



# Spintronic Analog-to-Digital Convertor (ADC) (20140257, Dr. Jian-Ping Wang)

**IP Status:** Issued US Patent; **Application #:** 14/532,746

## Novel MTJ-based ADC

A first-of-its-kind spintronic analog-to-digital converter (ADC) based on magnetic tunnel junction (MTJ) can convert magnetic signals directly into digital electrical signals. Spin Hall effect (SHE) and voltage assisted magnetization switching control MTJ magnetization and convert analog signals to digital signals.

This novel device features:

- Non-volatility and storage of conversion results
- Low power consumption
- Simple circuit
- Smaller footprint with higher bit resolution
- High conversion speed and very high (GHz) sampling rate

The device is fully compatible with standard CMOS technology, and because it uses electron spin during the analog to digital conversion, it is very energy efficient, fast and robust. The ADC works with any type of MTJ device, including in-plane MTJ or perpendicular magnetic anisotropy (PMA). This novel technology offers a new route for designing very fast, very high resolution, low cost ADCs in large scale.

## Faster, smaller, simpler devices

Traditional analog-to-digital converter (ADC) technology such as Flash ADC is limited by conversion speed, power consumption and circuit complexity. The conventional transistor-based ADCs also require more comparators. The novel design and circuit architecture of this new ADC replaces each comparator of the flash ADC with an MTJ comparable in size to a single transistor. The non-volatile MTJ saves space by significantly reducing the number of transistors. By using magnetoresistive devices as comparators, this new design produces smaller devices that consume less power and provide faster comparison between analog input values and reference voltages. It can allow for a wider range of MTJ device configurations and materials which could lead to reduced costs and improved circuit performance.

## Phase of Development

- Proof of concept

## Benefits

## Technology ID

20140257

## Category

Engineering & Physical  
Sciences/Instrumentation,  
Sensors & Controls  
Engineering & Physical  
Sciences/Nanotechnology  
Engineering & Physical  
Sciences/Semiconductor

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- Faster conversion speeds
- Smaller footprint
- Low power consumption
- Energy efficient, fast and robust
- Simple circuits with improved performance

### Features

- Spintronic ADC design based on MTJ
- Converts magnetic signal directly into digital signal
- Non-volatile
- Compatible with any MTJ device, including in-plane MTJ or perpendicular magnetic anisotropy (PMA)
- Replaces flash ADC comparator with transistor-sized MTJ
- Fully compatible with standard CMOS technology

### Applications

- Analog-to-Digital Converters (ADC)
- Electronic
- Sensors
- Mobile devices

### Researchers

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