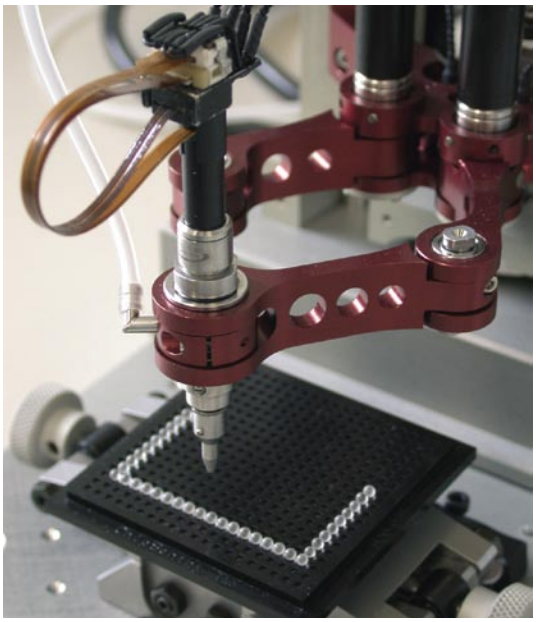
PARVUS – The Little Giant

- Miniature robot for precision assembly
- Control via dSPACE prototyping system
- Desktop assembly line

The trend to miniaturization that started with electronics has now reached the world of mechanical engineering, where it can also help to save on energy and materials. Machines for the precision assembly of very small parts are a typical example. A joint endeavor of the Institute of Machine Tools and Production Technology (Technical University of Braunschweig, Germany) and Micromotion GmbH produced a control system for PARVUS, a miniature robot that works just as precisely as conventional assembly robots, though these are often several times larger and more expensive. A dSPACE prototyping system was used in the project.

PARVUS the Miniature Robot

In designing PARVUS (Latin for "small"), we used a range of components from microsystem technology, among them micromotors and microgears. The result is a robot the size of a postcard that positions and assembles as accurately as its bigger brothers. Potential fields of use for the robot are the semiconductor industry (circuit board component placement) and optics (processing and adjusting lenses and mirrors). With PARVUS, automated assembly lines can literally be set up on a desk – instead of reaching the size of a gym as they do now.



▲ *The special feature of PARVUS is that its two arms are coupled at the hand axis. The complex motion sequences are controlled by a dSPACE prototyping system.*

Two Arms Instead of One

The special feature of PARVUS is the parallel structure of its arms. Parallel structure means that it has two arms coupled with one another at the hand axis. This construction ensures good stability and allows very precise, reproducible positioning. Controlling two coupled arms is more complex than controlling a single, independent arm, however. This is the reason why robots with a parallel structure have so far been used only rarely in industry despite their basic advantages. In PARVUS, the complex motion sequences are controlled with the aid of a dSPACE prototyping system based on a DS1103 PPC Controller Board. Using this equipment, our first prototype positions at a repeat accuracy of under 10 micrometers (µm). Theoretically, even a precision of under 1 µm is possible.

▶ *PARVUS the miniature robot – shown here with a matchbox to give an impression of size – positions workpieces at a repeat accuracy of under 10 µm.*

Controlling with dSPACE Equipment

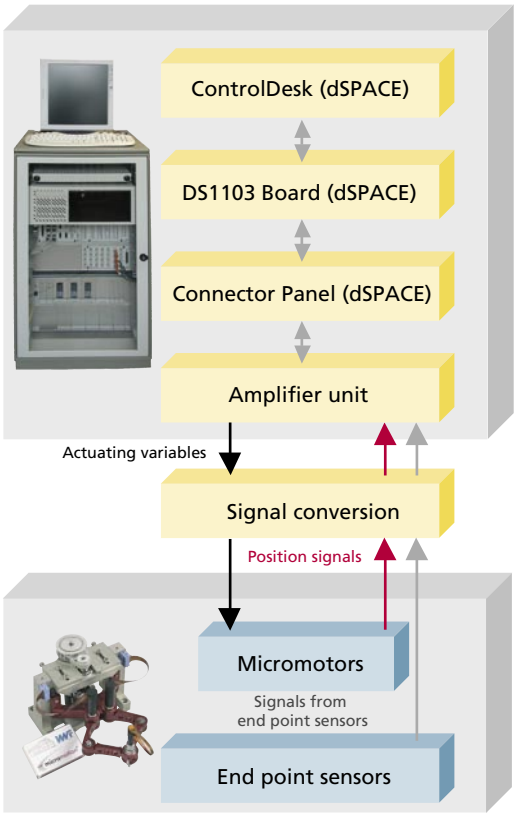
The advantages of the dSPACE system are the hardware's high performance and the ease with which it can be operated via ControlDesk, the experiment software. A further advantage is the ability to use MATLAB®/Simulink® to develop the robot control. This all adds up to a convenient working environment that enabled us to concentrate entirely on developing a fully-fledged robot control. Linear or circular interpolation is used to control the motion sequence of the robot arms. PARVUS has a total of 4 micromotors, which send position signals via encoder to the dSPACE prototyping system.

This in turn calculates the actuating values and returns them to the motors to keep the motion on course. The kinematic equations between the robot's arms and its working space are calculated in real time. To ensure the arm movement is sufficiently fast, the sample time is 0.1 milliseconds.

Assembly Line in Desktop Format

PARVUS the miniature robot is tiny compared with conventional assembly robots, but works just as precisely. So the assembly line of the future will fit on top of a desk. Miniature robots have obvious advantages over conventional assembly robots: They have a considerably lower energy requirement, because there is less mass to move.

They are also cheaper to produce, because not much material is needed to construct them. And if the robots ever have to work in clean rooms, the rooms themselves can be smaller and less expensive.



◀ *Schematic of the control. The convenience of dSPACE hardware and software saves a lot of time otherwise spent on technical details.*

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◀ *The robot's heart: the micro-harmonic drive (big picture) with tiny microgear (small picture).*