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HOW TO CHOOSE THE BEST MICROPOWER SWITCH OR LATCH MAGNETIC SENSOR FOR YOUR APPLICATION

By Allegro MicroSystems

INTRODUCTION

In the rapidly evolving landscape of electronic devices, the quest to optimize power consumption without compromise to performance is a paramount challenge to engineers.

This application note discusses operational principles of micropower Hall sensors that are pivotal to the increased operational efficiency and application performance of modern electronic systems. As the industry moves toward more-power-sensitive applications, selection of components that align properly with the specific needs of an application increasingly requires knowledge of the tradeoffs associated with micropower devices.

This application note discusses the fundamental principles that govern micropower switch and latch magnetic sensors and provides a comprehensive guide to device selection and integration of passive components for enhanced system performance.

MEETING THE NEEDS OF A LOW-POWER WORLD

The need for extended battery life and energy efficiency has increased the prevalence of micropower applications across various sectors. Many markets and applications can benefit significantly from micropower magnetic sensing technology.

Within the smart home, micropower switch and latch sensors enable highly efficient door locks and tamper detection in electric meters, and thereby enhance facility security and prevent energy theft. Open/closed detection systems for windows, doors, and portable electronics such as cell phones, tablets, and laptops also rely on micropower magnetic sensors for power-efficient operation. Heating, ventilation, and air conditioning (HVAC) systems use micropower switch/latch sensors in dampers, valves, and solenoids for precise control and better energy efficiency. Energy harvesting applications, where power is scavenged from ambient sources, also benefit from micropower sensors to maximize the use of harvested energy.

These applications showcase the diverse range of use cases for micropower magnetic sensing technologies to optimize energy efficiency and to extend battery life across consumer, industrial, and automotive domains. These applications all have unique requirements that must be considered to ensure the system operates at its best.

For example, an open/closed detection system for a laptop must be sufficiently responsive to the user and, simultaneously, sufficiently power-efficient to preserve battery power between charges. Alternatively, for a battery-powered tamper-detection system that monitors its environment infrequently, a slower update rate and response time might be appropriate to allow the design to fully leverage the low-power capabilities of the sensor. Micropower Hall sensors like the Allegro APS11753 [1] and APS12753 [2] have the performance, low power consumption, and design flexibility needed to make the proper tradeoffs in these applications and more.

The range of micropower magnetic sensing applications and their tradeoffs between power consumption and response time are illustrated in Figure 1.

Ultra-low-power systems frequently use small-form-factor coin-shaped cell batteries. Therefore, the ability of a sensor to maintain reliable performance when powered from these low battery cell voltages must be considered. With a supply voltage range of 2.2 V to 5.5 V, the APS11753 and APS12753 simplify the integration of high-performance magnetic sensors into energy-efficient battery-powered designs.

