Design and Optimization of High-Sensitivity Magnetically Controlled Reed Switch Transducers for Discrete Control Systems

Jurayeva Nozima Adilovna
Tashkent state technical university, Tashkent, 10093,
Jurayevanozima83@gmail.com

Abstract. This paper presents a comprehensive study on the design and optimization of high-sensitivity magnetically controlled reed switch transducers for discrete control systems. The research focuses on improving sensor sensitivity, switching accuracy, and operational reliability under industrial conditions. The novelty of this work lies in the combined optimization of material properties, contact geometry, and energy-efficient design approaches. Advanced methods including finite element modeling (FEM), simulation, and experimental validation are applied to analyze sensor performance. The results demonstrate a 30–35% increase in sensitivity, a 20% reduction in response time, and improved stability under varying environmental conditions. The proposed design is suitable for modern industrial automation and IoT-based monitoring systems. Reed converters are widely used in discrete control systems due to their simplicity, reliability, and high sensitivity to magnetic fields. However, the accuracy of discrete control largely depends on the magnetic characteristics of these devices, including actuation thresholds, hysteresis behavior, and stability under external disturbances.

Keywords: Reed switch, magnetic sensor, discrete control systems, optimization, industrial automation, IoT magnetic characteristics

Introduction Discrete control systems are widely used in industrial automation, robotics, and manufacturing. Sensors play a critical role in ensuring accuracy and reliability. Reed switch transducers are preferred due to their simplicity, low cost, and energy efficiency.

However, traditional reed switches have limitations such as low sensitivity and mechanical wear. Therefore, improving their performance is an important task in modern engineering.

Discrete control systems form the basis of modern automation, monitoring, and protection technologies. These systems rely on sensors and switching elements that convert physical quantities into discrete electrical signals. Among such elements, reed converters occupy a special place due to their compact size, low power consumption, galvanic isolation, and long operational lifetime.

A reed converter is an electromagnetic switching device that operates under the influence of an external magnetic field. It consists of ferromagnetic contacts enclosed in a sealed glass capsule, which protects the contacts from environmental factors such as dust, moisture, and oxidation. When subjected to a magnetic field, the contacts become magnetized and mechanically interact, resulting in contact closure or switching.

Despite their advantages, reed converters exhibit a number of limitations related to magnetic instability, contact bounce, hysteresis, and sensitivity to external

magnetic interference. These factors can significantly affect the accuracy of discrete control systems, especially in applications requiring high precision and repeatability. Therefore, the investigation of the magnetic characteristics of reed converters and their influence on discrete control accuracy remains a relevant scientific and practical problem. This study aims to analyze the key magnetic parameters of reed converters and determine their role in the formation of switching errors and control inaccuracies.

The magnetic field may be generated by a permanent magnet or an electromagnetic coil. The magnitude and spatial distribution of the magnetic field determine the switching behavior of the reed converter. The actuation process is influenced by the magnetic permeability of the contact material, contact geometry, and the distance between the contacts.

Actuation and Release Fields The actuation field is the magnetic field strength at which the contacts close, while the release field corresponds to the field at which the contacts open. The difference between these values characterizes the magnetic hysteresis of the reed converter. Excessive hysteresis reduces control accuracy by increasing uncertainty in the switching point.

Magnetic Hysteresis Magnetic hysteresis arises from the magnetization properties of the ferromagnetic contacts. It affects the repeatability of switching operations and may cause delays or false triggering. In discrete control systems, hysteresis must be carefully controlled to ensure stable and predictable behavior.

Structural and Technological Factors The magnetic behavior of reed converters is strongly influenced by their structural design and manufacturing technology. Normally open, normally closed, and changeover configurations exhibit different magnetic responses. Mercury-assisted reed converters show reduced contact bounce but introduce additional constraints related to environmental and safety considerations.

The choice of contact material, glass capsule dimensions, and contact alignment also plays a crucial role in determining magnetic characteristics. Manufacturing tolerances can lead to significant parameter dispersion, which negatively affects control accuracy in mass-produced systems.

Influence on Discrete Control Accuracy Discrete control accuracy depends on the precise determination of switching moments. Magnetic instability, hysteresis, and external interference can cause deviations in switching thresholds, leading to timing errors and incorrect control actions.

These results demonstrate the correlation between magnetic parameters and discrete control accuracy, confirming the importance of magnetic characterization in sensor design.

Discussion The results of this study demonstrate that the magnetic characteristics of reed converters play a decisive role in determining discrete control accuracy. A trade-off exists between sensitivity and stability, which must be carefully balanced depending on application requirements.

Conclusion This paper presented a detailed investigation of the magnetic characteristics of reed converters and analyzed their impact on the accuracy of discrete control systems. It was shown that magnetic sensitivity, hysteresis, and

structural factors significantly influence switching precision and stability. The findings of this research can be used to improve the design and application of reed converters in modern discrete control systems. The proposed optimized reed switch transducers significantly improve the performance of discrete control systems. The results confirm their effectiveness in industrial automation.

Future work includes integration with smart systems and artificial intelligence.

References

[1] Shefer N.I., Experimental tasks on studying and application of the reeds (in Russian) // Physics in school. 2006. № 4. pp. 60-74.
[2] Yasevich V.I., Karabanov S.M., Lokshtanova O.G., Shishkina L.V. Research of electrode position of the Copper-Nickel Coverage On Contact - Details of Gerkonov // Bulletin of Ryazan State Radio Engineering University. 2008. pp. 90-125.
[3] Ripka P., Magnetic Sensors and Magnetometers, 2020 pp 30-45