\*\*\* All-electrical manipulation of perpendicular magnetic tunnel junction through tilted spin polarization \*\*\*

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\*\*\* General Introduction \*\*\*

This dataset contains data collected in the measurements on perpendicular MTJ devices at Tsinghua University, as part of a journal paper to be published in Physical Review Applied.

It is being made public both to act as supplementary data for publications and in order for other researchers to use this data in their own work.

The data in this data set was collected in the Key Laboratory of Advanced Materials of Tsinghua University – School of Materials Science and Engineering, between October 2023 and May 2025.

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\*\*\* Purpose of the test campaign \*\*\*

The purpose of these experiments was to investigate field-free magnetization switching of perpendicular magnetic tunnel junctions through tilted spin polarizations.

\*\*\* Test equipment \*\*\*

The data in Figure 1, 3, and 4 were performed in the physical property measurement system (PPMS), Quantum Design. The data in Figure 2 were performed in homemade ST-FMR setup combining signal generator (Ceyear) and nanovoltmeter (Keithley 2182).

\*\*\* Description of the data in this set \*\*\*

This dataset has 14 sheets.

**Sheet 1 (Figure 1)**: column A and B are the *x*- (*H*z) and *y*-axial data (*R*), respectively.

**Sheet 2 (Figure 2b)**: column A and C are the *x*-axial data (*H*ext), while column B and D are the *y*-axial data (*V*).

**Sheet 3 (Figure 2c)**: column A is the *x*-axial data (*φ*), column B and C are the *y*-axial data (*V*).

**Sheet 4 (Figure 2e)**: column A and C are the *x*-axial data (*H*ext), while column B and D are the *y*-axial data (*V*).

**Sheet 5 (Figure 2f)**: column A is the *x*-axial data (*φ*), column B and C are the *y*-axial data (*V*).

**Sheet 6 (Figure 3a)**: column A and C are the *x*-axial data (*H*z), while column B and D are the *y*-axial data (*R*yx).

**Sheet 7 (Figure 3b)**: column A and D are the *x*-axial data (*J*), while column B, C, E, and F are the *y*-axial data (*R*yx).

**Sheet 8 (Figure 3d)**: column A is the *x*-axial data (*J*), while column B–H are the *y*-axial data (*R*yx).

**Sheet 9 (Figure 3e)**: column A is the *x*-axial data (*H*x), while column B and C are the *y*-axial data (*J*th).

**Sheet 10 (Figure 3f)**: column A is the *x*-axial data (*H*x), while column B is the *y*-axial data (Switching ratio).

**Sheet 11 (Figure 4a)**: column A is the *x*-axial data (*H*z), while column B is the *y*-axial data (*R*).

**Sheet 12 (Figure 4b)**: column A and column C are the *x*-axial data (*J*), while column B and D are the *y*-axial data (*R*).

**Sheet 13 (Figure 4c)**: column A is the *x*-axial data (*J*), while column B is the *y*-axial data (*R*).

**Sheet 14 (Figure 4d)**: column A is the *x*-axial data (Counts), while column B is the *y*-axial data (*R*).