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Linear Motor and Control System for Clean Room and Vacuum Environments

Throughout several inline manufacturing or assembly processes there is a need for a product transportation system. The Electric Drives and Controls group from Bosch Rexroth Corporation (www.boschrexroth-us.com) has joined forces with the Tecnotion company (www.tecnotion.com) to offer a revolutionary standard transportation system specifically for clean-room and vacuum environments.

This solution has proven itself in a PECVD process for solar cell production by the OTB Group in The Netherlands (www.otb.nl). The solar cell fabrication process requires a high vacuum environment. This application is the first of its kind and overcomes the tricky problem of having to move high-precision parts continuously and with great accuracy within a vacuum so that delicate assembly and manufacturing operations can be performed fast and effectively (Figure 1).

The LMS solution (Linear Motion System) achieves this both reliably and economically by using intelligent coils outside the vacuum environment, where all of the electronics are located. Only the moving parts necessary for conveying the products are located inside the vacuum. Absolutely no mechanical lead-throughs to the vacuum environment from the controls outside the vacuum are necessary.

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This transportation system is modular and expandable; it has no mechanical feed through and is easily adapted to the items to be transported.

The Technical Concept

The basic principle is the concept of a linear motor. A “normal” linear motor has a fixed magnet attached to a frame and a coil moving over the magnet. This principle can also be used the other way around - fix the coils and move the magnet. When the magnet is attached to a carrier, the carrier can move. Using multiple coils mounted on distances shorter than the length of the carrier magnet allows the carrier to move over a longer distance.

The coils and the magnet are sufficiently separated so that the magnet works in the process environment while the coils are located outside the process environment (see Figure 2). This solution is ideal for industries where the smooth, reliable and highly accurate movement of parts through the processing assembly stages is essential. Examples include display, optical equipment and solar-cell manufacturing as well as manufacturing in vacuum, clean-room, aseptic and gas sensitive environments.

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Implementation

While the basic technical concept is brilliant due to its simplicity, more complex technical issues had to be solved by the manufacturers. These issues include:

- Accurately measuring the positions of the carriers without contacting the carrier
- Moving the carrier smoothly as the control is taken over by the next coil in the system
- Smooth pre-collision detect where each carrier has its individual speed and can stop at certain positions for processing steps
- Multiple carriers moving like a “train” to transport larger products

To solve these issues, Bosch Rexroth and Tecnotion, have joined together. Tecnotion specializes in linear motor technology, including the engineering of linear drive solutions. They managed the solution related to the coil design and hall sensors for gathering position information. Bosch Rexroth, specializing in motion control systems, mechatronics and user-specific control solutions, handled the motion control elements (controller, integrated coil drives and control algorithms) in the system as well as the user interface software, calibration and commissioning tools.

Linear Motor

Since different types of applications use different types of linear motors, this carrier system can be equipped with Tecnotion’s standard iron core or iron-less

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linear motors (Figure 3). This enables customers to design-in a carrier system according to the design specification.

Carrier Temperature	: 110° C *
Vacuum	: up to 10^{-7} * mbar
Environmental conditions	: IP 62
Speeds	: up to 5 m/s*
Motor Force Fp	: up to 10 000 N*

* Depending on motor configuration and system design

Carrier Encoder (Hall Sensor)

For applications with an accuracy of <200 µ measuring can be done easily by an analogue hall sensor, which uses the magnet plate as the scale (Figure 4). The robust Hall Sensor is easily built into Tecnotion iron core linear motors.

Accuracy	: <200 µ
Repeatable accuracy	: ~40 µ
Resolution	: 10 - 20 µ

Motion control

The NYCe4000 integrated motion controllers from Bosch Rexroth are connected via network to a PC or PLC on which the user interface part of the control software is running. Each controller can control up to 10 coils and has the drive electronics for the coils integrated in the NYCe4000. The software controlling this system is available at the PC level where a user application can control the transportation system. Alternatively, the system can be driven via PLC control. Commissioning and calibration software packages are also available.

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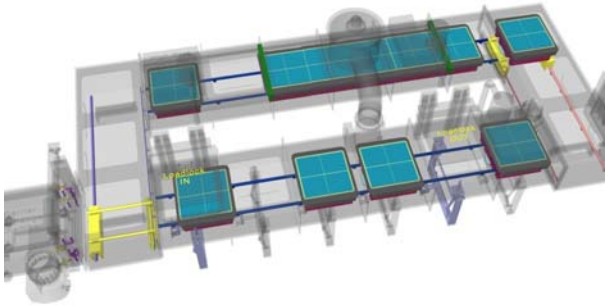
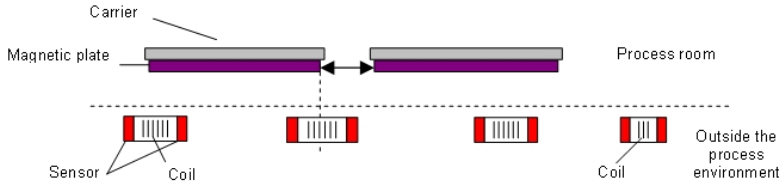
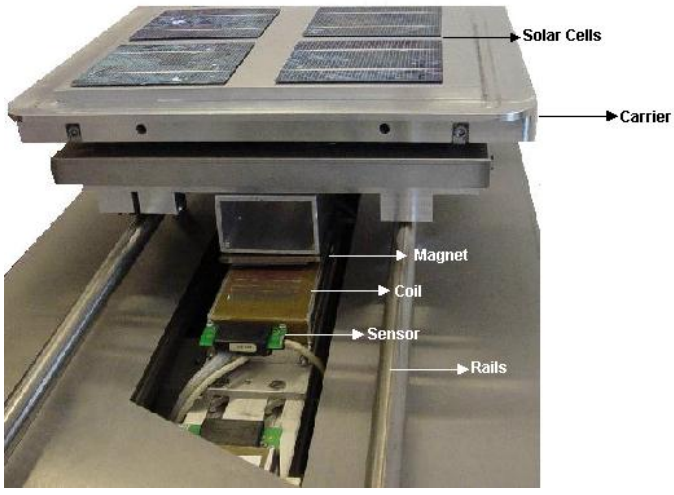


(Figure 1) Vacuum carrier system with 18 stations. The products move from Load lock IN position through the process area, to the Load lock OUT station.



(Figure 2)



(Figure 3)

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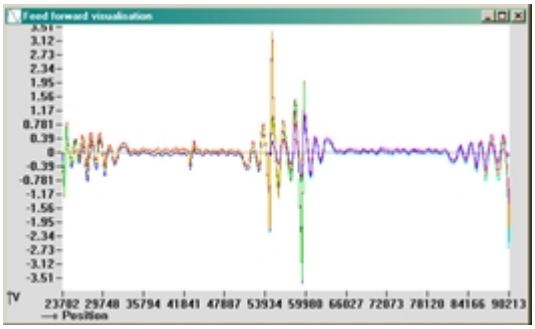

(Figure 4)

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