Portable Scanning and Acquisition System for miniature SEM

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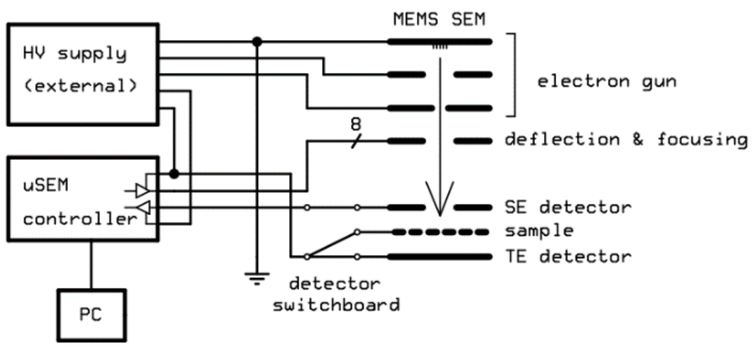
Introduction

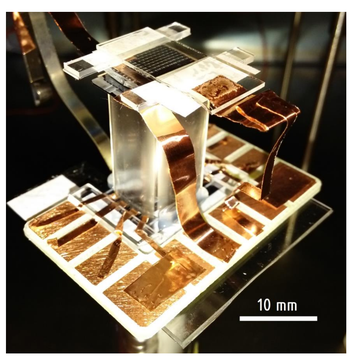
In research conducted on electron beam microsystems, it is necessary to develop appropriate electronic systems responsible for power supply, control and data collection. When the subject of research is a scanning electron microscopy, the required systems are: an electron gun power supply, a deflection systems controller and electron detectors. The system discussed in this article is designed to work with a MEMS microscope with a single, octupole stage of deflection and is a complete solution for imaging tests - it controls the beam and records signals from the detector. Only the electron gun requires power from a separate source, depending on its type and design.

Overview

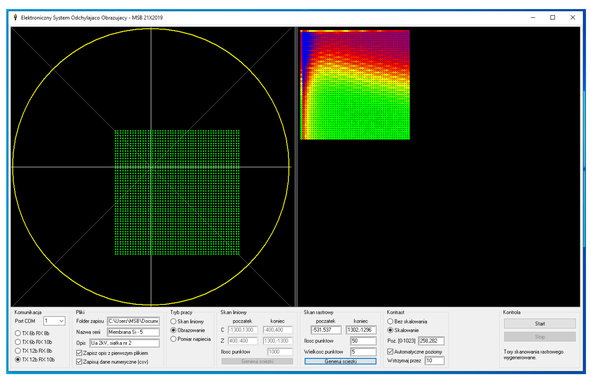
The presented system mostly fits into a 19" housing. It consists of an octupole deflector controller (on the left), data acquisition system and a detected signal preamplifier (separate unit – on the right).

Output voltages can reach ±120 V. Minimal detected current is 1 pA. The input and output circuits are isolated (floating), which allows working with µSEM structures of any configuration (detector or cathode at ground potential). A diagram of an example µSEM setup and close-up photo are shown below.



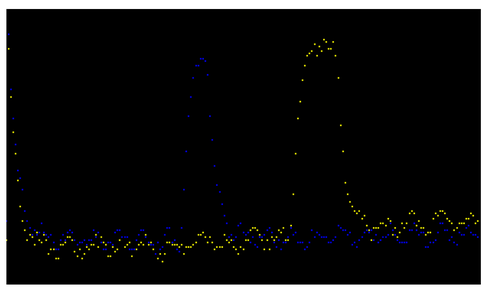


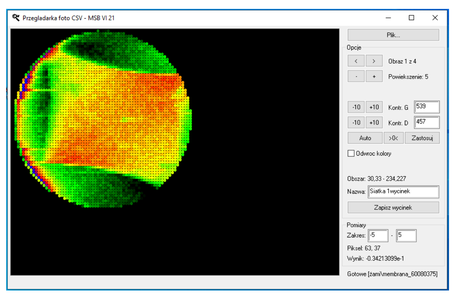
The control software allows working in three modes: line scan, raster scan and detector test mode. The deflection parameters are set separately in each mode via text input or graphical interface (“drag and drop” method). The data is saved in CSV files from which entire images can be restored and further processed with another specialized program, or data can be processed in any other way. Also, device can be used just as a digitally controlled, 8-channel HV power supply.



