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Higher Accuracy for Absolute Magnetic Position Measurement

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Summary:
The shift to absolute magnetic measurement requires new solutions. Existing absolute measurement solutions are either too expensive or not accurate enough. With new approaches, the impact of new measurement principles on accuracy will be demonstrated and the effects of key parameters for improving the accuracy will be discussed in detail. A summary of achievable accuracies will give engineers recommendations, how to choose the right absolute magnetic measurement solution.

Keywords: Absolute measurement, magnetic sensors, accuracy

Absolute measurement for positioning

Absolute measurement means that the system will provide a defined position at startup. Absolute systems do not need to perform a reference run to a home position as in an incremental system that counts increments and will start at 0 at startup, regardless of the actual position. There are also pseudo-absolute systems available, which will identify a position after a short move, e.g. with distance coded references.

Several different measurement principles are used for absolute measurements of positions. Positions can be measured in rotary and linear applications. The key task is finding the right measurement principles. The different principles – Nonius, Pseudo-Random-Code, Bit patterns, selected special approaches – can be used.

The nonius principle has been widely adopted in magnetic measurement, because it offers a lot of flexibility, as it can be used for both linear and rotary with the same sensor, for different measurement lengths or diameters.

The pseudo random code, where interleaved binary patterns decode many positions, is mostly used for linear applications. The key differences to the nonius solution are coarser resolution and the need to adapt the sensors to different tasks and different geometries.

Absolute binary patterns are used for rotary applications, where different tracks are patterned with different multiples of two patterns. To avoid jumps due to inaccuracies, the Grey pattern is used in many applications to provide a more fault tolerant approach.

Different other solutions are known, including an angle-based system.

Key parameters for absolute measurement

The first requirement is to understand, how many different positions need to be discerned. This is the resolution of the system. In many cases, this is based on the binary pattern, where the number of tracks describe the number of positions to be identified. A system with four binary tracks can identify 2^4 positions equal 16 positions. Therefore, the resolution of absolute measurement systems is described in a Bit number, in the example above a 4 Bit resolution. While low resolutions of up to 4096 have been the standard for rotary measurement for a long time, new solutions offer much higher resolutions, e.g. up to 20 Bit, meaning that a rotation can be discriminated in over 1 million different positions.

The next key parameter describing the application is the measurement length. Compared to incremental solutions, absolute solutions are built for a specific linear length and a rotary diameter.

The last parameter and most probably the most interesting for the end user is the accuracy. The accuracy denotes, how exact a system will achieve the required position. So, when the measurement system determines a position, this position is measured with other means, how well the measurement aligns with the reference measurement system. Depending on the application and requirements, linear accuracies are typically described in microns while rotary solution may be measured in degrees, arc minutes or arc seconds.

Impact on accuracy

The accuracy of a magnetic measurement has several critical factors. The sensor and its reproducibility between different parts will provide clean input or not, that can either be improved during signal processing or not. This signal processing will delete noise out of the measurement. One other factor is the algorithm for position determination that will have different accuracies.

Geometric factors also impact the accuracy. Typically, absolute measurements require multiple sensors and the alignment of these impacts the performance of the system. The next geometric influence is the alignment of the sensor over the scale. Misalignments effect the results considerably. Especially for rotary measurement solutions, eccentricity of the rotating part may have a key impact on the accuracy that can be achieved.

The last factor influencing the accuracy is the scale. Scales cannot be produced without variations between the elements that will be used for measurement. The accuracy of the scale will impact the accuracy of the measurement solution directly. As most absolute systems require multiple tracks, not only the errors in one track, but also the differences between the tracks will impact the accuracy result.

Approach for improving accuracy

In order to achieve higher accuracy, the first key element is the scale accuracy. If a linear scale can be produced with a higher accuracy, than the overall system is more accurate.

There are scales with different accuracies. If better than 3 microns can be achieved in a scale, that is good performance in today's standards.

The accuracy of rotary scales is typically diameter dependent. The bigger the diameter, the higher the achievable accuracy.

Improving scale accuracy requires many different tasks depending on the scales production method, but translates directly to a higher measurement solution accuracy which puts a high emphasis on this.

In rotary applications, eccentricity is a key parameter to achieve highest accuracy. Some systems already provide eccentricity correction to overcome the impact of this difficult to master issue.

The second key parameter is the sensing principle. While a PRC system does not provide good resolution, it will identify a position easily and accurate. Typically the resolution of the PRC is quite big and the resolution to low. With an added incremental track that is aligned with the bit positions of the PRC, the resolution can be improved and accuracy will increase, if the alignment of the two tracks is closely controlled while the tracks each are written as precise as possible.

Results

While older absolute systems will only achieve an accuracy of roughly 50 µm, the new approaches achieve results of 10 µm. BOGEN is working on scales that will help to achieve less than 10 µm accuracy, which will improve the absolute performance significantly.