

# A User Interface for Capillary Electrophoresis

The graphical user interface of the HP CE instrument is designed to be easily understood by users familiar with other separation methods but new to CE. It provides for method programming and simulation and for visualization of the status of the instrument and the running analysis.

by Alwin Ritzmann and Klaus Witt

The architecture of the user interface for the HP CE instrument is similar to HP's LC ChemStation. Like the LC ChemStation, it uses Microsoft® Windows as a platform. Because electrophoresis is seen as similar to HPLC and the same type of diode array detector is used, it made sense to us that the user interface should be similar. It also helps that both systems are developed at the HP Waldbronn Analytical Division.

The HP CE ChemStation consists of an HP Vectra 486/66XM or compatible computer with 12M bytes of RAM, a 420-Mbyte hard disk drive, an HP-IB (IEEE 488, IEC 625) card, MS-DOS® 6.xx, and MS Windows 3.1 or higher. The PC is in charge of data handling, which includes all functions with midrange timing requirements:

- Sequencing
- Collection of method parameters
- Method storage

- Long-term control of the instrument
- Error handling
- Collection of run-time data
- Data processing (e.g., integration)
- Report generation
- Message logbook and error log
- User-controlled liquid movements.

## User Interface Strategy

A major objective for the user interface was to help the user not be afraid of the measuring device. Because CE is a new separation technique, many users will be switching from other procedures they are already familiar with, and their expectations may be basically different. A person acquainted with slab gel electrophoresis will have no problems with high voltage, but sequence analysis programming and automatic data analysis with calibration will be new. A chromatographic

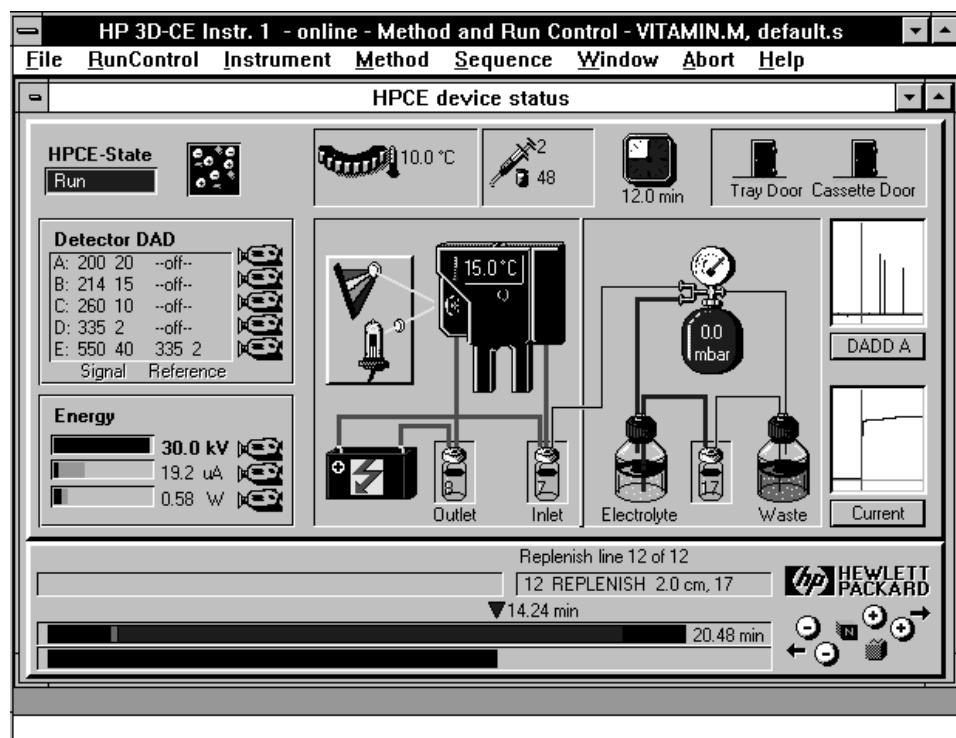
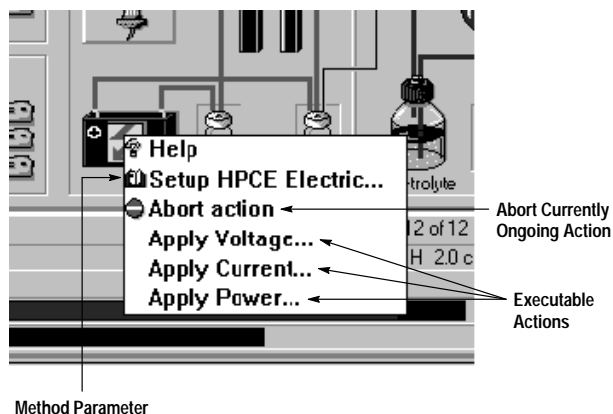


