# ENHANCING PERSONAL-MOBILITY SAFETY WITH A ROBUST SIDE STAND USING HALL-EFFECT SENSING

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## ABSTRACT

To build supply-chain-resilient systems, there is a strong desire to develop applications with alternative technologies. This application note focuses on the side-stand detection system, a critical safety feature in personal mobility, and demonstrates the feasibility of replacing common rare-earth magnets with lower-cost, supply-chain-resilient ferrite magnets. Through simulation and analysis, this application note shows that, with proper design considerations, a system using a Hall-effect switch and a ferrite magnet can achieve robust performance comparable to one using a rare-earth magnet, without compromising vehicle safety.

A side stand facilitates parking of personal-mobility vehicles, such as motorcycles, e-bikes, and mopeds. Failure to retract the side stand before riding one of these vehicles can create a significant safety hazard. To mitigate this risk, vehicle designs require a feedback system that prevents the engine from starting and provides an indication to the rider while the side stand is deployed.

A Hall switch, paired with a permanent magnet, offers a highly robust, noncontact method for detecting the stand position. [1]

The location of a side stand used to support a personal-mobility vehicle when parked is shown in Figure 1.

While rare-earth magnets, such as NdFeB-grade and SmCo-grade magnets, are often used for their high field strength, ferrite magnets are a compelling alternative due to their lower cost and supply-chain stability. The core of this application note provides a direct comparison between these two magnetic solutions within a Hall-effect sensing system. To provide the full picture, this application note first outlines the requirements for a side stand then briefly reviews common sensing technologies. However, the primary focus is a detailed simulation and evaluation of system performance when using a rare-earth magnet versus a selected ferrite magnet, providing engineers with a clear design path for a cost-effective and robust solution.

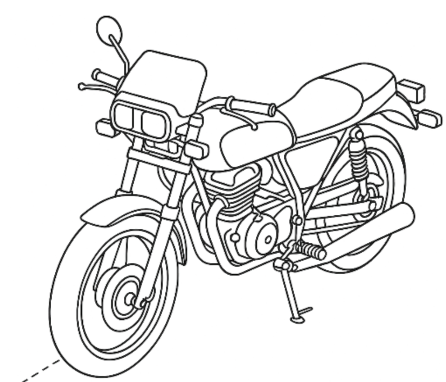


*Figure 1: Personal-Mobility Side-Stand Arrangement [2]*

[1] Selecting the Right Magnetic Switch or Latch for Your Application, Allegro MicroSystems Application Note AN296330, https://www.allegromicro.com/-/media/files/application-notes/an296330-how-to-select-the-best-switch-or-latch.pdf?sc_lang=en
[2] This content was generated by Allegro artificial intelligence and verified by the authors, February, 2026.

# OVERVIEW OF COMMON SWITCHING TECHNOLOGIES

## Mechanical Switch

A mechanical switch is a common contact-based solution. However, it is highly susceptible to failure from mechanical wear and tear, vibration, and exposure to environmental elements like water and dust. This often results in shorter product life and frequent product failures.

## Reed Switch

The Reed switch offers a contactless switching operation that overcomes the issues associated with a mechanical switch. However, the Reed switch consists of a fragile glass tube, which makes it vulnerable to damage from the shock and vibration common in personal-mobility applications.

## Hall-Effect Switch

The Hall-effect switch is a widely used noncontact solution. Its solid-state technology is immune to nonmetallic environmental contaminants and is resistant to shock and vibration. This offers a highly reliable, durable, and cost-effective solution suitable for a personal-mobility vehicle operating in harsh conditions.

# HALL SWITCH CLASSIFICATION [3]

## Unipolar and Omnipolar

**Unipolar Switch:** A unipolar switch responds to a single magnetic polarity (south or north).

**Omnipolar Switch:** An omnipolar switch responds to both south and north magnetic polarity. For production simplicity, an omnipolar switch provides pole-independent functionality.

## Three-Wire and Two-Wire Output

**Three-Wire Output:** A three-wire switch requires one pin each for VCC, GND, and OUT. An open-drain output is typical. This is a flexible and widely adopted topology in automotive applications.

