Short Description

Classification	Permanent Magnet Design for Joystick Applications
Unique selling proposition	Patent-Pending Design to ensure linear sensor outputs in Joystick applications in independence of axial movements

Detailed Description and Explanation
(Optimized Permanent Magnets for Joystick Applications)

General Basis

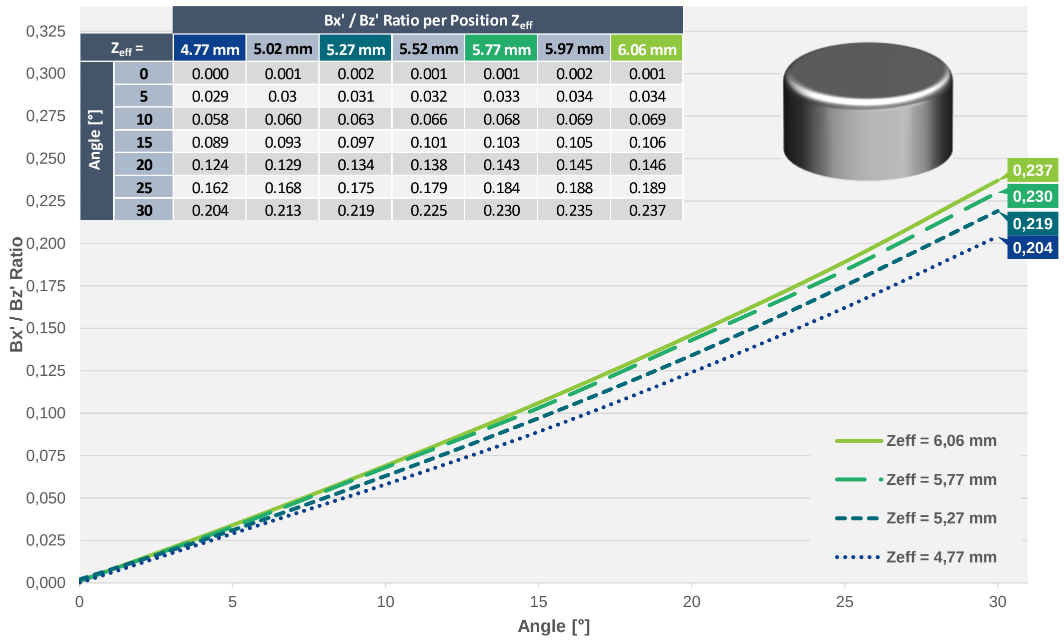
Magnetic sensing of joysticks mainly means to detect the angular polar position of the lever as well as of the azimuth angle. Best method is to use a magnet at the pivot position together with 3D-Hallsensor below the magnet. This provides a good linearity of the polar sensor output as a function of the polar angle. The azimuth angle is measured by the inverse tan of both Hall sensor components in the plane of joystick rotation. The magnetization direction of the magnet is always in axial direction. Its shape is cylindrical.

Best results for the polar angle are harvested when the so-called ratio signal is taken, which is the quotient between the radial and axial sensor output. The radial component is always the vector sum of both Hall sensor components in the rotational plane.

Problem Description

Usually, joysticks act in a manner that beside an angular polar and azimuthal movement an axial movement can be applied in addition, e.g. when the stick acts as a fire button. I.e. the axial position between the permanent magnetic field source and the sensor is being changed. At standard configurations this leads to a different steepness of the polar-angle signal, which would originate a positional jump when the fire button is triggered, see Fig. 1.

Bx'/Bz' Ratio over the angle [Standard Design]

