Movement & Positioning News

PI

Issue 25

DC Motor Controller for Complex Positioning Tasks

A few months after its introduction, the C-844 DC Motor Controller has already found many users for standard and OEM applications.

Concept

C-844 is a flexible, multi purpose, rack mount positioning and motion controller for DC servo motors and can be used for complex positioning tasks in research and industry.

C-844 offers 100+ commands for setting and reading servo parameters, acceleration, velocity, etc. on the fly, and advanced features such as S-curve profile generation, electronic gearing, velocity contouring, real time origin position capture and fast 32 bit PID – V-ff servo control.

Fig. 1, C-844 DC Motor Controller with M-500 Translation Stage XY-Combination and M-038 Rotary Stage

Features:

- Simultaneous Control of 4 DC Servo Motors
- Fast 32 bit Digital PID V-ff Servo Loop
- Integrated Linear Power Amplifiers (12 bit) and PWM Outputs
- Trapezoidal-Curve, S-Curve & Velocity Contouring
- LabView™ Drivers, Libraries for C, PASCAL etc.
- IEEE-488.2 and RS-232 Interfaces
- SCPI Command Language
- Non Volatile Macro Command Storage
- 16 I/O Lines for Flexible Automation
- 4 Analog Input Lines (10 bit)
- 12 TTL Inputs for Limit & Origin Switches
- Electronic Gearing
- Programmable Torque Limit
- Analog Velocity Monitor, 10 bit

(continued on page 2)

Voice-Coil Scanning System with PC-Plug-in Controller

The V-103 / V-106 Voice-Coil Scanning and Positioning System is designed for applications where small samples have to be positioned or scanned with high velocity and high resolution. It provides superior responsiveness over micropositioners with conventional screw drives.

Highlights

- Fast Scanning & Positioning
- X and XY Versions
- Velocity up to 50 mm/s
- Travel range: 6 mm
- Resolution: 0.1 µm
- PC-Card Servo-Controller with Windows™ software

The mechanics (X or XY stage) are driven by integrated non-contact, zero-friction voice-coil actuators. Scan velocities up to 50 mm/sec over a range of 6 mm are feasible (model QuickScan V-101: up to 250 mm/sec). Integrated linear encoders provide position resolution of 0.1 µm. Non-contact hall effect origin switches (repeatability better than 1 µm) are standard, too.

The digital controller comes on an ISA-Bus compatible PC-plug-in-card and features on-board linear amplifiers for two individual axes, a 32 bit PID-V-ff servo system and other goodies such as I/O lines and hardware interrupt capability.

A mounting plate and software tools (LabView drivers, Libraries in C, Pascal, Basic…) are included in the system.

Application examples:

Semiconductor testing, medical analytical equipment, micro dispensing applications, optical device testing, lens testing, scanning microscopy, micro manufacturing.

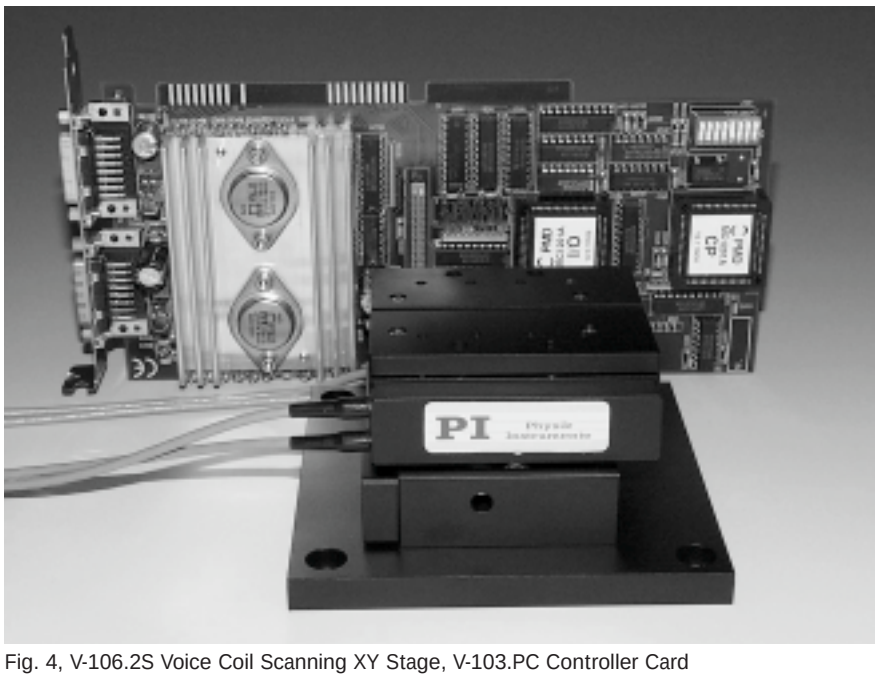

Fig. 4, V-106.2S Voice Coil Scanning XY Stage, V-103.PC Controller Card

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PI Scientist receives 1998 Technology Transfer Award