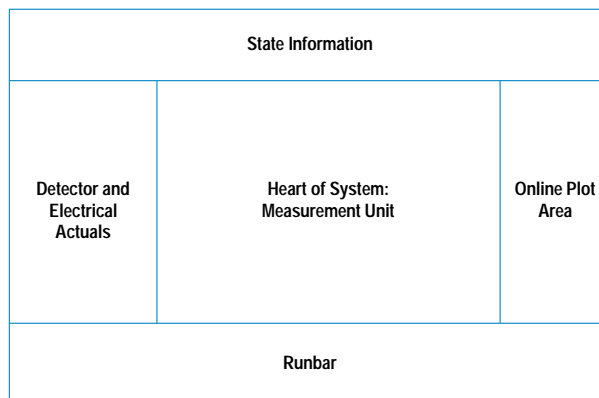
Fig. 1. Top-level window of the user interface of the HP CE instrument.



**Fig. 2.** A pop-up menu appears when a symbol is selected by a mouse click.

expert, on the other hand, will consider these aspects old hat, but step-by-step conditioning and the frightfully high voltage may be new.

A graphical user interface was selected to provide visibility into the operation of the instrument and thereby counteract any initial problems by conveying the feeling to the user that the measuring device is controllable. Communication with the user by interactive visibility is a great advantage. Many applications cannot be imagined without icons, 3D buttons, WYSIWIG, or multimedia anymore. It is far more comfortable to follow the consequences of one's behavior on the screen interactively.