**Two-Wire Output:** A two-wire switch simplifies wiring because only two connections are required: VCC and GND. A two-wire switch communicates its output state by modulating the supply current ($I_{CC}$). This reduces the length of the wire harness and the cost of the system. A small interface circuit might be required on the electronic control unit (ECU) side, as shown in Figure 2.

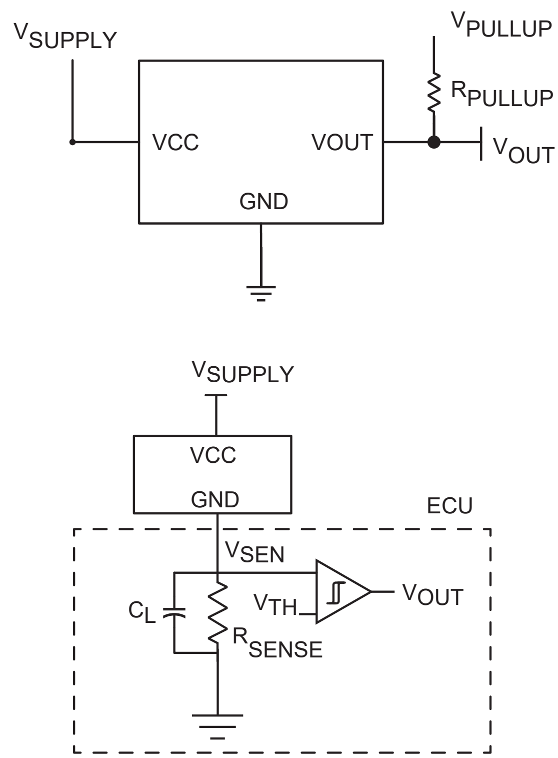



*Figure 2: Three-Wire Circuit (top) and Two-Wire Interface Circuit (bottom) [3]*

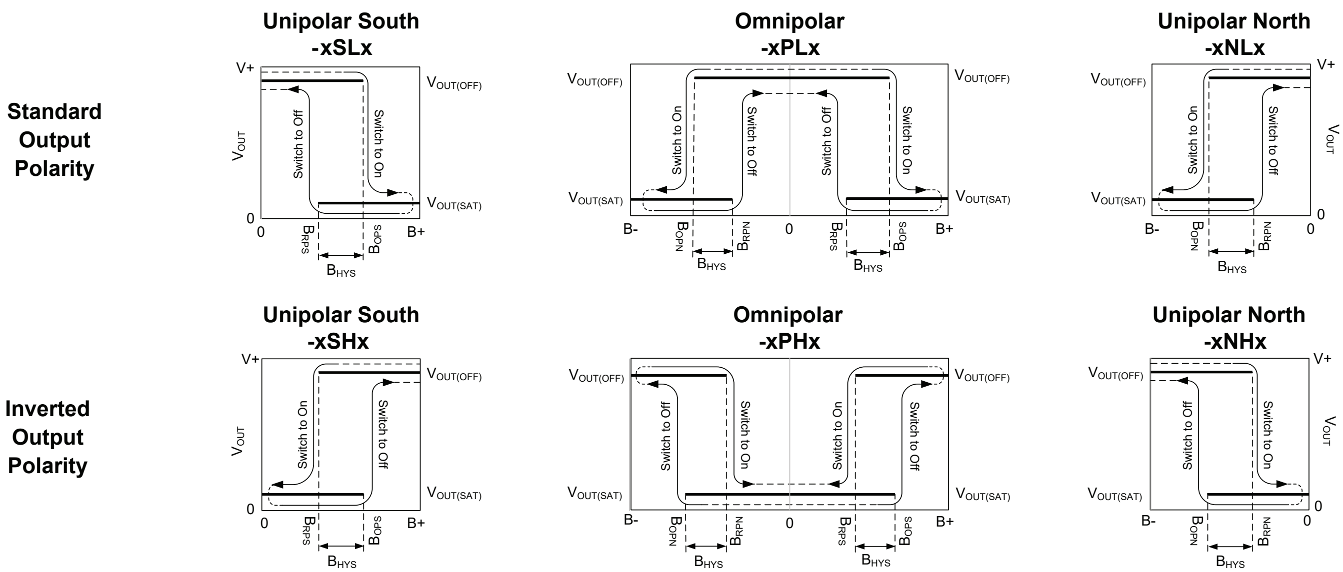
[3] Hall-Effect IC Applications Guide, Allegro MicroSystems Application Note AN2771, https://www.allegromicro.com/-/media/files/application-notes/an27701-hall-effect-ic-application-guide.pdf

## Standard and Inverted Output Polarity

Standard polarity results in a low output state when the applied magnetic field exceeds certain magnetic threshold. This polarity is traditionally used because it allows the "stand down" (i.e., deployed) state to directly control a warning lamp on the instrument cluster.

