

## Automatic Inductive Guidance System for Forklifts uses CANopen by Dr. Rolf Schmidt

**Floor space in modern high rack warehouses is very expensive, and every square foot saved also saves a high amount of investment costs. For this reason, warehouse architects design the aisles as narrow as possible. An automatic guidance system, which takes over the steering in the aisle, allows the operator much faster movements than manual steering. One important aspect of this application is safety for the driver and the vehicle through an automatic self-test of the guidance system.**

### Inductive Guidance System

With a resolution of up to  $\pm 0.04''$ , the inductive guidance system is the ideal high accuracy solution for forklifts operating within narrow aisles. Unlike systems with selective guide information, the continuous signal logging of an inductive solution carries all the necessary information. This allows real-time distance measurement to the racks, directional correcting, and emergency stopping as needed. With antennas on the front and on the back, the vehicles can be guided in both directions.

Part of an inductive guidance system consists of the inlaid floor guidance wire, which carries current with a defined ampacity and frequency. An antenna measures the magnetic field. Through the signal strength and direction of the magnetic field the system can determine its position to the guidance wire.

A steering controller then calculates set-points for the steering system. A simultaneous determination of the distance from the wall or racks allows the possibility of an emergency stop during this operation.

An inductive guidance system has advantages in harsh and blind surroundings against optical solutions. An accurate inlaid guidance wire allows interference-free operations, regardless of dust, dirt, snow, ice, unsteady or steep flooring.

The driver can control vehicles with an aided steering system during normal operation. Only in the narrow aisles does the automated guidance system take control of the vehicle. The transition from manual to automatic control is especially interesting. The transition time and distance traveled must be as small as possible.

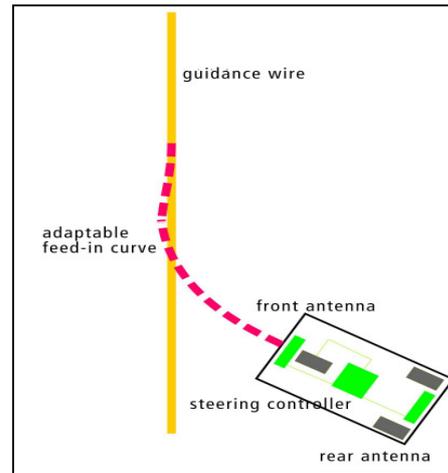


*MX-X forklift from Still Wagner*

## Enhanced System

STW, as a premier manufacturer of mobile electronics and measurement technologies for off-highway and on-highway vehicles, developed a new “state of the art” inductive guidance system, which allows the following improvements:

- Detection distance greater than 20” between antenna and guidance wire (guidance wire current of 100 mA) by way of digital and DSP (digital signal processor) technology
- Feed in angle of up to 70° through the arrangement of the antenna-coils
- Adjustable feed in chart to be flexible for local conditions
- Feed in speed of up to 1.6 mph

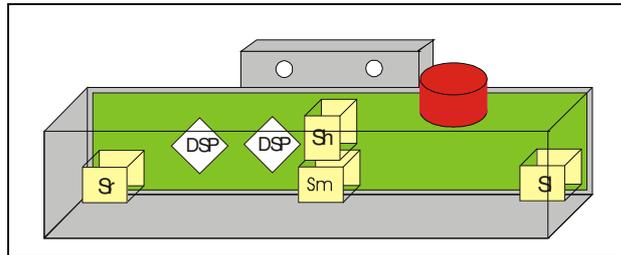


*Feeding in of the vehicle*

STW developed an antenna with four coils to detect the rectangle and horizontal parts of the magnetic field of the guidance wire, processed via DSP. The distance information is available on the integrated CAN-Bus or as an analog voltage signal.

The coil signals are filtered and examined on an adjustable frequency. After the feed in process the guidance wire current can also be controlled.

Together with a second DSP (for redundancy) the antenna is placed in a compact enclosure of 1.18” x 1.58” x 7.87”.



*Antenna Design*

The steering controller calculates antenna signals and vehicle parameters relative to pre-defined set-points, and sends the data via a second CAN interface to the steering system. During the feed in process the steering controller calculates the optimal feed in chart using the distance information to the guidance wire, the steering angle and the odometer information.

The feed in control starts with guidance wire signal detection at the front antenna. After getting the signal on the back antenna, the vehicle is controlled through both antennas. The feed in chart is also adjustable to the specific application. After reaching a certain distance to the guide wire, the autonomous mode begins.

The CAN protocol for the steering controller is CANopen. Available inputs and outputs might be used for auxiliary functions.

<b>Technical Data</b>	
Guidance wire frequency	5 – 12 kHz
Guidance wire current	40 – 150 mA
Antenna height above guidance wire	1.18” – 3.54”
Detection distance (Guidance wire current 100 mA)	> 20”
Resolution	±0.04”
Feed in angle	Up to 70°
Feed in speed	up to 1.6 mph
Max. guided speed	7.5 mph
CAN protocol	CANopen
Auxiliary inputs and outputs	On request

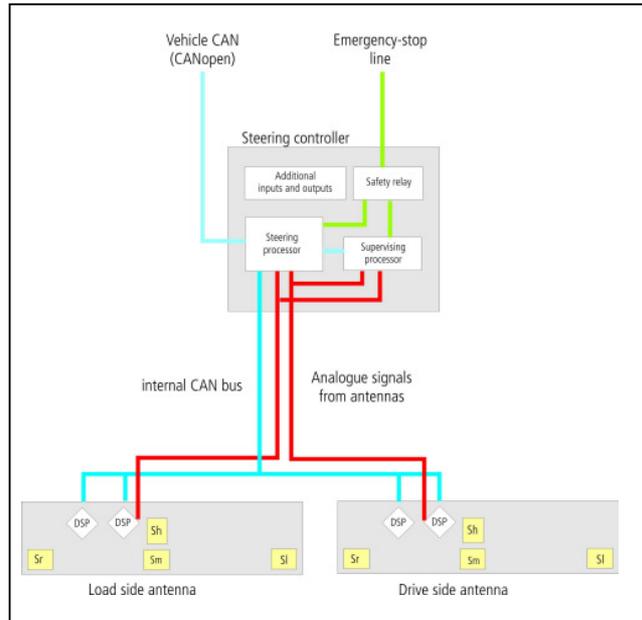
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## Safety

Due to the high demands for safety, the system is completely redundant and provides features to control one another.

- The four coil design of the antenna allows interferences in the magnetic field to be detected. It is also possible to adjust the system to a distorted magnetic field.
- The signal processing in the antenna, with two DSPs, is a completely redundant system. For additional safety, the data transfer from the DSPs via CAN and an additional analogue channel, is independent.
- The antenna signals are constantly being checked in the steering controller before the steering set-point will be processed. Additionally, a second processor monitors the antenna signals and set-points of the steering system.
- An emergency-stop routine, checking the steering set-points on the CAN from the steering-controller and from the separate monitor controller, is able stop the vehicle in a safe manner.



*Redundant Signal Processing*

The demand for more functionality and safety are increasing steadily. STW's developed automatic inductive guidance system shows an innovative solution, even in harsh environment.