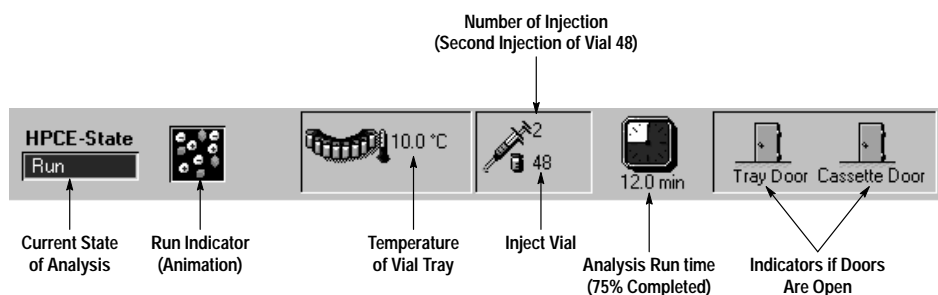


**Fig. 3.** Layout of the top-level window.

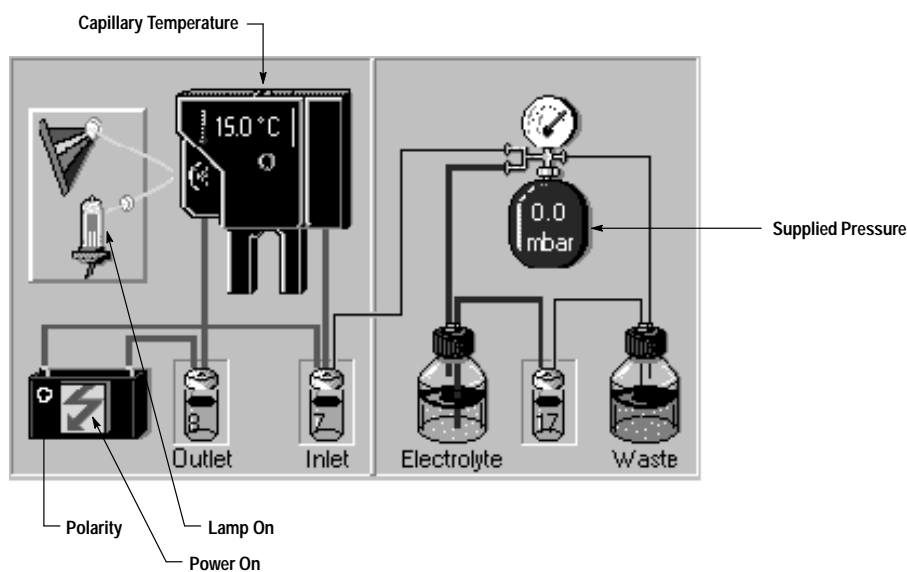
The graphical user interface of the HP CE system is designed particularly to address the following three objectives:

- Visualization of a programmable but automatically running process, as feedback to the user
- Context dependent or function-related access to specific settings or value groups
- Manual control of specific functions for which direct triggering is impossible or unreasonable in automatic operation.

Visualization means not only the extensive but clear representation of as many values, activities, or processes as possible, but also the ability to simulate a programmed method.



**Fig. 4.** Status line.



**Fig. 5.** Measurement unit display.

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## Development of a Common ChemStation Architecture

The HP CE user interface is based on a common HP ChemStation architecture. The architecture and many software components are shared with ChemStations previously developed for other analytical techniques. For example, because most of the HP CE ChemStation functionality is identical with the high-performance liquid chromatography (HPLC) ChemStation (automation, data acquisition, processing of measured data from the detector, and reporting), about 80% of the HPLC ChemStation code was reused. This article describes the evolution of this common software architecture and the core software components.

The term ChemStation was created to describe the use of a workstation as a tool for an analytical chemist. Independent of the analytical technique, the user works with a ChemStation to control the analysis system, acquire measured data, process the data, and create the analysis report. In addition, these complex functions must be fully automated for unattended operation. As PCs became very popular for the chemist's desk as well as in the analytical laboratory, HP product generation organizations, together with a system development group, defined the following objectives:

- Develop a ChemStation architecture based on the Microsoft® Windows platform.
- Develop reusable components from which various products can be assembled.
- Develop selected architecture-neutral components to be used for other data system platforms (e.g., UNIX® system-based workstations).

The architecture for the ChemStations is based on the available Windows technology. The development environment is based on the Microsoft development tools (C, C++, MS foundation classes, etc.). Both the Windows platform and the environment have evolved significantly during the last couple of years.

Because the common software components were developed by an international team, an appropriate infrastructure was set up to support the engineers working at two sites, one in the U.S.A. at Wilmington, Delaware and one in Waldbronn, Germany. A history management system (HMS), telephone conference equipment, small decision making groups, and system build processes were defined and implemented. The product development program was set up so that the software development groups were not isolated from the instrument development groups.

The infrastructure as it exists today is much different from the way it was defined in the beginning. As we learned how to deal with such a complicated environment, we went through several steps with the infrastructure and the organizational structure to make sure that the various software product generation groups were linked together.

The architecture and the development of the ChemStation products also went through several evolutionary steps. We always focused on clear product examples during the development of the core components. This approach made sure that

the software development met the instrument requirements for the various analytical techniques. We also had to maintain the architecture and the core components according to the fast-changing Windows platform technology.

The first step was to introduce software products for HPLC, HPCE, and UV/Vis instruments. All these software products were built on the available common software components. As an example, the analytical language processor, a BASIC-like language, is used in all the products as a common key component. In a second step we went further and built one core software product supporting HPCE, GC, HPLC, and analog-to-digital converters. "Plug and play" modules specific to various instruments and analytical techniques can be added to the core software product. This is the basis for the recently introduced multitechnique ChemStation, which provides control, automation, and data handling for up to four GC, LC, or CE instruments and an optional analog-to-digital interface. This product is always delivered with the core software and an individual module for one specific analytical technique. If the customer wants to add another instrument, either for the same analytical technique or to combine techniques (for example, HPLC with CE), another module can be ordered and installed to work with the core.

