

Easy integration of V-Gen and HumiSys relative humidity generators with other analytical instruments using simple command language

The user-friendly approach to the design of automatic control employed in the V-Gen and HumiSys RH generators simplifies integration with other analytical instrumentation and allows easy implementation of subsequent hardware changes. The firmware software monitors the state of the instrument and communicates with external world via serial port. Monitoring or changing states of microcontroller resources, e.g. A/D, D/A, and digital lines, is carried out by issuing simple commands from a master controller. Command handlers in the firmware software carry out the requested tasks. Basically, the instrument can be perceived as a black box that can be operated using a set commands.

Each executable command begins with two letters that define the command action and optional single digit specifying the action in more detail. Additional data follow some commands. Each command ends with coma. For example, a command starting with *da* means set a D/A channel. Additional digit after the two letters specifies the channel, e.g. *da1* specifies that the first channel is to be set. Since setting of a D/A channel requires additional data, namely what voltage is needed, the number from 0 to 4095 (0 to 5V range) must be added. Thus, *da14095*, sets the first D/A channel to 5V.

One single command, *rs*, reports state of all A/D and D/A channels and digital ports. Practically 3 types of commands: setting D/A channels, setting digital port A (command *pAn*, where n can range from 0 to 255), and reporting the system state are needed to effectively control the instrument. Additional command *READY*, serves as an inquiry to check if the system is on and ready.

Connection of external devices or sensors to unused microcontroller resources allows for easy transfer of data to a master controller. If the master controller software is designed in a flexible way variety of RH needs can be addressed using the RH generators. Typically, a PC platform is the preferred choice for the master controller due to its popularity and availability of many visual programming tools.

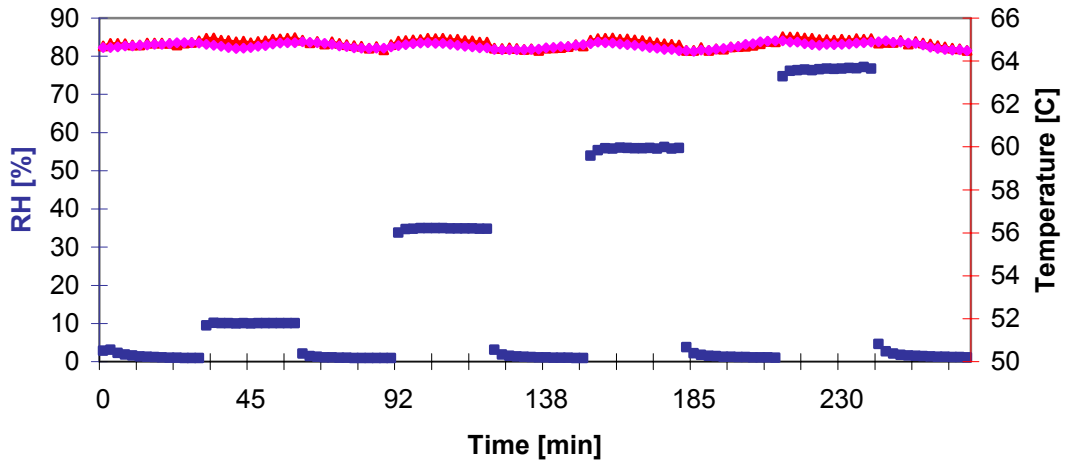
Using the command set, user-friendly application package for generating RH steps, diagnostics, calibration, graphing, reporting, and RH calculations has been designed. Taking advantage of the instrument design features the versatile software can provide automated RH option to many analytical instruments like TDA, DMA, X-ray diffractometers. Since the duration of RH steps is well defined, the user can easily synchronize the RH generator operation with other equipment. Ability to generate variety of relative humidity profiles, select different sensors for RH control, carry out experiment modification at any stage during run time, record data from other sensors are just a few features of the software that delivers powerful solutions to most RH needs.

