RHK Technology
Imaging the Future of Nanoscience

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R10

SPM CONTROL SYSTEM

REACHING FOR PERFECTION

A PERFECT MATCH FOR YOUR RESEARCH CHALLENGES

RHK MAKES THE IDEAL REAL

INTRODUCING THE RHK R10 CONTROLLER

RHK proudly introduces the newest addition to our long line of breakthrough SPM Control systems. R10 is RHK's tenth generation SPM control system, built on our industry-leading knowledge and experience extending back over more than 30 years.

R10 is the latest advance in the continuing evolution of the R-Series Family of Controllers. With its fresh, forward-looking emphasis on Modularity as its guiding principle, R10 presents a new Design Ethos to the world-wide SPM research community. RHK's unique Design Ethos brings practical adaptability and confident configurability to the forefront.

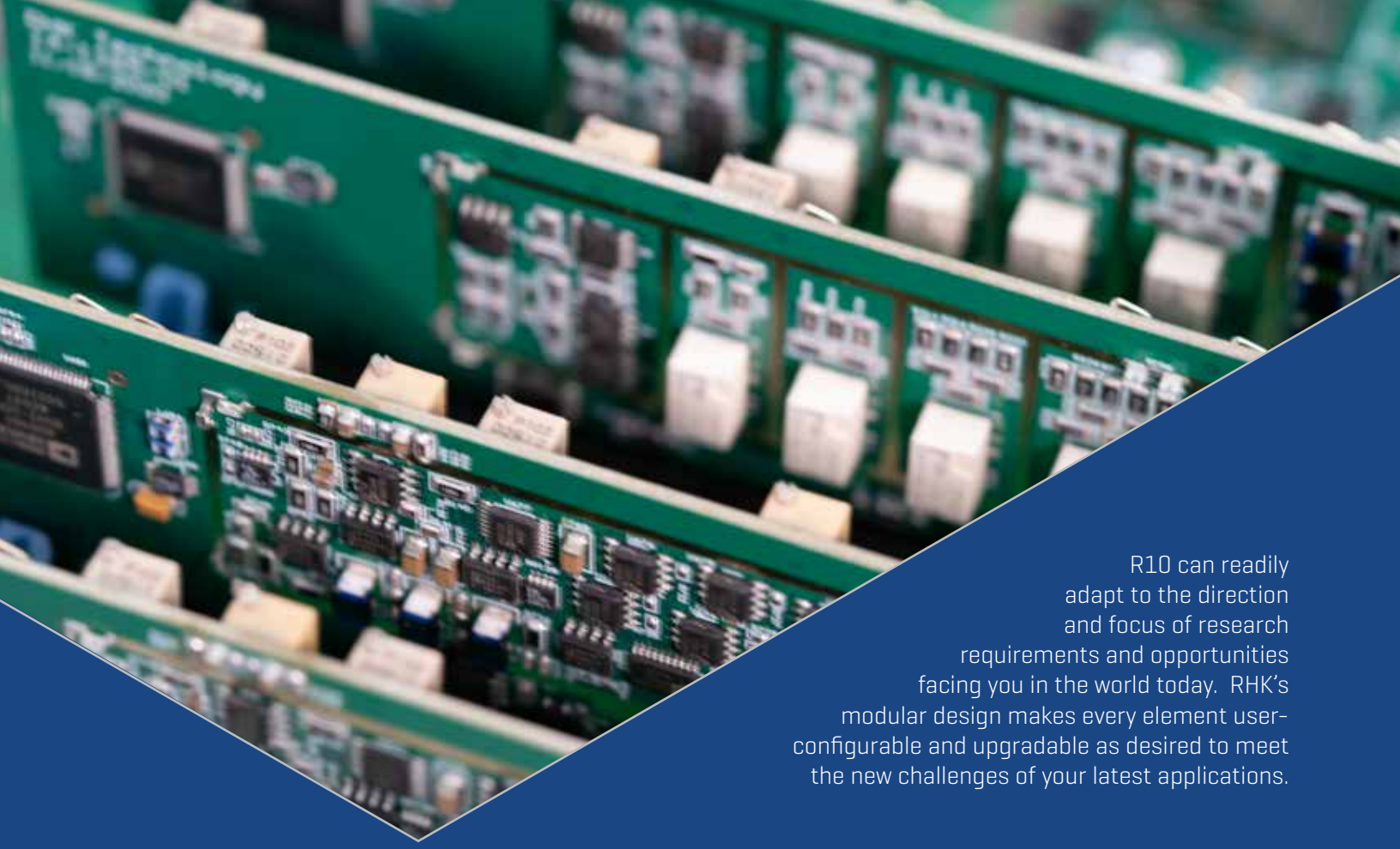
RHK LEADS THE CHANGE TO MODULARITY
THE FUTURE OF SPM CONTROL

With an eye for the newest capabilities and advances in electronics, RHK R&D recognized they could create a new, superior path. This brought far-reaching improvements to our new R10 software, firmware, and hardware, without limiting or sacrificing any aspect of Controller performance. With its optimized modular architecture, R10 further improves on controller capabilities and brings users forward to the best solutions.

RHK also dismissed the tired solution of yet-another-box for every function. To put it succinctly, the option of a meter-tall stack of unwieldy box-after-box-after-box, along with their jungle of cables, failed to meet our own performance demands and forward-looking Design Ethos.

R10 – ELEGANTLY SIMPLE, SIMPLY ELEGANT

In keeping with our fresh Design Ethos of optimized Modularity, we designed the new R10 as an elegant 1 or 2-box solution. R10 provides a separate unit for High Voltage Amplifiers if required, and a main unit for easy advancements by users themselves via firmware activation and quick-and-easy internal hardware plug-in modules to our unique backplane.



R10 can readily adapt to the direction and focus of research requirements and opportunities facing you in the world today. RHK's modular design makes every element user-configurable and upgradable as desired to meet the new challenges of your latest applications.

BUILD YOUR OWN FUTURE WITH R10 MODULARITY

