

Sensor Potentiometers ensure Safe Cornering:

## Segway Human Transporter – A Vehicle that's Fun to Drive

The Segway Human Transporter (HT) is a single-axle, self-stabilising scooter, which has gained in popularity over the past several years. The vehicle keeps itself and the drive in balance; braking, acceleration and steering are controlled by the operator shifting his weight or tilting his body.

The Segway Human Transporter owes its handling to a dynamic stabilization system, which basically functions like a human being's sense of balance. The tasks of the inner ear, eyes, muscles and brain are replaced in the Human Transporter with gyroscopes (which are also used to display the artificial horizon in airplanes), pitch and angle sensors, high-speed processors and powerful, brushless servomotors as drives for the wheels. For stabilization, the rider's center of gravity is continually determined, the data collected is processed and operation is adjusted accordingly automatically. For the drives this means that they are supplied with current reference values up to 1,000 times a second.

The vehicle therefore reacts to any change in body position of the rider. The rider shifting his weight to the front or rear controls driving forward and reverse. When standing vertically, the speed remains constant or the transporter stops. The latest model incorporates a new feature so that a slightly tilt the handlebars to the right or left results in a movement in either direction. This innovation results in an intuitive, natural kind of movement for the rider.

However, this does not apply to automatic control technology. The non-

linear, instable system sets demanding requirements. A large number of sensor signals have to be processed and put in context to each other, for example, during cornering. For this purpose, the measured values of the tilt sensors that detect the position of the base platform must be compared with the angle signal, which provides information on the position of the handlebars. Only then can the control electronics distinguish whether cornering is intentional or whether the rider is moving over rough terrain.

### **Sensor potentiometer detects the position of the handlebar**

On the latest model of the Segway Human Transporter the position of the handlebar is determined with a conductive plastic potentiometer mounted directly on the axis of the handlebar above the bearing block. The cost efficient angle sensor in a plastic housing from the Novotechnik product line is especially designed for use in industrial and automotive series production applications. For use in the Segway HT, the sensor was designed redundantly. Two complete systems with a measuring range of 0° to 140° each are integrated in the same installation space.

The SP28 sensor parameter supplies absolute, analogue output signals proportional to the angle of rotation that can be directly further processed by the Segway HT control electronics. The angle of rotation of the handlebar is constantly compared with the measuring signals of the tilt sensors. Cornering is initiated in case of a corresponding difference. In the process, the potentiometer operates with a resolution of <math>0.01^\circ</math> and a repeatability of  $0.03^\circ$ . The linearity is specified with  $\pm 0.3\%$ . However, the extremely compact angle sensor with a diameter of just 28 mm has a lot more to offer.

### **Rugged, long-lived and easy to install**

The rather rough environmental conditions do not impair the operation of the potentiometer, and even in tough outdoor use it easily achieves a service life of more than 50 million movements. The independently spring-

loaded multi-finger wipers made of precious metal, which pick up the measured value on the resistance path, ensure reliable contact even when subjected to heavy vibration. The permissible temperature range is between  $-40^{\circ}$  and  $+100^{\circ}$ . In the heat of summer, the angle sensor operates just as reliably as at arctic temperatures. Great importance was also placed on the stability of the housing: Just like the integrated mounting, it consists of high-quality, temperature-resistant plastic. The requirements for the dust and water protection class IP65 are also met in this design. This means the angle sensors are completely dust-tight and protected against jet water. The low current consumption (less than 1 mA) also complies with the requirements of mobile applications. The angle sensor hardly places any load on the batteries of the Segway HT.

Both mechanically and electrically, the potentiometer can be integrated well in the application. Mounting tabs with oblong holes simplify attachment and enable easy mechanical adjustment. Thanks to the push-on coupling, installation is not only carried out quickly, it also guarantees a play-free connection. The electrical connection is possible via either flexible leads or a prefabricated connector. The large core cross-section also enables connection with screw terminals. With their use in the Segway HT, angle sensors on a potentiometer basis have once again proven that there are still applications in which they are virtually without serious competition.