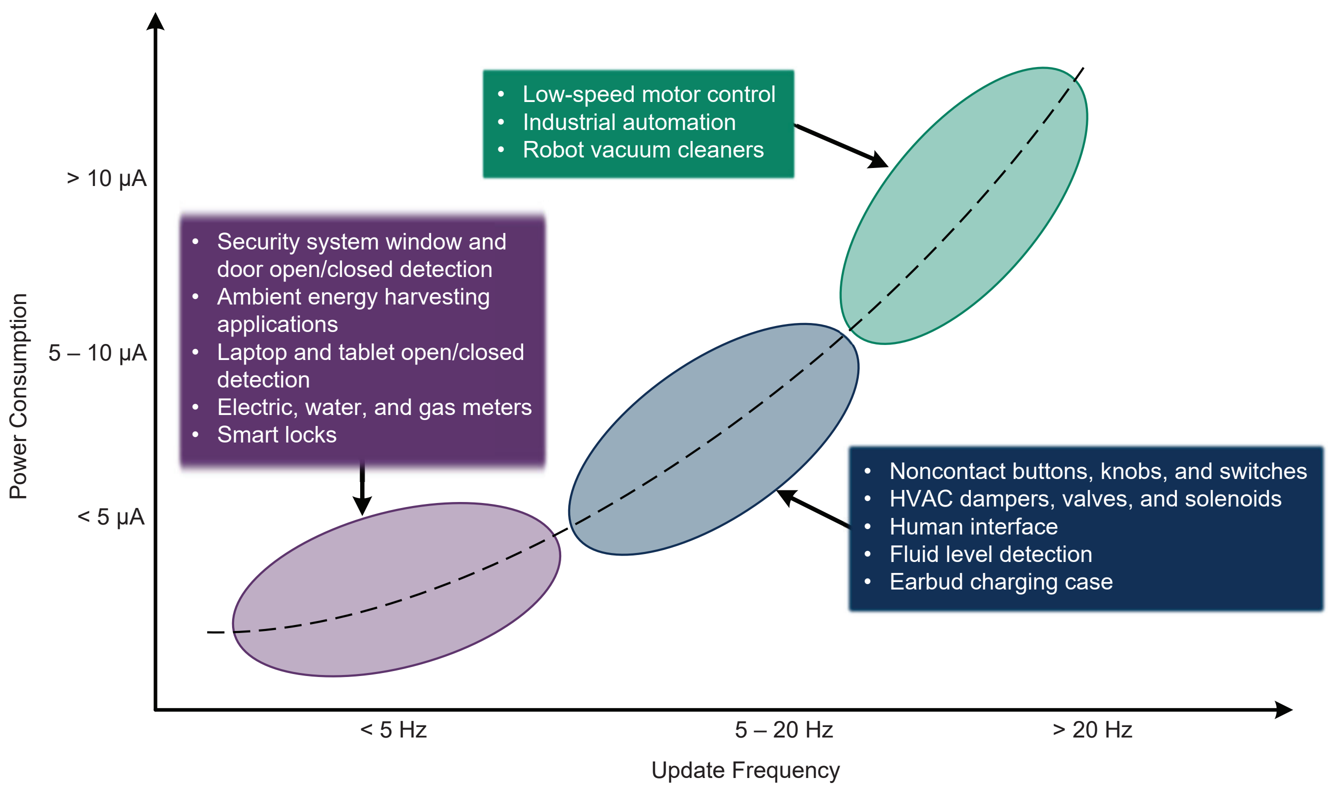

Figure 1: Micropower Device Applications

[1] https://www.allegromicro.com/en/products/sense/switches-and-latches/micropower-switches-latches/aps11753

[2] https://www.allegromicro.com/en/products/sense/switches-and-latches/micropower-switches-latches/aps12753

MICROPOWER LATCHES AND SWITCHES: CUTTING THE POWER

The goal of a micropower magnetic switch or latch is to minimize the power consumed and, simultaneously, to maintain the functionality and performance that the application demands. To achieve this goal, the APS11753 and APS12753 reduce the average current consumption through a built-in duty-cycle mechanism that periodically activates and deactivates the internal circuitry of the sensor. This cyclical process involves two distinct phases: an "awake" phase (t_{AWAKE}) and a "sleep" phase (t_{SLEEP}) (see Figure 2).

Awake Phase (t_{AWAKE})

During the brief period that is the awake phase, the transducer and signal path circuitry are active and the sensor stabilizes and measures the magnetic field. To minimize energy consumption, the duration of the awake phase is designed to be just long enough for accurate sampling and stabilization to occur.

Sleep Phase (t_{SLEEP})

To conserve power, after the awake phase, the transducer and signal path circuitry deactivate. During this sleep period, the output is latched to the last sampled state, which maintains the output state regardless of any changes in the local magnetic field. For most applications, this sleep phase does not have a meaningful impact on system operation.

Average Current Consumption ($I_{CC(AVERAGE)}$)

For a micropower switch or latch, the average current consumption ($I_{CC(AVERAGE)}$) is determined by the weighted average of current consumption across the sleep and awake stages ($I_{CC(AWAKE)}$ and $I_{CC(SLEEP)}$), typically calculated as:

$$I_{CC(AVERAGE)} = \frac{I_{CC(AWAKE)} \times t_{AWAKE} + I_{CC(SLEEP)} \times t_{SLEEP}}{t_{AWAKE} + t_{SLEEP}}$$

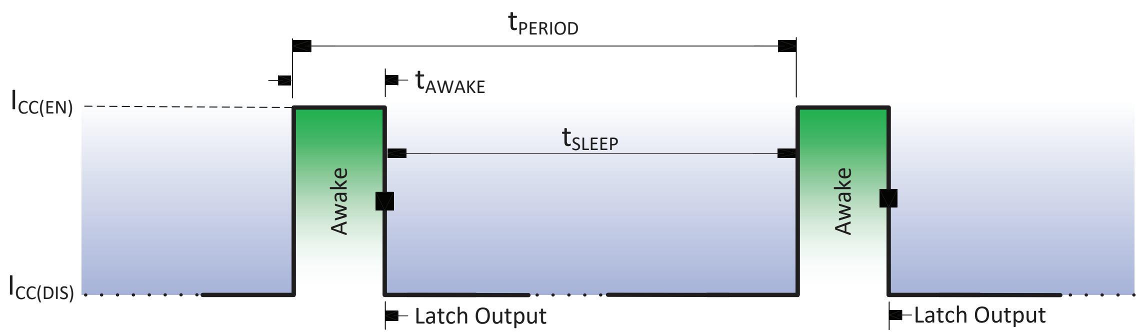

Figure 2: Periodic Update of Device Output

Output Electrical Configuration

Typically, a magnetic switch or latch sensor has either an open-drain or a push-pull style of output configuration. Devices that have an open-drain configuration require an external pullup resistor for proper operation. The current that flows through this resistor must also be considered in the overall power budget of the end system. Use of a larger-value resistor to limit current draw might seem like an obvious design choice; however, in practice, leakage currents from the output transistor of the sensor generate offsets that limit the maximum value of the pullup resistor.