← Window of the control software. Preview of the scanning area (shown as a grid of green dots, each representing point to be scanned) is on the left, while the actual acquired image is displayed on the right.

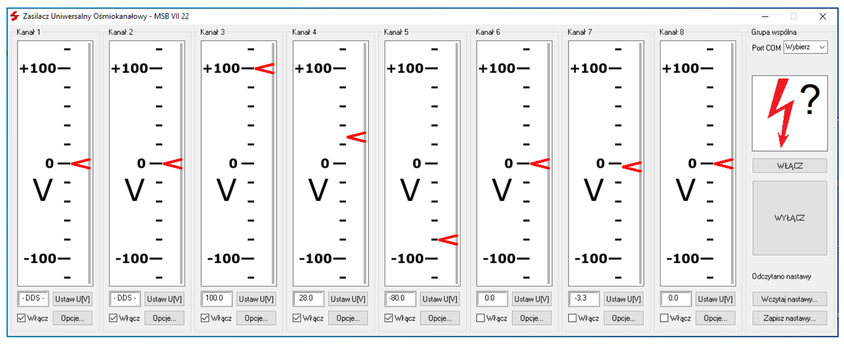
Result of „line scan” mode – a diagram showing signal amplitude as a function of beam position on two, user defined scan lines. →





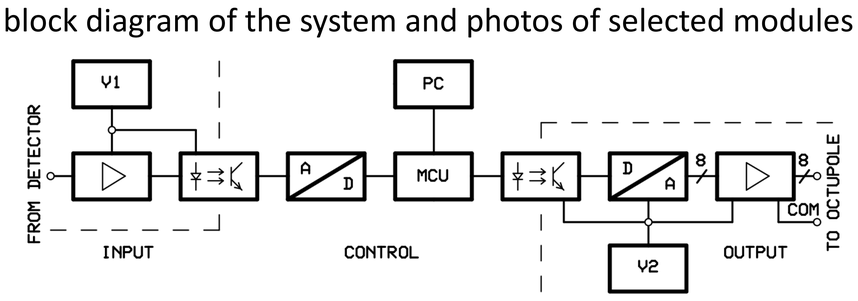
← „CSV Picture Viewer” – a program for viewing and processing acquired images. Also, value of current measured in each pixel can be recalled.

8-channel HV power supply control software. Each channel can be operated in real time by hand (text input or mouse drag) or can act like a DDS generator (square, triangle, sine wave). ↓

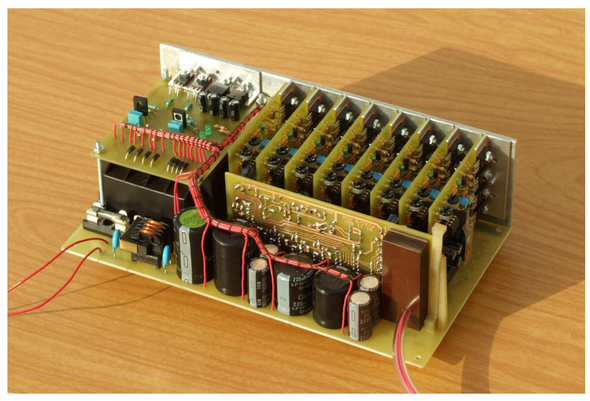


Details

Communication with the device takes place via a virtual serial port at a speed of 115.2 kb/s. This allows to analyse up to 1280 points per second. Computer sends the settings of 8 output channels that control the deflection system, and then receives the current measurement result from the detector. A block diagram of the system and photos of selected modules are shown below:

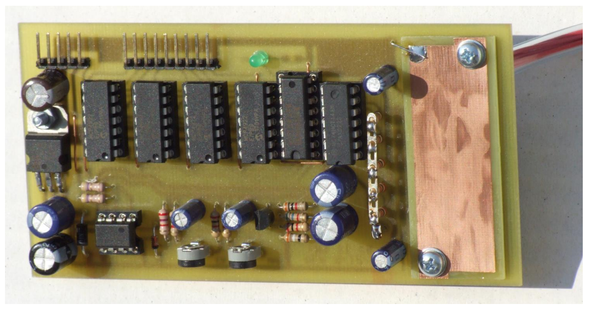


← Block diagram of the System. V1, V2 – external, optional HV power supplies. Input circuitry includes isolated preamplifier (external, sensitivity 1 nA) and 10-