For new researchers, R10 Modularity offers a confident starting path at a surprisingly affordable cost. A highly capable *Entry* level R10 is within reach for most researchers. By design, it is readily expandable over time. As funding allows, the same *Entry* level R10 is upgradable to the *Advanced* level, and even beyond to the *Professional* level. Plus, within each of these levels, R10 capabilities can be further tuned and enhanced to tackle your most specialized needs. R10 functions and configurations are available for even the most established and experienced researchers in nanoscience. Thanks to RHK's unique, simple-yet-sophisticated Modularity, you can depend on RHK for highly customized upgrades to pioneer your research into new fields.

Systems can start with as few as two analog input channels (ADC) and be upgraded to as many as eight. Basic systems can start with four analog output channels (DACs) and be upgraded to twelve. More than 40 channels of data can be simultaneously acquired and displayed when fully configured. All levels of R10 retain RHK's fully linear power supplies to assure the ultimate in low-noise performance.

BUDGET YOUR FUTURE, WITH R10 MODULARITY

RHK's R10 Design Ethos goes much deeper than our uniquely configurable hardware and software elements. Modularity is built into the very core of R10, including new, breakthrough choices of how you acquire it.

R10 enables you to decouple hardware from software purchase. This unique option allows hardware to be purchased now and software expense to be deferred to future budgets. Meanwhile, the traditional purchase with a permanent software license is still an option. You decide which works best for your situation. Here are examples of R10's novel Purchase-or-Rent choices:

1

R10 Software Subscription: If your start-up funding is tight, an *R10 Software Subscription* enables you to purchase the software you need and pay for it over an extended timeframe. Many institute budgets will pay monthly software fees out of their Departmental Maintenance allowance, freeing up more of your budget. This makes more funds available to advance hardware and control capabilities – and your research results – today, not later.

2

R10 Rent-a-Feature: If tough research goals make you question whether adding a new enhancement to your controller might advance your work, *R10 Rent-a-Feature* enables you to "Try Before You Buy" for real-world confidence and proof about your upgrade decisions. Will more lock-in amplifiers allow you to track multiple harmonics simultaneously? Rent up to 6 LIAs and try it out. With *Rent-a-Feature* you'll know if it's best to purchase them permanently or end the rental. Or, if you only need advanced capabilities occasionally, another R10 option is to purchase an Entry-level R10 and enable the expanded features only when necessary.