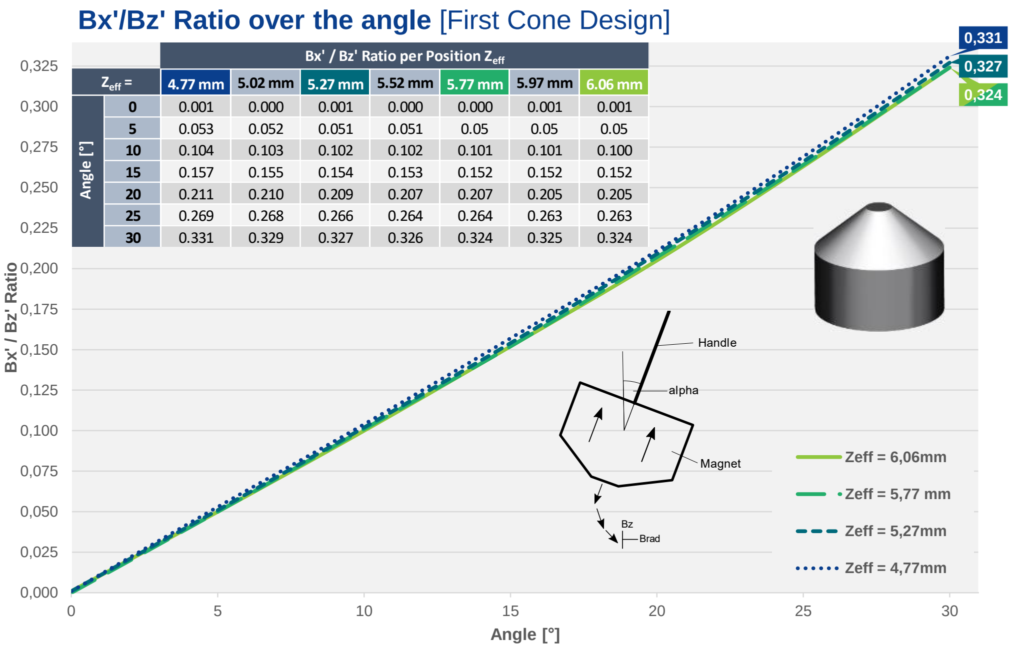


	Bx' / Bz' Ratio per Position Z_{eff}						
Z_{eff} = / Angle [°]	4.77 mm	5.02 mm	5.27 mm	5.52 mm	5.77 mm	5.97 mm	6.06 mm
0	0.000	0.001	0.002	0.001	0.001	0.002	0.001
5	0.029	0.03	0.031	0.032	0.033	0.034	0.034
10	0.058	0.060	0.063	0.066	0.068	0.069	0.069
15	0.089	0.093	0.097	0.101	0.103	0.105	0.106
20	0.124	0.129	0.134	0.138	0.143	0.145	0.146
25	0.162	0.168	0.175	0.179	0.184	0.188	0.189
30	0.204	0.213	0.219	0.225	0.230	0.235	0.237

Figure 1: Ratio Signal for a simple cylinder magnet at different axial magnet positions, when the stick is used, e.g. as a fire button

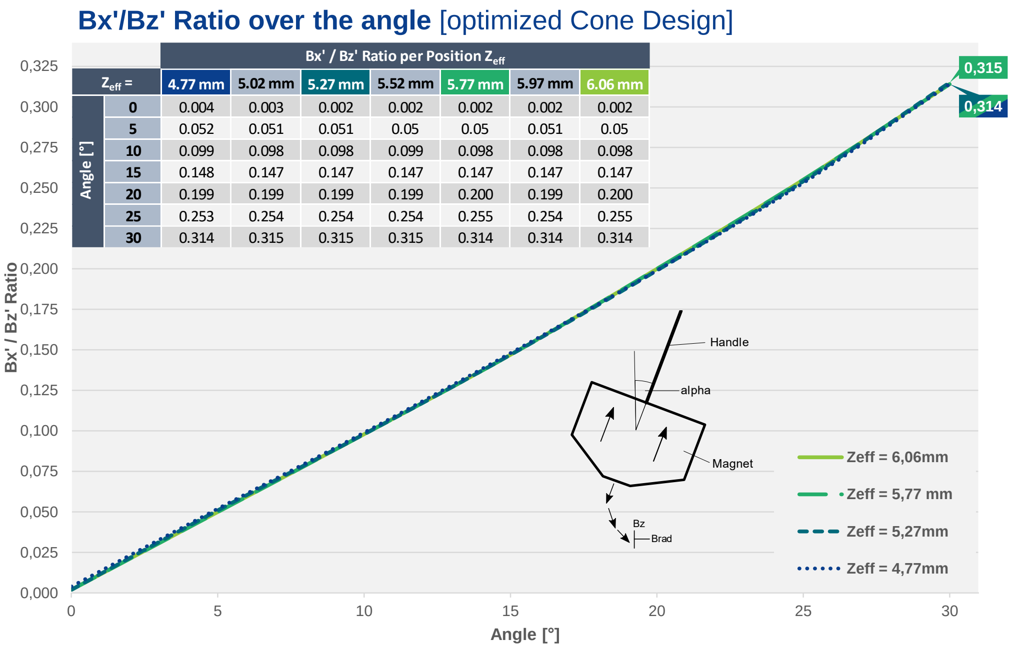
Patent Pending Solution

An MB invention led to a cone shaped extension for respective magnets which solves this problem. Fig. 2 shows the principle together with measurements of a tested sample and same curves as above. Here nearly no axial dependence of the polar angle signal can be observed. The steepness of the cone as well as its dimensions like axial length and size of its head face have to be adjusted to the base dimension of the magnet and to the magnet sensor distance. The center of the cylindrical part is still corresponding to the pivot point. The principle is valid for all magnetic materials from injection molded Ferrite magnets up to strong sintered NdFeB specimen. Fig. 3 shows when the same magnet as in Fig. 2 has been fine-tuned according to its cone dimensions. A perfect concordance of signals can be observed.



Angle [°] / Z_{eff} =	4.77 mm	5.02 mm	5.27 mm	5.52 mm	5.77 mm	5.97 mm	6.06 mm
0	0.001	0.000	0.001	0.000	0.000	0.001	0.001
5	0.053	0.052	0.051	0.051	0.05	0.05	0.05
10	0.104	0.103	0.102	0.102	0.101	0.101	0.100
15	0.157	0.155	0.154	0.153	0.152	0.152	0.152
20	0.211	0.210	0.209	0.207	0.207	0.205	0.205
25	0.269	0.268	0.266	0.264	0.264	0.263	0.263
30	0.331	0.329	0.327	0.326	0.324	0.325	0.324

Figure 2: Magnet with cone structure and its ratio signal at different axial positions. Illustration of the tested magnet shown on the right. Nearly no axial dependence can be observed



Angle [°] / Z_{eff} =	4.77 mm	5.02 mm	5.27 mm	5.52 mm	5.77 mm	5.97 mm	6.06 mm
0	0.004	0.003	0.002	0.002	0.002	0.002	0.002
5	0.052	0.051	0.051	0.05	0.05	0.051	0.05
10	0.099	0.098	0.098	0.099	0.098	0.098	0.098
15	0.148	0.147	0.147	0.147	0.147	0.147	0.147
20	0.199	0.199	0.199	0.199	0.200	0.199	0.200
25	0.253	0.254	0.254	0.254	0.255	0.254	0.255
30	0.314	0.315	0.315	0.315	0.314	0.314	0.314

Figure 3: Magnet from Fig. 2 with further fine-optimization of the cone shape, without any axial position dependency

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