Inverted polarity results in a high output state when the applied magnetic field exceeds a certain magnetic threshold. For clarification, refer to Figure 3.

Select the appropriate polarity based on the ECU requirement.




**B- indicates increasing north polarity magnetic field strength, and B+ indicates increasing south polarity magnetic field strength.**

*Figure 3: Hall Polarity* [3]

## $B_{OP}$ AND $B_{RP}$ MAGNETIC THRESHOLDS

The magnetic field required to activate the device and turn on the output transistor is called the magnetic operate point ($B_{OP}$). When the magnetic field reduces, turn-off of the output transistor occurs. The magnetic field required to turn off the device once it is activated is called magnetic release point ($B_{RP}$). The difference between $B_{OP}$ and $B_{RP}$ is called hysteresis and is used to prevent switching bounce due to variations in magnetic field. The magnetic field, as well as $B_{OP}$ and $B_{RP}$, is temperature dependent and affects overall performance.

The typical transfer characteristics of a Hall switch are illustrated in Figure 4 for the case of $B_{OP}$ of 250 G and $B_{RP}$ of 150 G:

- When the magnetic field exceeds 250 G, the output of device reduces to the low state, 0.3 V.
- When the magnetic field reduces to less than 150 G, the output increases to the high state to pull up the voltage.

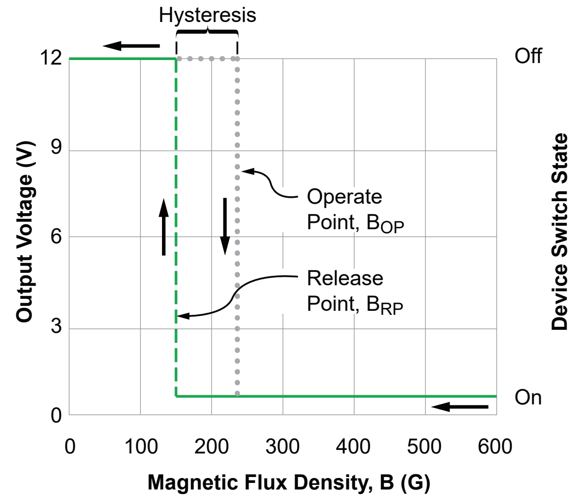



*Figure 4: Magnetic Transfer Characteristic*

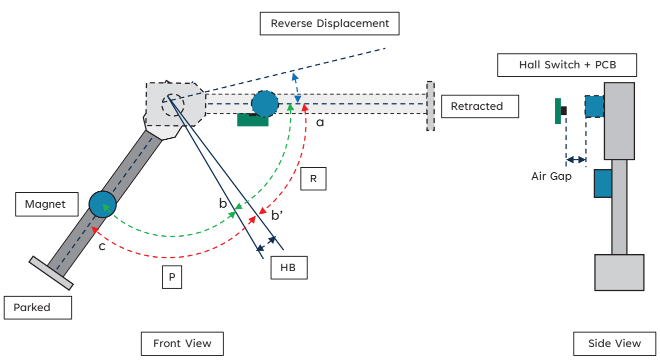
## PERSONAL-MOBILITY STAND USING HALL-EFFECT SWITCH

A side-stand arrangement where the relative movement between a stationary Hall switch and the magnet attached to the stand is illustrated in Figure 5. For this application, the “active zone” is defined as the angular range spanning the fully retracted (up) position of the side stand. This zone, which is characterized by the peak magnetic field strength, provides a definitive signal that the vehicle is safe to operate. The switch-active zone is defined as the span of the angle across which the Hall switch should operate, which guarantees the state at a given angular position.