November 26, 1998

Dr. Xianbin Zhao (Fig. 2) is the winner of the Technology Transfer Award issued by the Chamber of Industry and Commerce, Braunschweig, Germany. The former PTB (German Institute of Standards) scientist was awarded this coveted prize together with PTB head of Department Micrometrology, Prof. Dr. Günter Wilkening for his achievements in developing ultra-high-resolution, ultra-high-linearity capacitance sensors and NanoPositioners for the purpose of improving Scanning Probe Microscopes.

After joining PI in 1995, Dr. Zhao developed a complete line of capacitance sensors and a line of ultra-high precision multi-axis NanoPositioning Stages featuring integrated six-axis active trajectory control for sub-nm flatness scans (Fig. 3).

Fig. 2, Dr. Xianbin Zhao

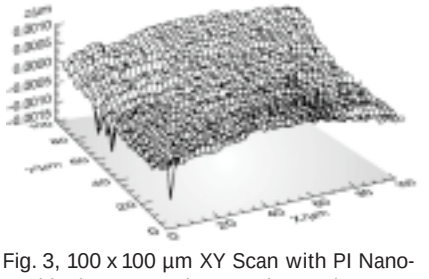


Fig. 3, 100 x 100 µm XY Scan with PI Nano-Positioning Stage shows sub-nm Flatness

Software for C-844

DCMove: Interactive User Interface

DCMove is a graphical user interface for easy setup and operation of C-844 motor controllers. It runs on all Windows™ platforms and provides communication via RS-232 and IEEE 488 interfaces.
DCMove is equipped with scalable slide buttons for position and velocity control (see Fig. 6). In addition, a command-line editor is available for communication using the SCPI command-set. An integrated command parser provides compatibility with mnemonic commands such as those used with the C-842 and C-832 motor controller cards.
Two macro editors (one using the C-844 internal macro capability, the other using the PC) support programming of complex motion sequences.

Fig. 6, Operating Panel for one Channel (up to 4 can be opened simultaneously)

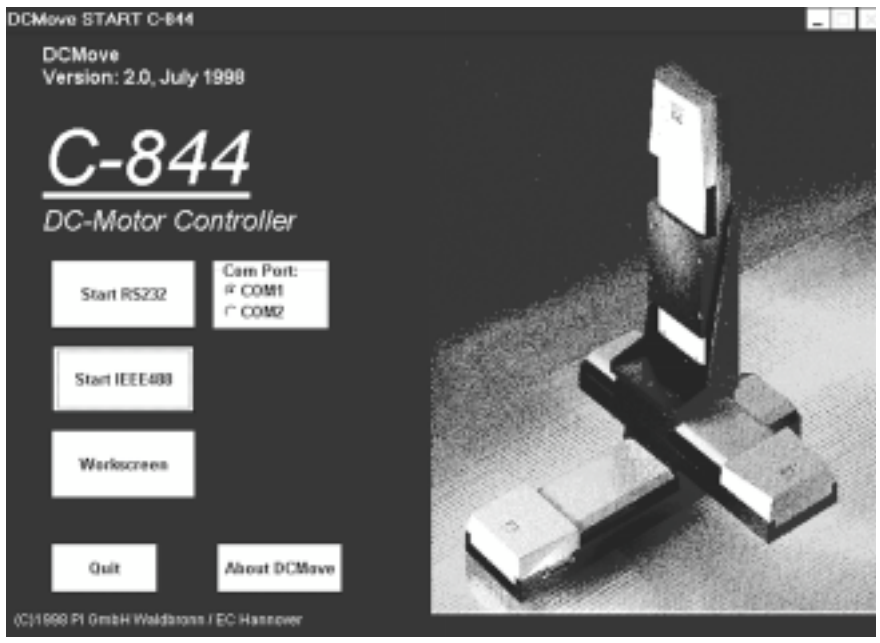


Fig. 5, DCMove Start-up window

Further Software for C-844:

- LabView™ Driver, Libraries for C, PASCAL etc.
- Terminal Emulation Software

Piezo Actuators Improve Accuracy of Precision Machining Processes

PI introduced their first line of piezoelectric actuators more than 25 years ago. The technology's unique features such as responsiveness, stiffness, life time and infinite resolution have opened many markets since then, from semiconductor testing to precision machining.
Typical precision machining piezo positioning systems are equipped with special waterproof casings which also provide the mechanical interface to the tooling machine and the tool. Optional integrated metrology systems feature resolution in the nanometer and sub-nanometer range for closed loop operation with digital or analog motion controllers.
Today, PI Piezo Actuators and Piezo NanoPositioning Systems are used throughout the world, often in applications that run 24 hours a day, seven days a week. They improve manufacturing precision of crank shafts, bearings, cylinders, pistons, mirrors, optics etc. in crucial processes such as milling, turning, grinding, out-of-roundness boring or wear compensation of tools.
PI affiliate PI Ceramic manufactures the special high-load piezo ceramics required for the tough environment of machining applications, with lifetimes of several billion cycles.
Integrated temperature sensors monitor the PZT ceramics temperature, an additional safety feature for continuous dynamic operation (e.g. in fast servo tooling applications, Fig. 7). The E-480 High Power Amplifier with Energy Recovery (Fig. 8) evaluates the temperature sensor feedback and alerts the operator before a critical temperature threshold is exceeded. The E-480 amplifier provides **2000 W peak power** in a voltage range of 0 to 1000 V.

Fig. 7, Piezoelectric Tool Servo

Fig. 8, E-480 High Power Amplifier with Energy Recovery

DC Motor Controller for Complex Positioning Tasks

(continued from page 1)

Real Time Operating System

C-844 is based on multi-processor architecture including a fast DSP motion control chip set providing trajectory generation and closed loop digital servo control based on position information supplied by incremental encoders. A host processor features real time communication and high level command handling with advanced func- tions such as stackable macro commands (up to 16 macros, up to 100 commands per macro, non volatile storage). For communication, both RS-232 and IEEE488 interfaces are integrated.

Integrated Power Amplifiers

Integrated, low noise, 15 Watt linear power amplifiers allow operation of all PI micropositioning systems without additional external amplifiers, reducing costs and simplifying the set-up. In addition to the analog motor output, PWM (Pulse Width Modulation) output signals can be activated by software to drive micropositioners such as the M-500 Family of Translation Stages.

SCPI Programming Language

The command language complies with the SCPI (Standard Commands for Programmable Instruments) standard which is a user friendly tree-structured language reflecting the device function- ality. The C-844 is prepared for future firmware updates via the RS-232 interface.
A variety of software tools such as LabView drivers, libraries in C, PASCAL and BASIC and a Windows™ operating program for instant, easy operation are supplied with the system (see "Software for C-844").

Novel Signal Processor Kills Self-Generated Vibration

PI holds Exclusive License for novel technology based on Research at the Massachusetts Institute of Technology (MIT)

A growing number of processes in manufacturing and testing require positioning resolution and accuracy in the nanometer and sub-nanometer realm. Apart from accuracy, the time factor is becoming more and more critical, especially in automated high-tech applications.

PI now offers the Mach™ *Throughput Coprocessor,* a unique plug-and-play solution for all processes requiring highest precision and ultra-fast response (”Nanometer-Precision in Milliseconds“).

