Vortis™ Combi Controller – The combined high-end solution for JPK Scanning Probe Microscopes and Optical Tweezers systems

One system for all nano-force applications

Combining atomic force microscopy (AFM) and optical tweezers (OT) provides access to an extended range of force measurements and applications. These include single molecule force spectroscopy, the mechanical analysis of very soft biological matter such as membranes and other cellular components. Imaging and scanning on the atomic scale is also possible. Both techniques show the highest performance in specific applications and, in combination, they represent the ultimate force measurement toolbox.

Full flexibility

The Vortis™ Combi fully digital controller can operate the AFM-based NanoWizard®, ForceRobot® 300 and CellHesion® 200 heads as well as the NanoTracker™ optical tweezers systems. The versatile NanoWizard® instruments feature a large number of scanning and imaging modes for the precise mechanical, topographical and electrical characterization of the smallest samples. While the ForceRobot® system is optimized for high-

throughput, single molecule force spectroscopy, JPK's CellHesion® option is the tool of choice to investigate cell-cell interactions and cellular adhesion. With the NanoTracker™ OT system, the lower limit of detectable forces is stretched to an incredible 0.1 pN with ultra-high time resolution to detect and analyze the fastest processes with unmatched accuracy.

With AFM, we typically have samples that are surface bound since the preferred direction of force measurement with highest sensitivity is along the z-axis (perpendicular to the sample surface). In scanning mode, these systems are capable of acquiring structural information at atomic resolution or to measure mechanical surface properties for even delicate samples like living cells.

On the other hand, optical tweezers operate with suspended samples and combine precise 3D manipulation with high resolution force measurements. The sensitivity of force detection in these setups is highest in the x/y plane.
With the new Vortis™ Combi controller, researchers can benefit from the best of both worlds - AFM and OT- in one versatile setup.

Simple conversion from SPM to OT control

Up to now, covering the full spectrum of nanoscale force measurements from femto- to nanonewton, in 2D and 3D, for surface bound and suspended samples, two completely independent systems were required. JPK's Vortis™ Combi reduces the instrumental complexity to the minimum. One PC with dedicated software programs for SPM and OT and one controller that is capable of managing both types of operation minimizes the required space, expense and user training time. Data from the different techniques may be conveniently processed, analyzed and compared using one sophisticated data processing software platform.
The hardware switching between two different instrument types only requires the exchange of a snap-in circuit board that holds the specialized communication ports. Within minutes, the system can be converted from AFM to OT.

Upgrade pathway

Upgradability is independent of the initial setup. With the new Vortis™ Combi control station, NanoTracker™ optical tweezers as well as AFM based systems of the NanoWizard® family (including CellHesion® and ForceRobot® heads), can be easily complemented with any other JPK device without the need for an additional control station. The Vortis™ Combi fully supports all functions of the JPK product family including the access to internal and the feed-in of external signals.

Application fields

Together, optical tweezers and atomic force techniques cover an enormous range of possible applications. From AFM data, extremely detailed images of sample topography and highly localized material properties can be generated. Force measurements include the investigation of single cell and intracellular properties and processes, single molecule measurements, binding and adhesion on single- or multi-molecular levels, dynamic molecules, material properties, micro-rheology and many, many more.

System specifications

Controller hardware

- AD conversion
  - 4 high speed 16 bit ADC channels with 60 MHz
  - 12 ADCs with 18 bit and 800 kHz
  - 3 ADCs with 18 bit and 100 kHz (for scanning)
  - 24 bit ultra precise ADC with 2.5 MHz
- DA conversion
  - 3 high speed channels with 14 bit and 120 MHz
  - 8 channels 24 bit DAC with 400 kHz
  - 2 channels with 16 bit and 1.6 MHz
- Signal generation for oscillating modes
  - 1x 14 bit DDS with 240 MHz +/- 1 V @ 50 Ω
  - 3 x 16 bit reference output up to 15 MHz
- Lock-in amplifiers
  - 2 high speed lock-in amplifiers running with 60 MHz, frequency range from 1 kHz to 10 MHz
  - 1 mid speed lock-in amplifiers with 800 kHz, frequency range up to 300 kHz
- Feedback loops
  - Multiple feedback loops are implemented with fully configurable transfer function
  - Phase-locked-loop (PLL) integrated for Frequency Modulation

- Thermal noise acquisition up to 3.25 MHz
- Software controlled digital filters
- High speed data capture
- Processing and interface hardware
  - Modular design with PPC technology
  - Power PC @ 660 MHz
  - Gigabit Ethernet for interfacing with the PC
- Scanner controls
  - 3 channels closed-loop control via capacitive sensors
  - 3 channels -20 to +120 V scanner drive (4. channel optional)
- User signal access via Signal Access Module (SAM)
  - 27 analog inputs
  - 23 analog outputs (DACs and signal monitors)
  - 8 digital inputs and 12 digital outputs
  - 2 digital inputs for photon counting and 2 gate inputs (TTL, CMOS and NIM pulse compatible)
  - +/- 5 V, +/-15 V and 3.3 V auxiliary power outputs

Computer setup

- Premium PC system (please ask for current specs)
- 2 x 22" flat screens

SPM and OT Control Software

- Easy-to-use Java based graphical user interface
- Fully automated access to all control parameters and data acquisition channels
- Scripting option for user developments
- Automated force calibration through thermal noise method
- Command line interface for low level access
- Complete support of external hardware and accessories

JPK DP DataProcessing Software

- Java based for use with Linux® or Windows®.
- Standard SPM image processing modules on board with advanced filtering, leveling module and analysis modules
- AFM and OT force curve module including batch processing
- Various analysis functions such as cross section and distance measurement, single molecule/material mechanics and oscillation fitting functions
- Overlay of different signal channels
- Highly flexible data formats

Additional information

- CE compliant
- Weight: approximately 20 kg
- Dimensions: 50 cm x 45 cm footprint; 50 cm height
- Power consumption: 300 W max.