Increasingly stringent testing of materials properties in the presence of water vapors requires precise generating of RH stream that needs to be delivered to test chambers of specialized analytical equipment. Such tasks can be easily accomplished using V-Gen. The abilities to track the temperature of test chamber using small size RTD and automatically adjust other settings at the source to maintain constant RH level at the target are very attractive features of the fundamental two-temperature method employed in VGen, especially in cases where installation of RH probes is cumbersome due to small size of the chamber. Combining the capability of generating dew points up to 90 °C, dry purge, and preparing the condenser for the next step during dry purge operation, one can generate sharp RH steps of different dew point values and duration time for studying kinetic processes.

In chambers where a small size RH probe can be mounted, it can be used either for control or monitoring of the generated RH stream depending on the selected control mode. For example, in the figure shown below, the relative humidity (blue) and temperature (pink) data from the RH probe were used for

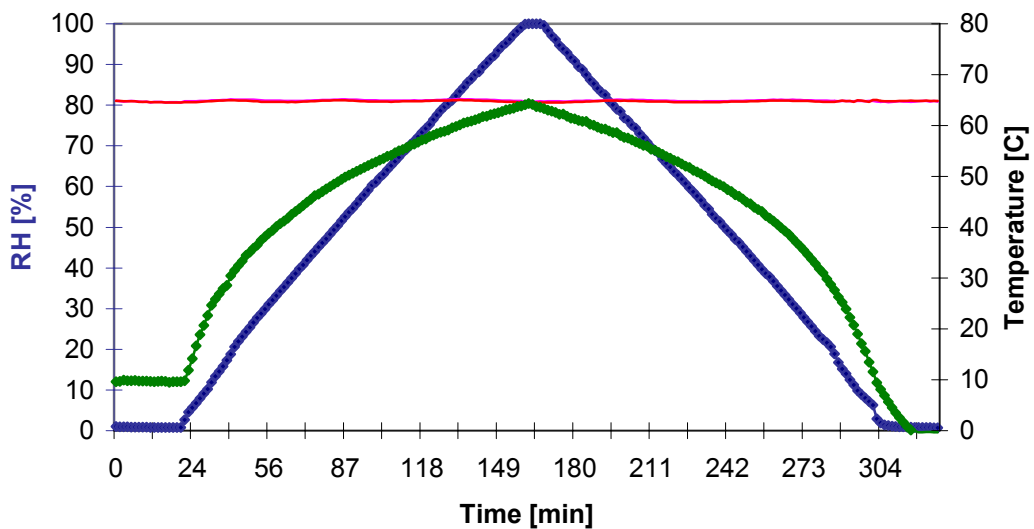
monitoring and the external RTD temperature sensor (RTD2) was used for reading temperature (red) in the chamber. The V-Gen software automatically adjusts the condenser temperature to account for fluctuations in the chamber temperature in order to provide the requested constant RH level. In this operational mode, the RTD2 temperature was used for control of RH.

RH and Chamber Temperature vs. time



In addition to typical stair-case RH profiles, the large number of RH steps available for an experiment definition (up to 1000) and intervening them with dry purge allows for generating more complex profiles for specific applications. Using large number of steps with short duration time it is easy to generate linear lines with different slopes.

RH and Temperatures vs. time



In the figure shown above the experiment begins with a 20 minutes dry purge that is followed by linear ramp from 5 to 100% RH and back from 100 to 5 % RH. The experiment ends with another 20 minutes of dry purge. In the initial drying the condenser is prepared already to generate 5% RH at the chamber temperature of about 65 °C. After the last step of the symmetrical RH profile the condenser temperature is set to its default state at 0 °C and the final drying continues for 20 minutes. The condenser temperature depicted by the green line clearly exhibits the nonlinear dependence of needed dew point values to generate linear increase or decrease of RH. Obviously, the point where the condenser temperature reaches the temperature of the experimental chamber results in 100 % RH. Opposite to the first example, the RH probe data (humidity and temperature) were used for RH control and the RTD2 temperature was used for monitoring purposes. The temperature read by the RH probe (pink) and the temperature read by the RTD2 (orange) are overlapped.

Other control scenarios using different RH sensors and experimental setups can be easily accomplished as addition of new functionalities to the master controller software can be done quickly. If need be, new command handlers can be written for new external devices that can be hooked up to the microcontroller. Thanks to the modular design of hardware and software, the RH generators are powerful tools for automated control of RH in many analytical setups.