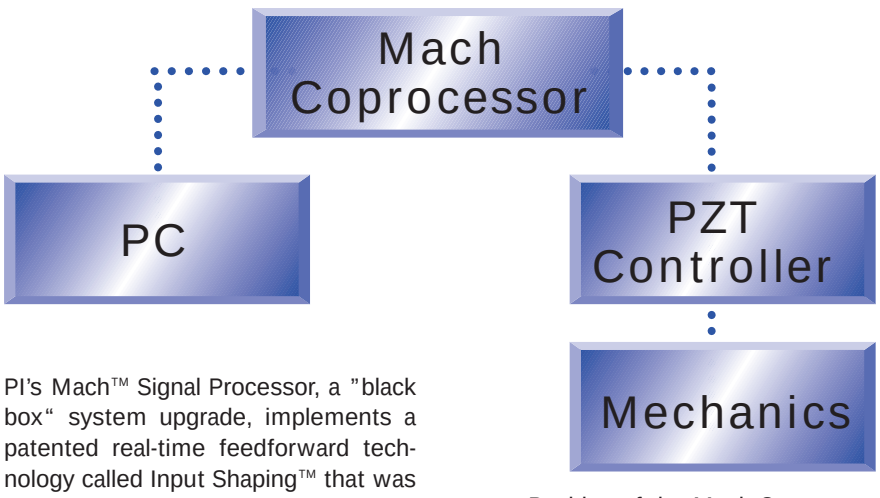


Fig. 9, Position of the Mach-Coprocessor in the Positioning System

PI’s Mach™ Signal Processor, a ”black box“ system upgrade, implements a patented real-time feedforward technology called Input Shaping™ that was developed based on research at the MIT (Massachusetts Institute of Technology). PI holds an exclusive license agreement with Convolve, Inc. (the technology’s commercialization company) for marketing Input Shaping™ with piezoelectric NanoAutomation™ products.

The solution to the problem ”Nanometer-Precision in Milliseconds“ can usually not be achieved by ”simply“ improving the accuracy and responsiveness of the NanoPositioning system. For example, the force that a NanoStage applies to its load and fixturing will cause them to vibrate in their resonant modes. At the same time, the recoil force that the stage confers to its supporting structure (which is equal and opposite to the force applied to the load) will in turn excite resonances in the supporting structure. Usually these vibrations can take hundreds of milliseconds to damp away, which is several orders of magnitude longer than the settling time of the unloaded NanoPositioning stage.

Conventional control techniques cannot significantly improve this situation, since the main problem is caused by the reaction of elements outside the servo loop. In addition, most systems show several resonant frequencies.

All these problems can be solved by plugging the Mach™ Coprocessor in-line between the controlling computer or function generator and the PI controller. It’s patented technology simply stops the NanoPositioning stage from exciting resonances in the supporting structure or payload. Therefore, the point of interest in the positioning system can settle in $1/f_0$ where f_0 is the lowest resonant frequency in the system.

Mach is installed outside the feedback loop (Fig. 9) and, in operation, receives no information from the motion device, computer or other system elements. It requires no modification to the customer’s setup, application software or servo parameters which is why open loop positioning systems also benefit from Mach’s unique performance.

Setting up Mach is very easy. First, the vibration frequencies created by the NanoPositioner’s actuation are measured (e.g. by a Polytec non contact Laser Vibrometer) at the point of interest. Next the frequencies are fed into a coefficient-generating utility running on a World Wide Web page and the resulting coefficients are then downloaded into the flash RAM in the Mach™ Box. The Coprocessor is now capable of modifying all input signals (in real-time!) in a way that resonances at the point of interest cannot be excited.

Mach is not to be confused with a filter. It works with random signals as well as with periodic waveforms such as sine, triangular or square waves. Mach even neutralizes transients with the same efficiency.

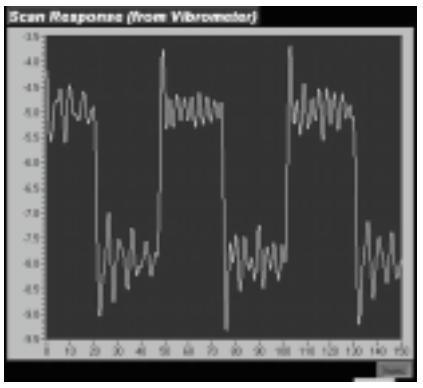


Fig. 10, Laser Vibrometer measurement of fixture resonance, excited by the rapid movement of the NanoPositioning Stage (which is not overshooting!) without Mach

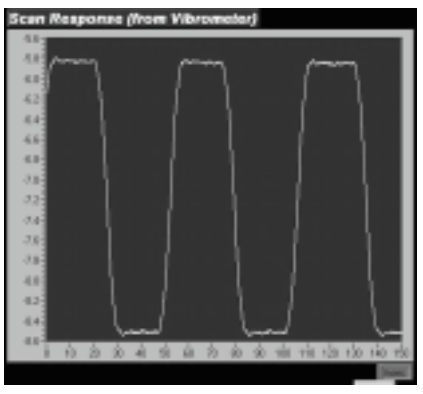


Fig. 11, Mach nullifies the fixture’s resonant recoil behavior. The servo parameters are the same as with Fig. 10 (Mach shows equal performance in open loop set-ups!)

