

RHK Technology

Application Note:

Extending R9 Capability by Programmatic Control with LabVIEW

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Introduction

R9 controller provides great versatility in performing scanning probe based measurements. The IHDL space enables users to tailor experiments flexibly by configuring the hardware connections from an intuitive graphical interface. In terms of front panel operations, while a great deal of useful functionalities have already been integrated in the R9 software, the user may still desire specialized capabilities to support their unique applications. Fortunately, taking advantage of the TCP server built-in to the R9 software, customized functions and experiment automations can be achieved by combining R9 with an external programming platform. Here we discuss the implementation of LabVIEW based remote control of R9 system. We note that similar functionality should also be possible with any other script/graphical based programming platforms that support TCP/IP communication protocols.

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System Requirement

R9 software version 5.0.1.3 or above. The implementation discussed here is based on Window 7 PCs. Applications in other OS environments might also be possible but remain untested. LabVIEW (short for Laboratory Virtual Instrument Engineering Workbench) is a system-design platform and development environment for a visual programming language from National Instruments. The discussion here is based on LabVIEW version 2012 or higher. It is our speculation that any LabVIEW versions with TCP/IP functions can be used here.

Implementation

To enable the LabVIEW control, a remote computer needs to be on the same network as the R9 controller and its controlling

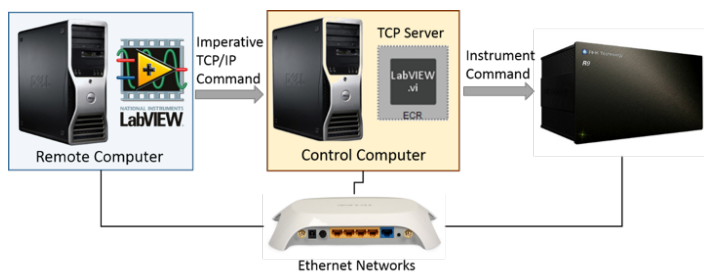


Figure 1 General connection diagram for implementing LabVIEW remote control

computer (Fig.1). Labview can also be installed on the controlling computer directly. In R9's IHDL space, the TCP server needs to be enabled, which can be done by including the "LabVIEW.vi" palette (in the external

hardware group) in the hardware space. Depending on the configuration, LabVIEW TCP/IP command should be addressed to the specific IP of the controlling computer and the preset port of the TCP server. A list of imperative TCP/IP commands are available from RHK that allow the external control of almost all the functions in R9, such as scan parameters, feedback loop gain settings, analog outputs as well as tip and sample motions. A simple example is illustrated in figure 2, where LabVIEW VI can be used to position the tip precisely by numerical coordinates. Such functions are very useful for accurate addressing of single nano-objects identified from previous scans.

Examples

LabVIEW remote control can enable numerous interesting functions through R9 such as synchronization with external instruments, automatic scan data acquisition and scanning probe based lithography.

Here we briefly discuss two examples. First, in many applications, scanning based microscopy image acquisition is a time consuming task. When the scan of a large irregular shape is required, users often face the tough choice of either setting up a large scan that involves many insignificant sample areas and unnecessary tip wearing or performing a series of smaller scan which requires significant human attention.

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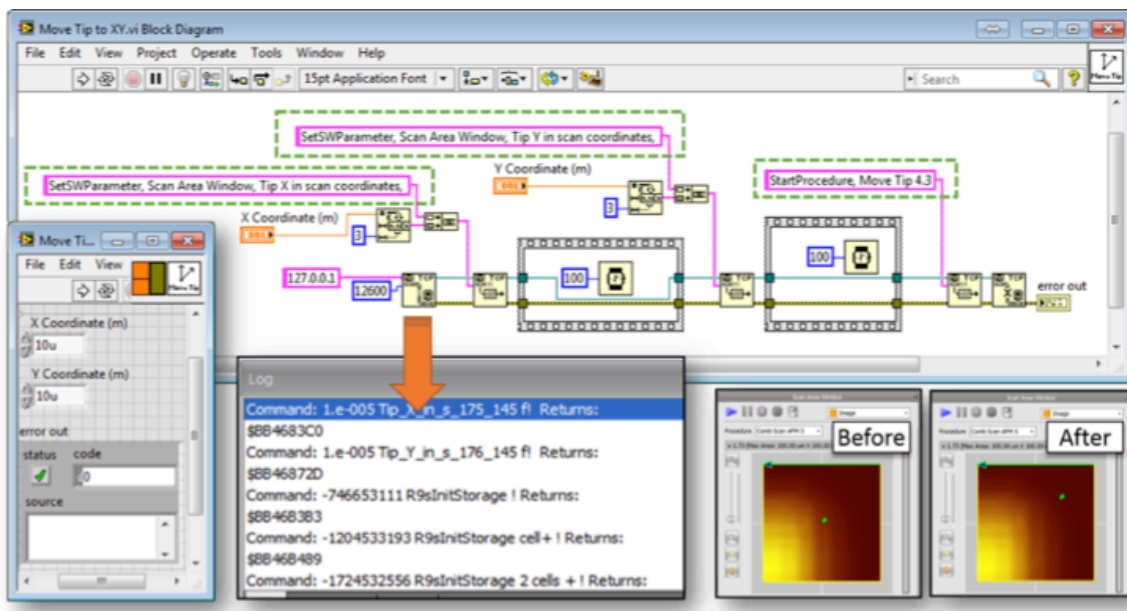


Figure 2 Simple example: move AFM tip by precise numerical coordinates. Imperative TCP/IP command sent by LabVIEW are translated to series of instrument commands through R9 software. Once the VI's execution is finished, tip is successfully relocated to (10 μ m, 10 μ m), as can be visualized from the R9 scan window.