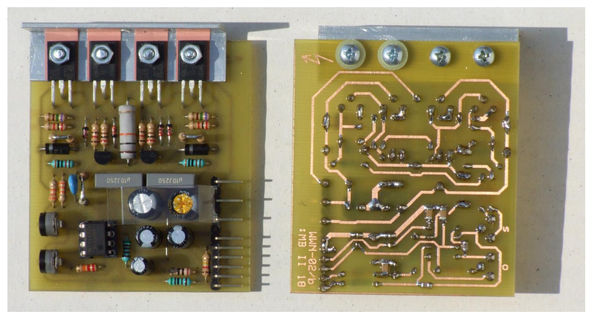


10-bit A/D converter built in ATmega328 MCU. Input can be biased with high voltage from V1, up to 4 kV.

← Output block of the system, including necessary power supplies, eight output amplifiers, D/A converters and digital optocouplers.



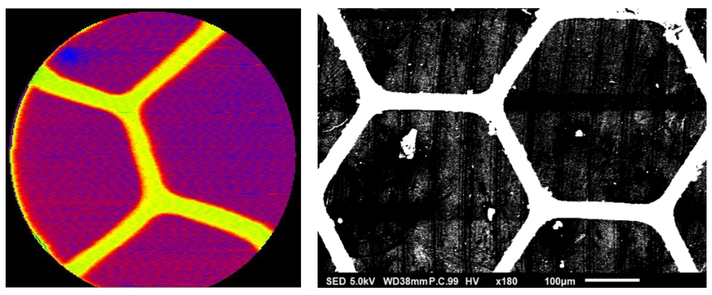
← D/A converters, reference voltage source and optocouplers card. It provides isolation of digital bus withstanding up to 4 kV, allowing whole output module to be biased with high voltage from V2. D/A resolution is 12 bit.



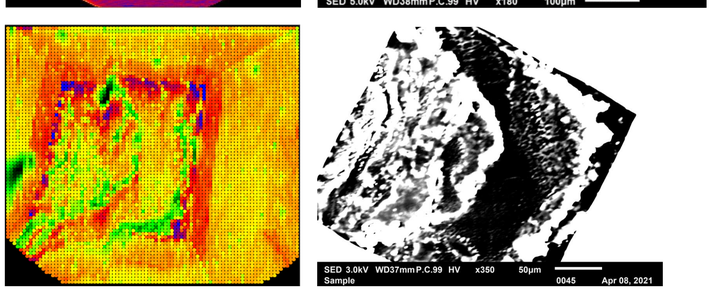
← Output modules of the system – HV amplifiers converting 0 ÷ 5 V signal from DACs to the levels of ±120 V. Settling time 50 µs, 1mA current limit. Circuit can both source and sink current.

Images

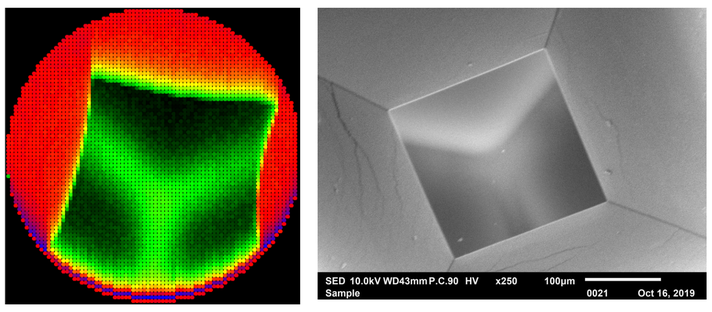
Sample images obtained with this system are shown below (on the left) with reference images from JEOL JSM-IT100 (on the right). An electron gun of JEOL scanning microscope was used as an electron beam emitter instead of the MEMS structure, in order to achieve as small as possible spot diameter and to overcome related limitations of resolution. Acceleration voltage was 4kV, contrast not exceeding 2 nA.



← 30 µm wide crossbeams of hexagonal calibration grid. SE detector was used, +30 V bias.



← Si_3N_4 membrane covered with yeast. Recorded with SE detector plate.



← 30 µm wide crossbeams of hexagonal calibration grid under Si_3N_4 thin membrane. Recorded with TE detector (on the left) and with SE detector of JSM-IT100 (on the right).

Acknowledgments

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