The magnetic field profile versus stand rotation is illustrated in Figure 6. Per design requirements, when the stand moves from the retracted position to the parked position along path abc, the magnetic field remains greater than $B_{OP}$ in the switch-active zone; and, when the stand moves past point b, the magnetic field reduces to less than $B_{RP}$ , which ensures release.

When the stand moves from the parked position to the retracted position along path cb’a, the magnetic field remains less than $B_{RP}$ in the switch-inactive zone; and, when the stand moves past point b’, the magnetic field exceeds $B_{OP}$, which ensures operation.

In the case of a loose spring, such as from mechanical wear and tear, the side stand might move slightly. This can cause the magnetic field to cross the $B_{OP}$ and $B_{RP}$ thresholds repeatedly, which results in output chatter. Air-gap variations, temperature, and aging affect the overall magnetic field. The switch should have margin sufficient to maintain the magnetic field at greater than the $B_{RP}$ threshold in the retracted position.




*P = Parked, HB = Hysteresis Band, R = Retracted (i.e., Switch-Active Zone)*

*Figure 5: Side-Stand Arrangement in Two-Wheeler*

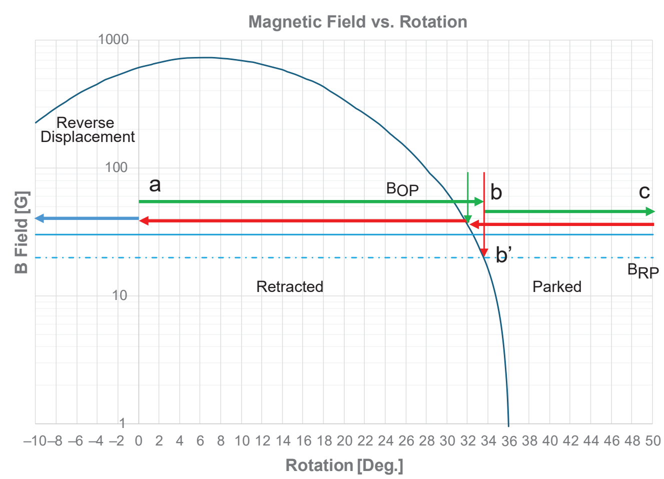



*Figure 6: Magnetic Field vs. Stand Movement*

## SIMULATION STUDY AND RESULTS

To quantitatively compare the in-system performance of rare-earth and ferrite magnets, magnetic simulations were performed using the Finite Element Method (FEM) in ANSYS Maxwell 3D software. This analysis helps to visualize the magnetic field profile differences and to determine the design tradeoffs required to successfully substitute a ferrite magnet for a rare-earth magnet.

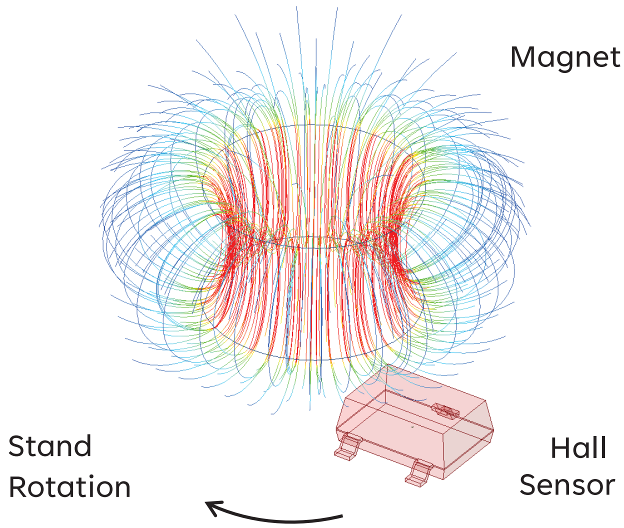



*Figure 7: Example of Visualization of Magnetic Field Profile*

### Typical System Specifications

- Rotational angle: 0° to 105°, where zero represents the horizontal position.
- Switch active zone: 0° to 36°
- Accuracy: ± 5°
- Must remain in the active state through –10° of reverse rotation.

### Magnet Selection

Typical magnetic properties for neodymium and ferrite magnet are listed in Table 1. The coercive force of a ferrite magnet is significantly weaker than the rare-earth magnet, so a ferrite magnet results in weaker magnetic fields. To meet the performance of a rare-earth magnet, a larger ferrite magnet is required. This study compares a rare-earth [N42] magnet and a ferrite [Y40] magnet.