3

High Voltage Amplifiers: R10's modular flexibility provides three choices regarding HVAs. If your SPM system does not require High Voltage Amplifiers, then you can opt out and avoid an unnecessary cost. If you do need a set of HVAs, you can simply purchase and plug them in. And finally, if you expand your SPM to a dual-probe design, you can easily acquire a second HVA set and readily plug them in as well. Remember, R10 Modularity means you only purchase what your system really requires at that time. So, if you already own an older analog controller like RHK's SPM100, you can even utilize its HV amplifiers. R10 puts you in control!

R10 GROWS WITH YOU

Most importantly, RHK's R10 Modularity frees users from future risks of obsolescence or insufficient capability to achieve their research goals. It gives users the ability to make advanced choices with fresh confidence. R10 empowers you with the freedom to tackle daunting new challenges a step at a time and within budgetary constraints.

Furthermore, when new software/firmware capabilities and hardware components are developed in the future, your modular R10 will not be obsoleted out of the picture. It is built to grow with your work over time. R10's flexibility allows you to readily integrate and harness novel powers while protecting you from obsoleted chips, boards, or other components.

Here is a real-world example: Each analog input channel (ADC) and analog output channel (DAC) is contained on its own circuit board module. As technology progresses and new components are introduced, RHK will develop improved modules that harness these new advantages and benefits. RHK's updated boards can enhance or replace existing modules to keep your system state-of-the-art and delivering peak performance.

R10 grows with your needs and industry capabilities. Your R10 investment will continue to pay dividends in your accomplishments, your research, and your success.

R10 PUTS YOU IN CONTROL!

- ✓ Future-Proof
- ✓ Obsolescence-Proof
- ✓ Feature-Proof
- ✓ Application-Proof

R10 BUILT FOR A PURPOSE

YOUR RESEARCH, YOUR SUCCESS

ELEVEN TOP TEN R10 ADVANTAGES

1 **More cost-effective, more capable, and more configurable.** That's how and why RHK created our new R10. R10 makes all these advantages easy, effective, and real every day. Our Modularity Design Ethos delivers top technology without compromise, plus fresh options for an economical entry point and virtually unlimited expansion of ground-breaking strengths.

2 **R10 can readily change with the direction and focus of research needs.** Modular design makes every element user-changeable in your own lab to meet the new requirements of your latest applications. R10 set-ups can be one box if you don't need HVAs, or two units if you do. And if you want to upgrade to dual-probe capability, just plug in a second HVA unit – it's simple and fast. Upgrades simply plug inside your R10 box via our new motherboard design rather than running out of internal space or stacking up more complexity with external boxes and cables.

3 **R10 Modularity eliminates capability sticking points and constraints** while minimizing costs and uncertainties. R10 Modular Hardware, Software, and Firmware architecture helps make R10 Future-proof, Feature-proof, Application-proof, and Upgrade-proof.

4 **R10 provides significantly larger FPGA capacity –** enough room for another decade or more of growth in new cutting-edge capabilities.

FPGAs (Field Programmable Gate Arrays) are the digital heart of the R-Series Family of Controllers. When R9 was introduced in 2010, by design its FPGAs were only half full. Over years of RHK upgrades, improved customer capabilities slowly filled up R9's FPGA. Advancing to R9*plus* allowed for even more new advantages. Yet once again, these valuable, fresh capabilities consumed all the R9*plus* space.

Today, with R10, all the features and advantages of the prior R9*plus* take up only 40% of the new, expanded R10 FPGAs. R10 delivers generous room to grow and take full advantage of future expanded functions and capabilities.

For example, with its expanded on-board memory, R10 now captures data at full 100 MSPS rate in burst mode for 1 full second, instead of 5ms for the R9 controllers.

5 **R10 is uniquely budget-friendly.** Choose STM-only or AFM/STM as a starting point. Then select one of three pre-configured factory models -- Entry, Advanced, or Professional. All models are upgradeable as desired to meet your specific research needs. You can easily get started with a capable basic set-up to use now, then further equip it as needs change and budget permits.