Hexapod as Surgical Robot

The Fraunhofer-Institut für Produktionstechnik und Automatisierung (IPA), Stuttgart, Germany, has realized the first functional surgical robot prototype. The principal goals of the new technology are increased safety of micro-surgical procedures and feasibility of micro-therapy.

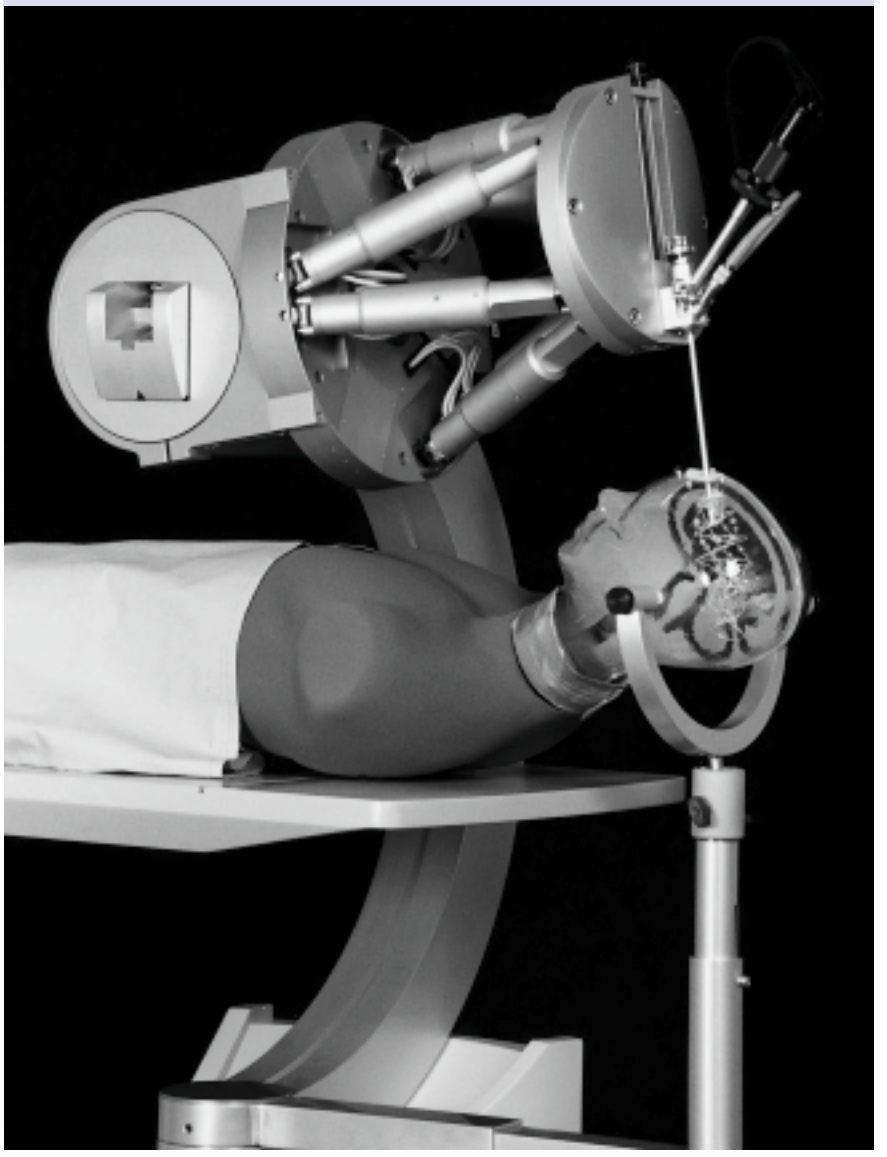
An ideal mechanical solution was found in the PI M-850 Hexapod, a six-degree-of freedom parallel-kinematics micropositioning system (see Fig. 12). Providing higher stiffness, load capacity and accuracy in a smaller package than conventional ”stacked“ multi-axis positioners, the hexapod principle allows submicron precision even under high loads.

The hexapod which serves as modular platform for different instruments, such as endoscopes, is controlled by a cockpit similar to a flight simulator. The cockpit also enhances the surgeon’s spatial understanding of the operation site, the endoscope’s position and speed.