*Table 1: Magnetic Property Comparison*

| Material | Remanent field or remanence [G] | Coercive Field [kOe] |
|---|---|---|
| Ferrite Y40 | 4400 | 4.15 |
| Neodymium N42 | 13150 | 11.8 |

## Results

Based on extensive simulation studies, magnetic switch APS11203-3SL and magnets N42-D5H3, Y40-D5H3, and Y40-D7H10 were selected. Results with these components are presented.

The magnetic field profile produced with a rare-earth N42 magnet with typical $B_{OP}$ and $B_{RP}$ points is depicted in the figures that follow with solid and dotted horizonal lines, respectively. As the magnetic field reduces to less than the minimum $B_{RP}$ threshold at approximately 34°, the switch releases.

To ensure switch functionality, the worst-cases of $B_{OP}$ and $B_{RP}$, with minimum and maximum levels, are plotted in Figure 9 and Figure 10:

- As shown in Figure 9, at approximately 36°, the magnetic field reduces to less than the minimum $B_{RP}$ threshold, which is where switch-release occurs.
- As shown in Figure 10, at approximately 32°, the magnetic field reduces to less than the maximum $B_{RP}$ threshold, which is where switch-release occurs.

These results show that the switch-active zone varies from 32° to 36°. These results, which serve as the performance baseline in this study, do not account for magnet manufacturing tolerances or aging effects. The data confirm that, using the rare-earth magnet, the switch remains active with sufficient margin through –10°.

Similar results are shown for the Y40-D5H3 magnet in Figure 11, Figure 12, and Figure 13, and for the Y40-D7H10 magnet in Figure 14, Figure 15, and Figure 16.

With the smaller Y40-D5H3 ferrite magnet, the switch-active zone shifts between 27° to 34°. Crucially, it is also observed that the margin at –10° is reduced, highlighting a potential performance tradeoff for this smaller ferrite option. However, use of the larger Y40-D7H10 ferrite magnet results in a switch-active zone between 42° to 47°, and sufficient margin at –10°. This result is key because it demonstrates that a larger ferrite magnet can indeed replicate the robust performance of the rare-earth magnet baseline switch and can be rearranged to meet the active-zone requirement.

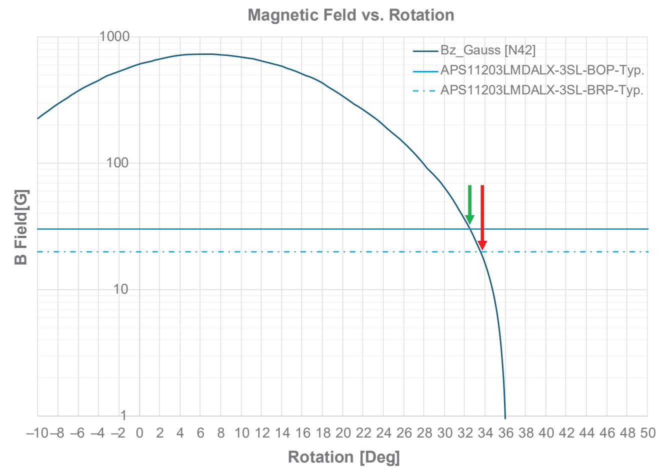



*Figure 8: Simulated Magnetic Field Profile Using Rare-Earth (N42-D5H3) Magnet with Typical $B_{OP}/B_{RP}$ Thresholds*

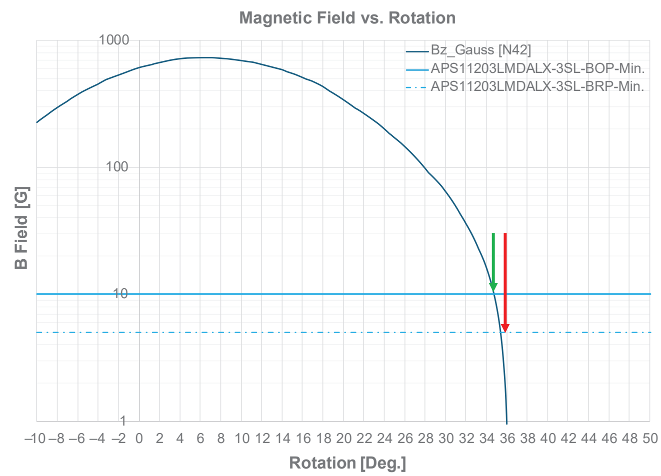



*Figure 9: Simulated Magnetic Field Profile Using Rare-Earth (N42-D5H3) Magnet with Minimum $B_{OP}/B_{RP}$ Thresholds*