This approach is very efficient and highly appreciated by our customers and field people. If the customer knows how to operate one product it is easy to operate the ChemStation for another analytical technique. The customer can concentrate on the analytical technique and always finds the same user interface. Other techniques, such as UV/Vis, SFC, and so on, share all the common components from the core and therefore are on the same architecture.

This approach has resulted in a very high reuse level—between 65% and 85%—and ensures that all the products meet high quality standards with a reasonable amount of testing and software validation effort.

Development of the common ChemStation architecture was only possible through the involvement and cooperation of many people throughout various HP organizations, who deserve a great deal of credit for these achievements.

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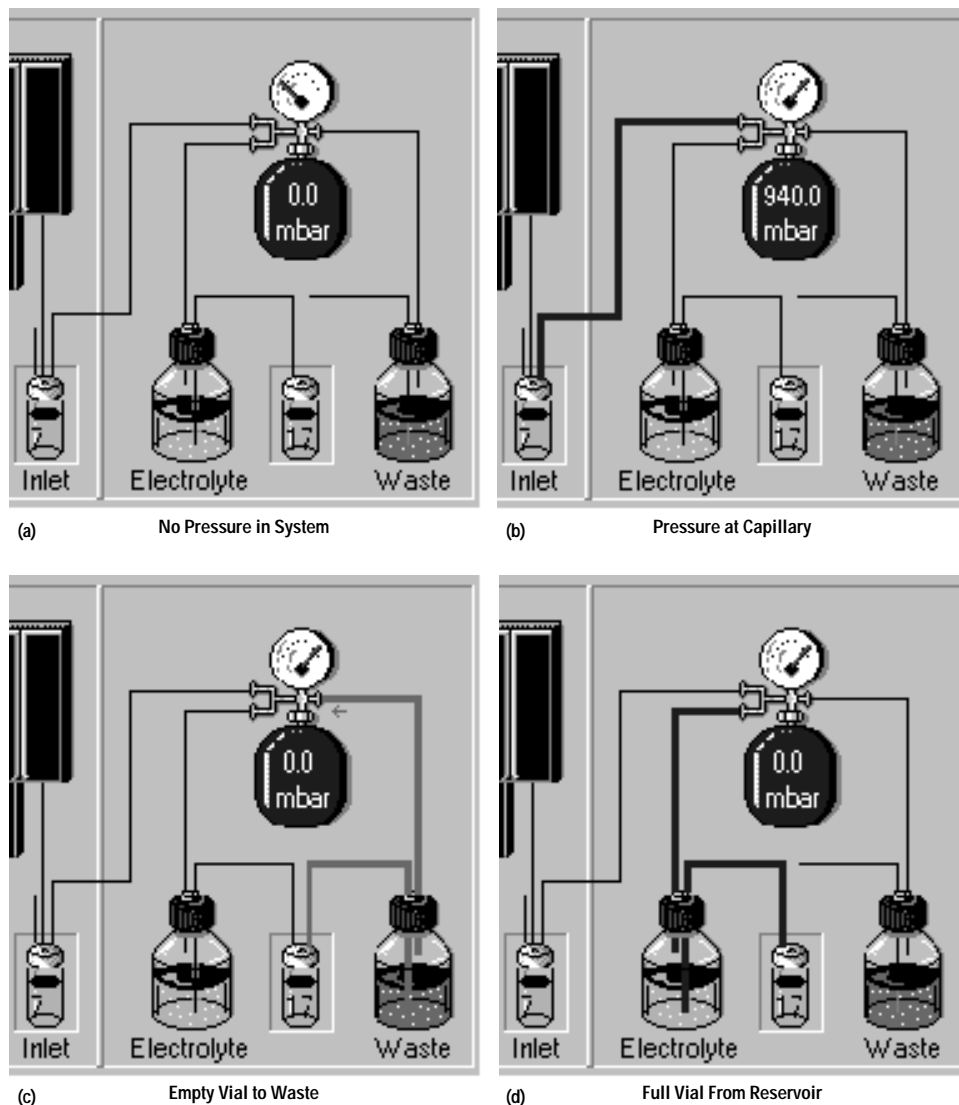
Simulation is an advantage when, for example, a process that will run for a long time needs to be checked quickly for completeness and consistency, or when a method is being edited whose execution would not be possible given the present state of the measuring device.