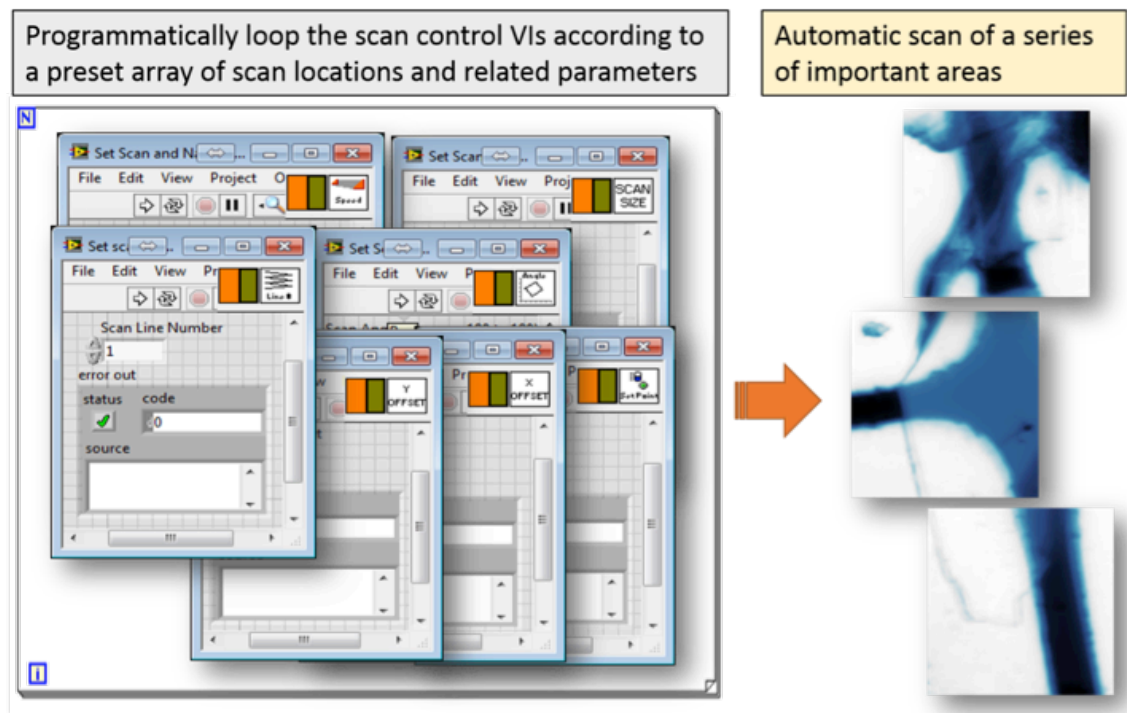


Figure 3 Scan sequence can be automated by combining LabVIEW program with R9 software

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With the aid of LabVIEW assisted scan automation, the dilemma can be easily solved. As illustrated in figure 3, when capturing scan image of an irregular InSe flakes, the LabVIEW programs is written to trigger a series of small scans of interesting areas only. Between each scan, parameters such as scan speed, scan angle, line number, scan position, tip engaging set point and tip bias can be programmed according to a preset array. Scanning time is reduced by more than 2/3 comparing to simply scanning a large square area and no human intervention is required during the automated scan series. Second example demonstrates the probe based nanolithography capability. In our application, a biased AFM probe is used to control the metal-insulator transition at an oxide interface in the nanoscale. To fabricate complex nanoelectronic devices using this technique, we developed LabVIEW programs to drive the tip motion according to vector based pattern designs and control the tip bias and touch down force programmably (Fig.4). Lithography pattern design is done by an open source vector drawing software “Inkscape”. LabVIEW VIs are written to translate the vector drawing into machine recognizable coordinate information. These coordinates as well as synchronized bias/force values are then passed along to R9 through the TCP server to control the probe activity. In the meanwhile, data acquisition of sample resistance/capacitance using external instruments can be simultaneously controlled by LabVIEW.

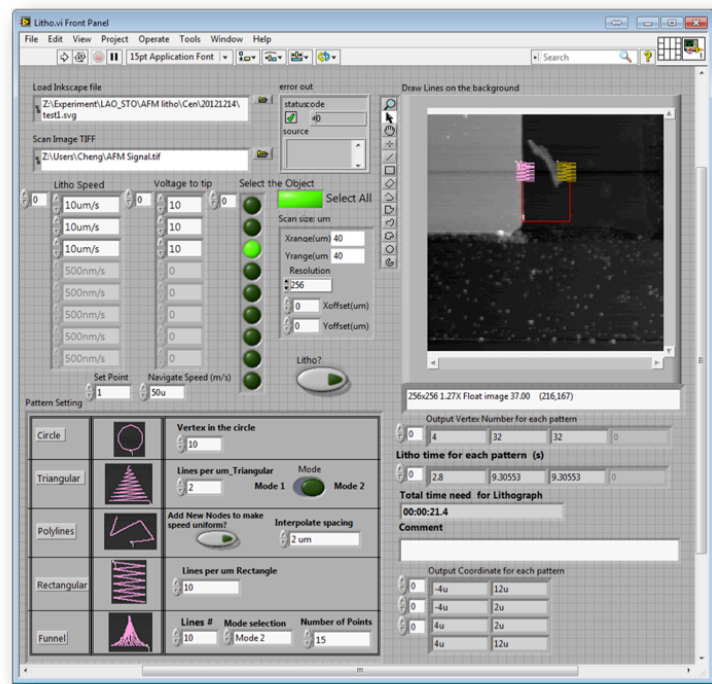


Figure 4 Controlling tip position programmably by LabVIEW, scanning probe lithography can be performed

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