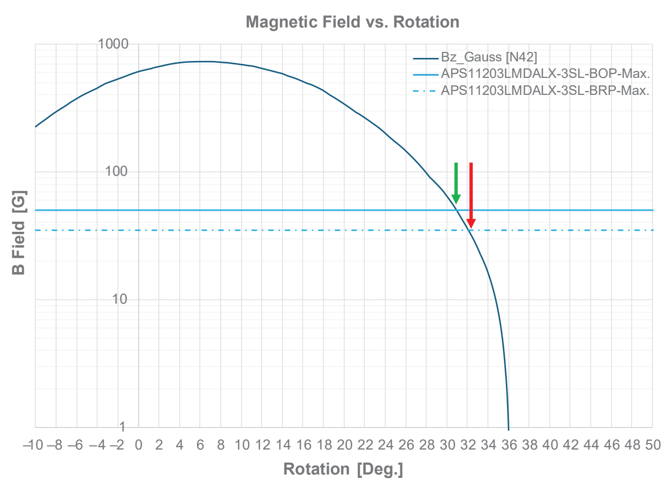



*Figure 10: Simulated Magnetic Field Profile Using Rare-Earth (N42-D5H3) Magnet with Maximum $B_{OP}/B_{RP}$ Thresholds*

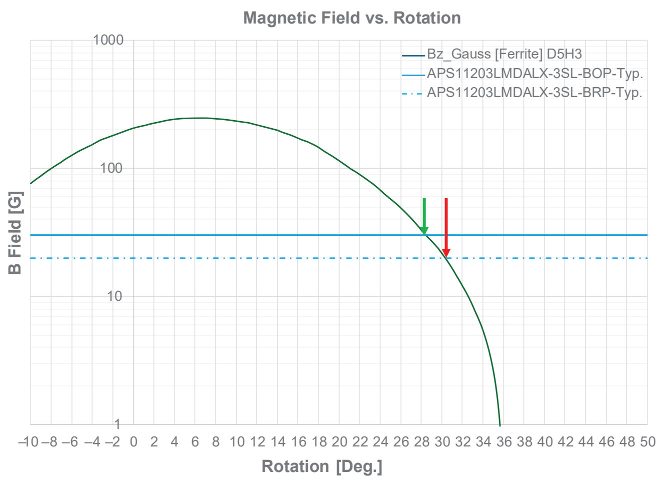



*Figure 11: Simulated Magnetic Field Profile Using Small Ferrite (Y40-D5H3) Magnet with Typical $B_{OP}/B_{RP}$ Thresholds*

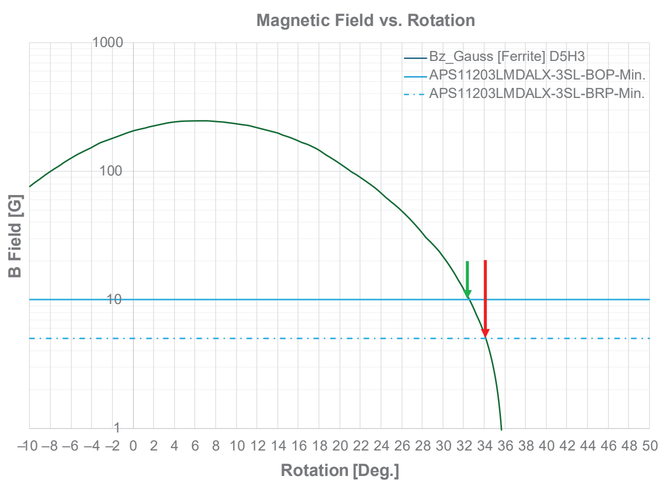



*Figure 12: Simulated Magnetic Field Profile Using Small Ferrite (Y40-D5H3) Magnet with Minimum $B_{OP}/B_{RP}$ Thresholds*

