnetic anisotropy sandwiched between two fixed layers with strong perpendicular magnetic anisotropy. This type of spin torque oscillator can generate large-amplitude microwave signals with the frequency that is the sum of the precession frequencies of the free layers. Using micromagnetic simulations, we map out the available dynamic and static phases on the current-damping phase diagram of the system. We find that current-induced hysteretic switching occurs between macrospin-like precessional states and static vortex states. Switching between these states takes place via transient vortex states, and we show that its hysteretic nature derives from the energy barrier to vortex creation and annihilation at the free layer edges. We employ Thiele's equations to describe the current-dependent trajectory of the vortex core in the transient regime, thereby developing a model for critical switching currents in this system.

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