IPA engineers consider this novel system the first step towards the ergonomic operating room of the future.

Special thanks to Prof. Westkämper and Dr. Thomas Weisener of IPA for supplying the information and graphics.

Fig. 12, Hexapod Surgical Robot with Endoscope and Phantom (Courtesy of IPA)



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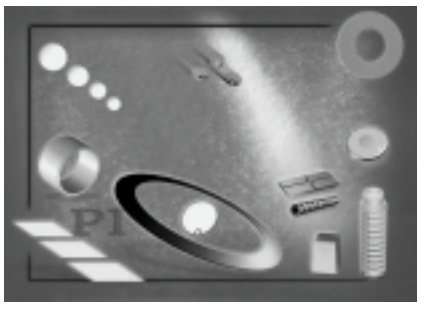
New Catalog on Vibration Isolation and Opto-Mechanical Components

The new catalog features honeycomb table-tops, breadboards, vibration isolation systems and the PI opto-mechanical System. General properties and basics of vibration isolation systems are explained in the introduction section.

Short Form Catalog: Piezoceramic Materials



PI Ceramic introduces the new short form catalog "Piezoceramic Materials". This catalog describes the wide range of Lead Zirconate Titanate (PZT) materials available for OEM applications. Information is included on material properties, stock shapes, standard tolerances, effect of temperature on material parameters, and helpful formulas.

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NanoCapture Software for E-710 Piezo Controller

Versatile Tool for Analysis and Optimization of Piezo System Response

- Measures System Response, Step and Settle, Resonant Frequency, Bode Plots
- Allows Optimization of all Servo Parameters
- Increases Throughput

The new NanoCapture Software (for Windows 95/NT) increases the versatility and performance of the E-710 Digital Piezo Controller. In addition to standard functions for the operation of Piezo NanoPositioning Systems, NanoCapture features advanced measuring and analysis functions such as resonant frequency, overshoot (Fig. 13), step and settle, Bode plots (Fig. 14), etc.
These features are specifically useful when the mechanical properties of a (factory-) calibrated system are changed at the operational site by parameters such as increased or reduced payload, different orientation or different damping conditions.
In this case, servo parameters such as gain, notch-filter frequency, etc. need to be adjusted to maintain optimum system response and stability. NanoCapture supports the operator providing system resonant frequency, rise and settling time by analyzing the dynamic position feedback data of the NanoPositioning System's integrated capacitance sensor (no other metrology or measuring instruments are required!). Based on these data, servo parameters are easily adjusted for optimized settling under any load condition (Fig. 15).
NanoCapture even allows setting the position sensor's zero position for a perfect match of the Piezo Controller's electrical range and the NanoPositioning system's mechanical range. All settings (downloaded to the E-710 Controller) are stored in non volatile flash RAM. PI keeps data files of each E-710 Controller calibrated at the factory for easy restoration of the original settings after shipping.

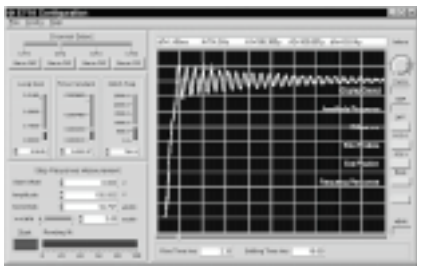

Fig. 13, Open Loop System Response (measured with NanoCapture)

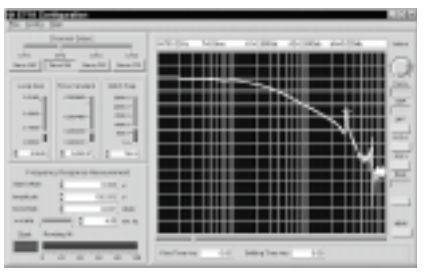

Fig. 14, Bode plot (measured with NanoCapture)

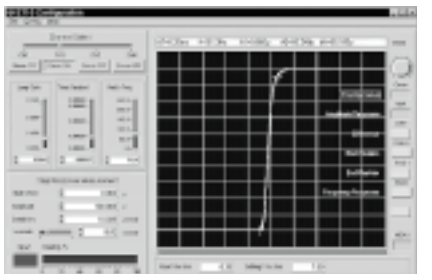

Fig. 15, Closed loop step and settle after optimization (measured with NanoCapture)

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