6 **R10 lowers the initial start-up price for a surprisingly small cost of entry.** Models start at only $25,000 in the USA.

7 **R10's Software Subscription enables hardware and software to be purchased separately.** Hardware can be paid from one budget while software is paid from another. R10 Software is available as either a one-time purchase or via an annual R10 Software Subscription, which keeps the initial expense to a minimum. Many institute department budgets will pay for the subscription out of their departmental maintenance allowance while you protect your capital budget.

8 **R10's Rent-a-Feature lets you try an advanced option** not included in your base package before you actually buy the upgrade. For example, imagine being able to try - for a very low cost and without purchasing - up to 6 lock-in amplifiers (LIAs) with just a download. No new hardware or interconnecting cables required. Once you have evaluated the difference that the rented extra LIAs make for your research, you can decide whether to purchase them as part of your permanent configuration.

9 **R10 Modular Personal Power:** Expand capabilities of every aspect of each model with quick downloads or plug-in self-configuring boards. Easy expansion in your own lab readily addresses changing research needs. Across all three models, only purchase extra elements when you need them for any given stage of research. They will self-install and self-configure. Enjoy the ease and convenience of modular improvement, one board at a time. For further expansion power, multiple R10 controllers can be digitally linked to add an almost unlimited number of input/output channels and processing power with precise data synchronization between units.

10 **Use your own PC** instead of having to buy an RHK PC. Save money or customize a PC for your specific requirement. Fully configured PCs are still available.

11 **R10 is simultaneously both familiar and new.** RHK's design provides ongoing, tried-and-true continuity with earlier RHK models. This continuity means that existing Scripts still work across R-series generations. And we have streamlined R10's GUI, without your having to re-learn it.

HOW DO WE TOP ELEVEN TOP 10 ADVANTAGES?

...WITH THE SAME GREAT IN-DEPTH TECH SUPPORT!

FRONT PANEL OF THE *NEW* R10

Ultra-high speed 100 MS/s ADC. Input has programmable gains, offsets, AC/DC coupling and 50Ω/1MΩ impedance.

Ultra-high speed 100 MS/s DAC. Output has programmable scaling and offset.

Buffered monitor of differential input signal

External input to modulate drive signal

Duplicate of CH1 Ultra-high speed modules

100 MHz pulse counters

High-speed 1 MS/s ADCs

Buffered monitor of differential input signal

Four general purpose 1 MS/s DACs

Four general purpose 1 MS/s ADCs

Differential input to 100 MS/s ADC. Also differential output from 100 MS/s DACs.

Four general purpose 1 MS/s DACs with single cable to interface to the R10-HVA high voltage amplifier

Differential inputs to 1 MS/s ADCs and Differential outputs from 1 MS/s DACs

REAR PANEL OF THE *NEW* R10

32 Digital I/O lines to interface to hexternal equipment

Low noise ±5V and ±15V to power customer-supplied circuits

Input power selectable for 100V, 120V, 230V 50/60 Hz.

High speed digital links to external modules and other synchronized R10 controllers