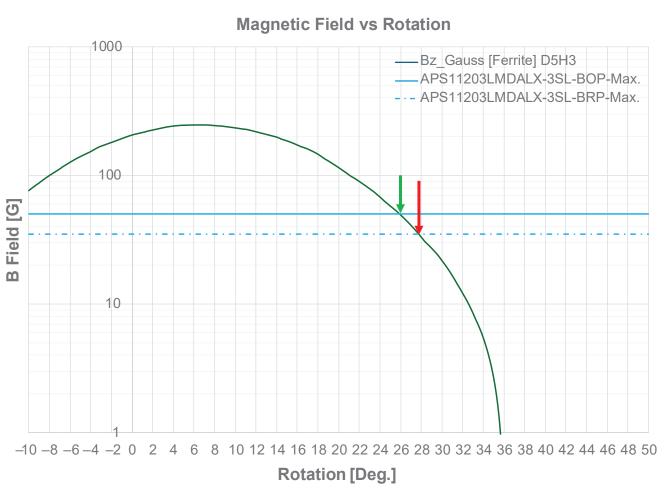



*Figure 13: Simulated Magnetic Field Profile Using Small Ferrite (Y40-D5H3) Magnet with Maximum $B_{OP}/B_{RP}$ Thresholds*

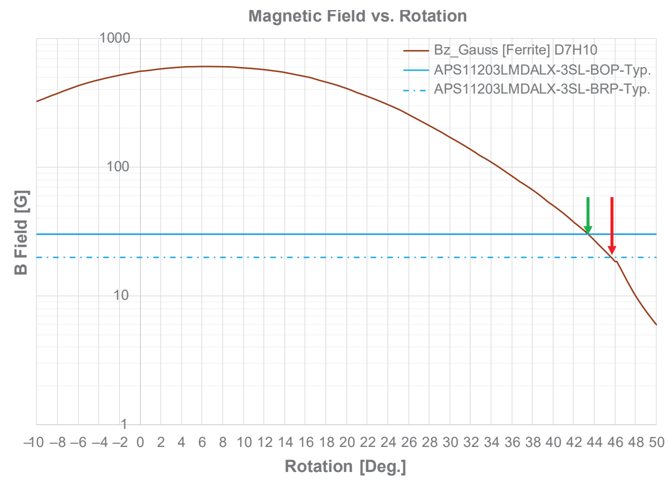



*Figure 14: Simulated Magnetic Field Profile Using Large Ferrite (Y40-D7H10) Magnet with Typical $B_{OP}/B_{RP}$ Thresholds*

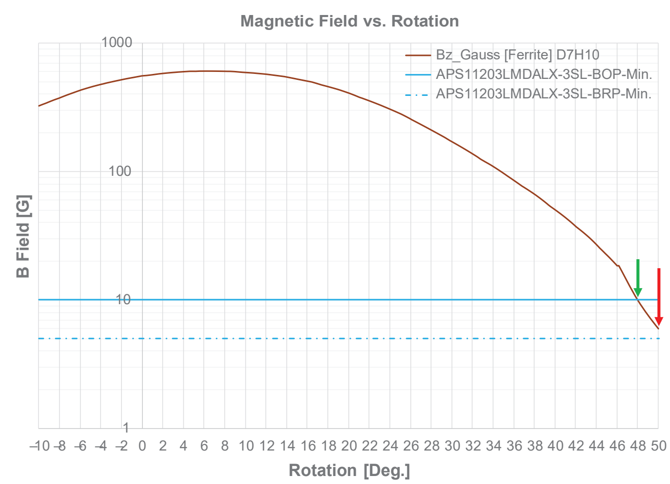



*Figure 15: Simulated Magnetic Field Profile Using Large Ferrite (Y40-D7H10) Magnet with Minimum $B_{OP}/B_{RP}$ Thresholds*