For micropower applications, it is usually better to select a device like the APS11753 or APS12753, with a push-pull style of output. In this configuration, an internal transistor serves to pull up the output such that the external pullup resistor and its associated energy losses are eliminated. This method also provides the benefit of a reduced part count.

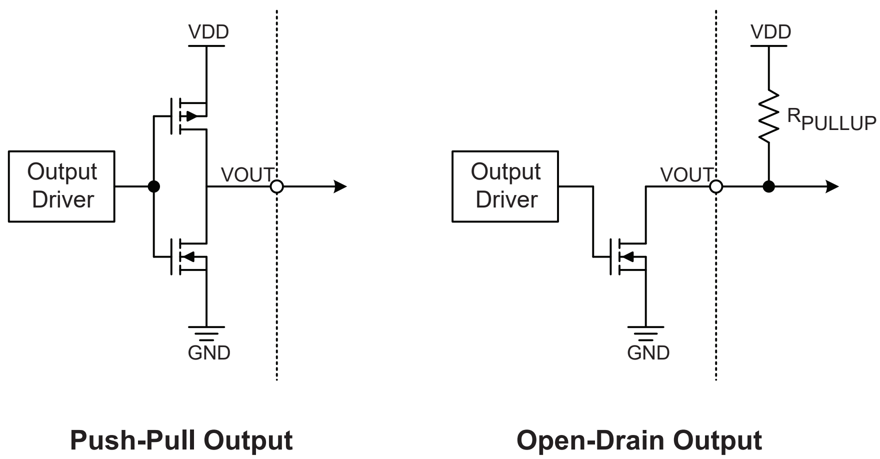

Figure 3: Output Driver Configuration Comparison

Relationship Between Update Rate and Battery Life

To meet specific application requirements, the available configuration options for the APS11753 and APS12753 provide flexibility in device response time and power consumption. To illustrate this, a simulation of the state of charge of a coin cell battery is shown in Figure 4. The simulation is based on the estimated current consumption of two different configuration options of the APS11753 low-voltage micropower switch. As can be observed, the different update rates greatly affect battery life:

- The device with t_{SLEEP} = 1.5 ms depletes the battery in less than 4,000 hours.
- The device with t_{SLEEP} = 48 ms depletes the battery after more than 47,000 hours.

CONCLUSION

To select the proper micropower switch or latch, power-consumption requirements must be considered carefully, in balance with the required sensor update rate.

This application note:

- Explores the functionality and benefits of micropower Hall sensors, such as the Allegro APS11753 and APS12753 devices; and
- Highlights the impact that Hall sensor selection has on energy efficiency and battery life in application.

By understanding the key considerations presented here, engineers can confidently choose the optimal Allegro MicroSystems magnetic sensor solution to meet their specific application requirements and to create a path forward for innovative, energy-conscious designs.

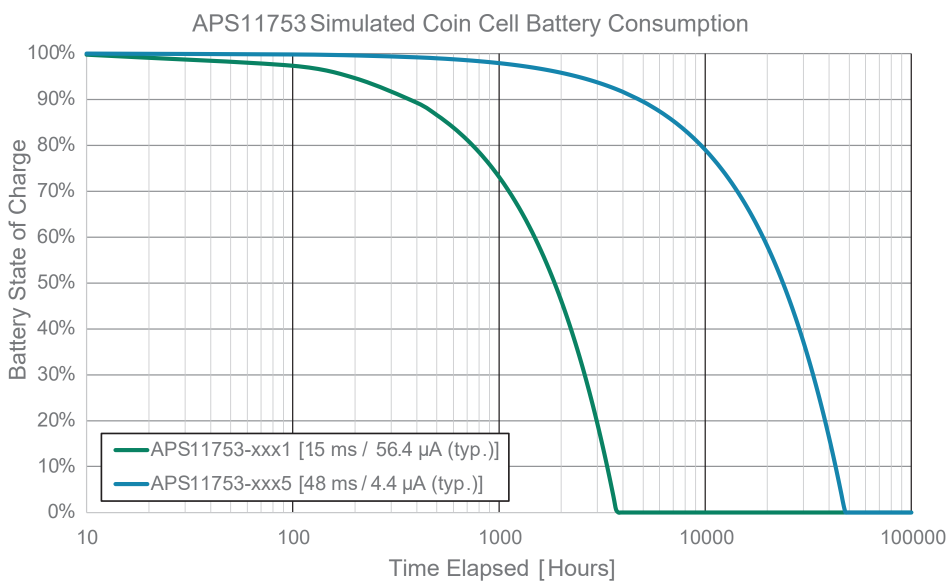

Figure 4: APS11753 Simulated Battery Life Comparison

Revision History

Number	Date	Description	Responsibility
–	January 8, 2025	Initial release	J. Bader

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