USB port for firmware upgrades

Ethernet link to host PC

HVA HIGH VOLTAGE AMPLIFIER OF THE *NEW* R10

FRONT PANEL

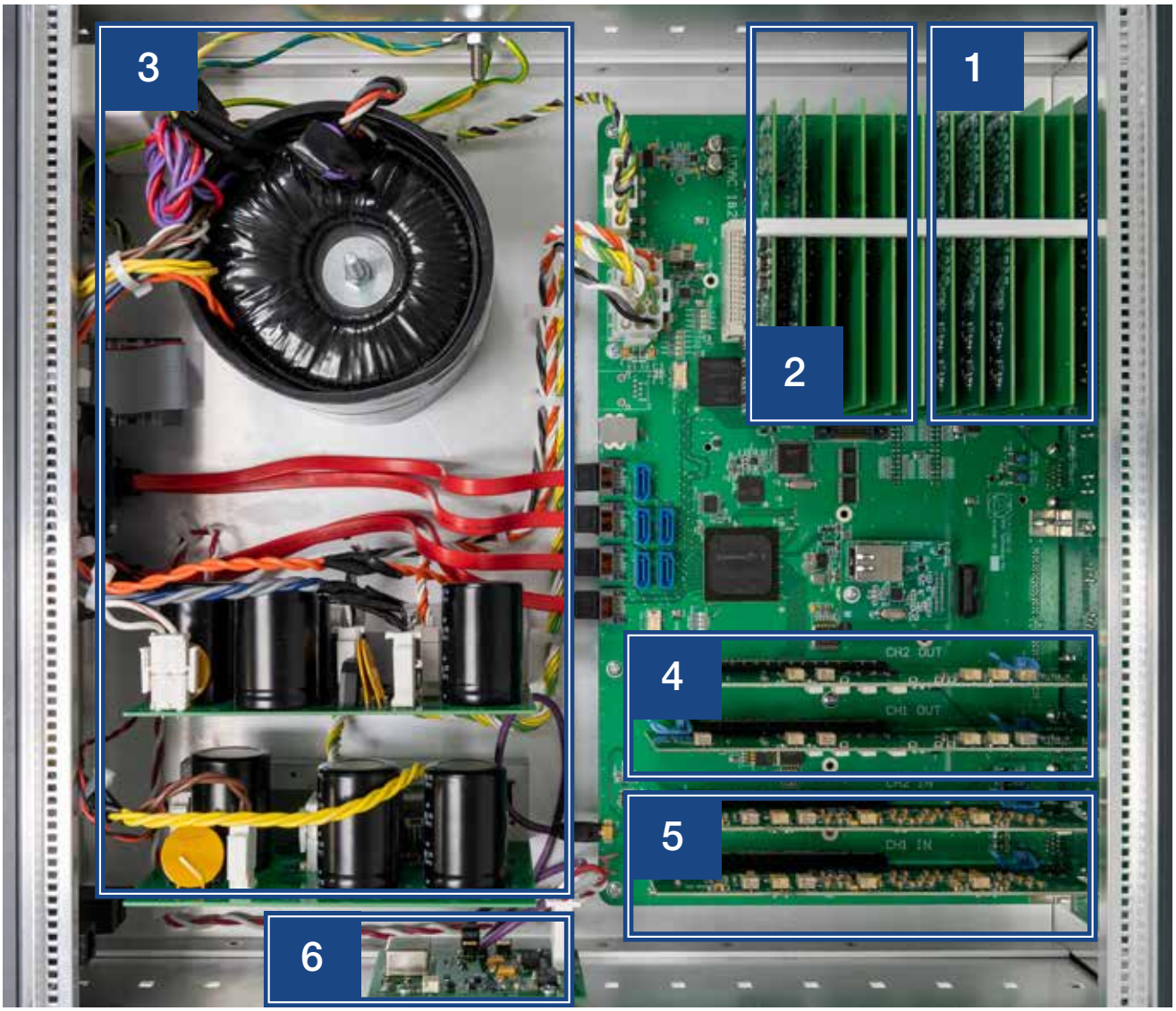
BNC inputs to the eight internal high voltage amplifiers.

Multi-channel input for connection to R10.

REAR PANEL

Input power selectable for 100V, 120V, 230V 50/60 Hz.

Outputs from eight high voltage amplifiers.



INSIDE VIEW OF THE *NEW* R10

1	Up to ten 1 MS/s DACs
2	Up to six 1 MS/s ADCs
3	Fully linear power supply for ultimate low-noise performance
4	Up to two 100 MS/s DACs
5	Up to two 100 MS/s ADCs
6	Ovenized, ultra-high stability 100 MHz clock for ultimate frequency resolution