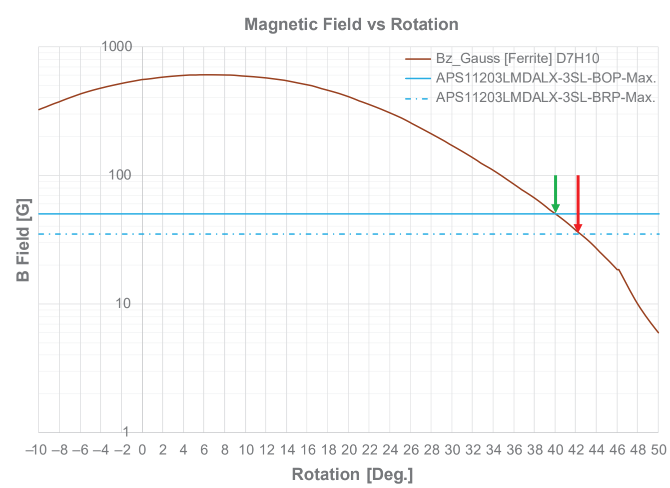



*Figure 16: Simulated Magnetic Field Profile Using Large Ferrite (Y40-D7H10) Magnet with Maximum $B_{OP}/B_{RP}$ Thresholds*

## QUICK SELECTION GUIDE

Allegro is world's largest magnetic sensor manufacturer offering various devices to suit automotive and industrial applications.

Allegro offers a wide range of magnetic switches suitable for two-wheeler side-stand applications. Some recommended parts are shown in Table 2. For a complete range of devices, visit www.allegromicro.com.

## CONCLUSION

This application note demonstrates that, with careful design, a cost-effective ferrite magnet can achieve performance comparable to a rare-earth magnet in a side-stand detection system. By following the simulation and design guidance presented, engineers can confidently implement a robust and reliable solution using the Allegro APS11203 [4] Hall-effect switch, mitigating supply-chain risks without compromising on safety or performance.

*Table 2: Allegro Magnetic Family*

| Switch | Type | Package | Features |
|---|---|---|---|
| APS11203LMDALX-1PL | Unipolar | SOT-23 | Commonly used: Requires south-facing magnet. |
| APS11203LMDALX-3SL | Omnipolar | SOT-23 | Offers ease of manufacturing because the switch operates independent of magnetic polarity. |
| CT8111 | TMR | SOT-23 | Tunneling magneto-resistance (TMR) offers high sensitivity suitable for weak magnets, such as ferrites. TMR operates with lower supply current. |
| APS11450 | Unipolar and omnipolar | 3-pin SIP and SOT-23 | ASIL-compliant planar Hall for safety-critical requirement. |

*Table 3: APS11203 Specifications*

| Part Number [1] | Typ. Switch Point Magnitude | | Operating Temperature (°C) | Mounting | Packing [2] |
|---|---|---|---|---|---|
| | $B_{OP}$ (G) | $B_{RP}$ (G) | | | |
| APS11203LMDALX-1PL0 | 15 | 10 | –40 to 150 | 3-pin SOT23-3 surface mount | Tape and reel, 10,000 pieces per 13-inch reel |
| APS11203LMDALX-3SL0 | 30 | 20 | | | |
| APS11203LMDALX-5SL0 | 95 | 70 | | | |
| APS11203LMDALX-7PL0 | 200 | 150 | | | |
| APS11203LMDALX-8PL0 | 280 | 225 | | | |
| APS11203LMDALX-9PL0 | 400 | 335 | | | |
| APS11203KMDALX-1PL0 | 15 | 10 | –40 to 125 | 3-pin SOT23-3 surface mount | Tape and reel, 10,000 pieces per 13-inch reel |
| APS11203KMDALX-3SL0 | 30 | 20 | | | |
| APS11203KMDALX-5SL0 | 95 | 70 | | | |
| APS11203KMDALX-7PL0 | 200 | 150 | | | |
| APS11203KMDALX-8PL0 | 280 | 225 | | | |
| APS11203KMDALX-9PL0 | 400 | 335 | | | |

[1] For additional packing options, contact Allegro MicroSystems.
[2] For options not listed in the selection guide, contact Allegro MicroSystems.

[4] APS11203 Datasheet, https://www.allegromicro.com/-/media/files/datasheets/aps11203-datasheet.pdf?sc_lang=en

*Revision History*

| Number | Date | Description | Responsibility |
|---|---|---|---|
| – | February 27, 2026 | Initial release | K. Desai |



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