R10 SPM CONTROL SYSTEM CAPABILITIES AND FEATURES

Fully integrated SPM control platform	All connections between modes and measurements are made through software in the digital domain, providing maximum flexibility and signal purity. Patented graphical hardware and experimental set up system allows fast and easy customization.
Digital Lock-In Amplifiers: Up to 6 LIAs or 2 PLLs & 4 LIAs	Up to 2 PLLs and six lock in amplifiers can be configured to work independently or be linked together to track multiple harmonics. Reference frequencies from <1 Hz to over 10 MHz can be generated and demodulated. Demodulation bandwidths from 10mHz to 100kHz. Patented method allowing precise tracking of sidebands even with rapidly moving reference frequency.
Feedback Loops	Up to 9. Feedback loops are calculated at 200 kHz.
Kelvin Probe	Measure multi-frequency KPFM. Feedback loop measures Contact Potential. All AC and DC modes available.
Multi-Speed Data Path	Revolutionary method providing simultaneous high speed (16-bit @ 100 MHz) and high precision (22-bit @ 25 kHz) measurements with perfect synchronization.
Probe Guard/LockGuard	Fast, fail-safe tip approach, approach stops within 5µs of input setpoint detection. LockGuard stops scan and withdraws probe within 5µs of out-of-range parameters. Auto-continue scan when back in range.
Time-Based Data Acquisition	All data and events are captured on a time basis for later examination. Changes to measurement parameters such as scan speed, feedback loop set point, bias voltage, are stored to sub-pixel precision in the data file and displayed on stored images.
Second Scan Generator and Feedback Loop	Control 2 separate scan systems from one R10 controller. This can be a single scan head with two scanners (large and small range) or two independent scan heads.

dataSAFE	All data is stored to the HDD at the end of each scan line to prevent data being lost in the event of a power outage. The last 100 files of all data types (topographic, spectroscopic, FFTs, oscilloscope traces) are stored on the HDD for future analysis.
Microscope Diagnostic Tools	Transient Recorder: detect transients as short as 10ns. Transient Recorder: 100 MS/s acquisition for one second. 50MHz bandwidth FFT; Oscilloscope with 4 channels @50kHz; Data Logger records data up to five days.
Access all I/O Signals	Configurable control routing and acquisition of 60+ I/O signals.
First-Stage Preamplifier	RHK or 3rd Party. Direct control of Femto multi-gain preamps.
IHDL/Inventor SDK: Interactive Hardware Development Language	User-customized routines. Supports LabVIEW VIs, MATLAB, Python, etc., without added software modules.
PerfectSpec	Optimize spectroscopic measurement techniques. Parameters such as bias voltage, setpoint, feedback loop speeds can be set independently for the topographic and spectroscopic segments of the same measurement.
DataWatch	DataWatchers can be inserted in procedures to ensure parameters stay within safe values or to trigger new processes. Responses as fast as 5µs.
Built-in Bias modulation	Directly modulate output bias DAC with sine waves as small as 10 µV. Modulate frequencies up to 10 MHz.
Z-position modulation	Directly modulate output DAC with sine waves as small as 10 pm.
Multi-frequency modulation and detection	Internal oscillators and lock-ins can be synced to provide multi-frequency excitation and multi-harmonic detection. Patented design guarantees exact phase matching even during frequency sweeps.
Power supplies	All-linear supplies eliminate high frequency switching noise.

R10- HVA HIGH VOLTAGE AMPLIFIER MODULE

High-Voltage Amplifiers (HVA):	Eight high voltage amplifiers with ±150V (±215V upon customer request) . Voltage can be software limited to any value less than maximum, such as 0-60V. Six channels @ 5 kHz bandwidth. Two channels @ 25 kHz bandwidth.
Safe operation	All outputs short-circuit protected. All outputs disconnected from microscope and connected to ground during start up and shutdown to prevent transient on scanners.
Inputs	Single four channel connector when interfaced with R10. Individual BNC connectors for stand-alone operation.
Additional 8x HVA	Second R10-HVA can be added to double number of high voltage channels.

R10 SPECIFICATIONS

Analog Inputs	**Ultra-high speed input channels**
Sample rate	100 MS/s
Quantity	Up to 2
Analog bandwidth	17 MHz
Input range	± 10V, ± 1V switchable under software control
Input impedance	50 Ω, 1 M Ω switchable under software control
Effective Resolution	16 bit @ 100 MHz , 18 bit @ 6.25 MHz, 20 bit @ 390 kHz, 22 bits @ 25 kHz, 24 bit @ 1.5 kHz
Programmable gain	Up to 512x at full bandwidth
Input offset	Input signal can be offset via software to correct for errors in external signal amplifiers.
Programmable AD/DC coupling	Input signal can be AC or DC coupled as defined in software configuration.

Analog Inputs *(Continued)*	**High speed input channels**
Sample rate	1 MS/s
Quantity	Up to 6
Input range	± 10V
Analog bandwidth	1 MHz
Effective Resolution	24 bit @ 200 kHz, 26 bit @ 12 kHz

Analog Outputs	**Ultra-high speed output channels**
Output rate	100 MS/s
Quantity	Up to 2
Analog bandwidth	17 MHz
Output range	± 1V/ , ± 10V on separate outputs
Effective Resolution	16 bit @ 100 MHz , 18 bit @ 6.25 MHz, 20 bit @ 390 kHz, 22 bits @ 25 kHz, 24 bit @ 1.5 kHz
Programmable attenuation	Up to 1024x at full bandwidth
Output offset	Output signal can be offset via software to correct for errors in external signal amplifiers
	High speed output channels
Sample rate	1 MS/s
Quantity	Up to 10
Analog bandwidth	100 kHz
Effective Resolution	20 hbit @ 1 MHz , 22 bit @ 62 kHz, 24 bit @ 3.9 kHz
Digital pulse counting	Four channels @ 100 MHz count rate
Digital Input/Output	32 DIO lines

Scanning Tunneling Microscopy (STM)
Topography | Current

Modulated STM STS Spectroscopy
I(V) | dI/dV | d^2I/dV^2 | dI/dZ | Hyperspectral Mapping

Contact AFM
Topography | Lateral Force (LFM) | Conductive (C-AFM) | Spreading Resistance Imaging | Force Modulation (FMM)

Intermittent Contact AFM
Amplitude | Phase | Drive | Pogo

Amplitude Modulation AFM
Topography | Phase | Feedback

Magnetic Force Microscopy (MFM) Electrostatic Force Microscopy (EFM)
Two-pass DC/AC | Lift DC/AC | Single-pass, Two-pass | Amplitude Modulation | Frequency Modulation

Kelvin Probe Force Microscopy (KPFM)
Single-pass, Two-pass | Amplitude Modulation | Phase Modulation | Frequency Modulation | dC/dZ imaging | dC/dV imaging

Piezo-response Force Microscopy (PFM)
Voltage | Current | Force

Frequency Modulation AFM
qPlus® | Shear Force (SFM) | Cantilever | Tuning Fork | df | Dissipation

Scanning Capacitance Microscopy (SCM)

Scanning Thermal Microscopy (SThM)

Multi-frequency AFM

Scattering Scanning Near-field Optical Microscopy (sSNOM)

AFM Spectroscopy
Force-distance | Amplitude-distance | Phase/distance | I(V) | Hyperspectral mapping | df/Z | drive/Z

Nanolithography
Bias or Force controlled patterning | User defined patterning — *Patterns and coordinates saved and loaded from standard file*

ENJOY THE POWER OF TEN!

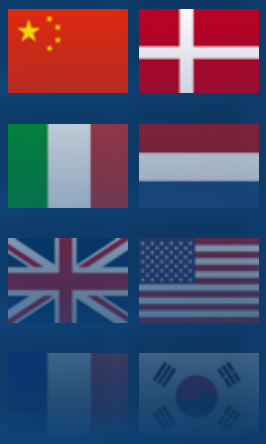
- Agile and Powerful
- Flexible and Cutting-Edge Performance
- Fast and Accurate
- Ready-to-use and Challenge-Ready
- Economical and Effective

These specifications can change at any time without notice.

RHK's Global Customer Base & World-Wide Sales Channels

RHK LOCATIONS

SYSTEMS IN OVER 40 COUNTRIES



And growing!

RHK delivers compelling value and proven quality to broaden the frontiers of atomic scale research. We stand ready to meet your specifications and exceed your expectations. In addition to industry leading control systems, RHK supplies a wide range of Scanning Probe Microscopes and complete Surface Science research systems. Every day, in university and government labs around the globe, RHK research platforms lead to new discoveries. Founded in 1981, RHK Technology brings over 40 years of experience to the design and manufacture of advanced UHV SPM instruments. Our installed base continues to grow and now includes over 1,500 installations.

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