### User Interface

The HP CE ChemStation has one .EXE file and one top-level window, including the command processor. The top-level window contains child windows that are activated on user request. A status window and the online diode array detector plot window are shown by default. The top-level menu is user-definable and supports additional short menus.

As the name capillary electrophoresis indicates, we are dealing with an analytical measuring method taking place in a capillary with the help of an electrical voltage. The capillary is selected by the user based on specific criteria and is reeled up in a cassette which is then inserted in the measuring device. A picture representing the cassette forms the center of the top-level window of the graphical user interface (see Fig. 1).

In the top-level window, the state of the HP CE instrument is shown. Any important information is obvious at a glance. In accordance with the setup in the instrument and following the function as it is seen by the user, the respective functional



**Fig. 6.** Replenishment system displays. (a) No pressure in system. (b) Pressure at capillary. (c) Vial being emptied to waste. (d) Vial being filled from reservoir.

elements are arranged around the cassette. The user can immediately associate functional modes with the stylized pictures and thereby get a clear impression of the process and present status even without having much experience.

Each group of functions is represented by an icon or symbol showing the current state. A user who has a specific intention can select the component on the graphical interface that comes closest to it. If the mouse pointer is clicked on a component, a pop-up menu field appears close by, listing the functions linked to the component. In the case of the detector, for example, the pop-up menu offers lamp on/off or wavelength selection. When the battery icon is clicked, a pop-up menu of electrical parameters shows up (see Fig. 2). A specific icon in the menu field (the book symbol) immediately shows whether an action results in the modification of the method.

Fig. 3 shows the layout of the top-level window. Wherever possible, a combination of analog and digital display was chosen. Analog display facilitates the quick qualitative grasp of data by the human mind. Precise representation is realized by the additional digital display. In the analog display of the electrical parameters, for example, bar charts make states quickly visible to the user without too much thinking.

For example, one can recognize at once whether the programmed value has been reached and how far away the actual value is from the system limit. These things could be conveyed with the digital display alone, but would be much harder to comprehend.

#### Status Line

In the left corner, the topmost line shows the current state of the instrument (Fig. 4). Different colors are used to help the user visualize the instrument state. For example, green is used for all ready, blue for running, yellow for not ready, and red for error states. Text matching the respective state is displayed in the field. To the right, there is a run indicator in which an animation starts running as soon as an analysis begins. The animation quickly provides optical feedback that an analysis is in process without requiring the checking of different states beforehand.

A clock in the status line displays the times for different actions. It is not a 24-hour clock, but displays the time elapsed relative to the total time. A full turn of the clock symbolizes the total time of a process. The precise elapsed time is displayed digitally below the clock. The clock runs

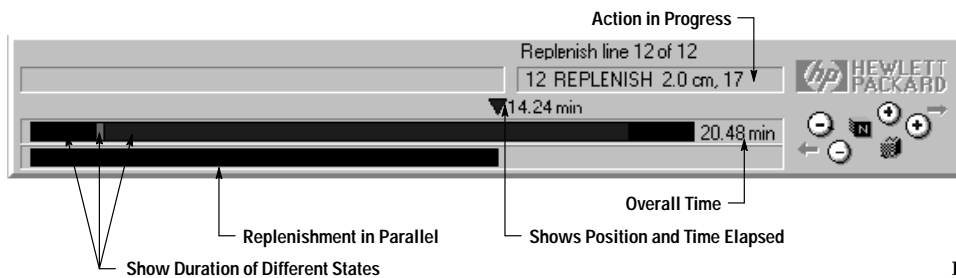


Fig. 7. Runbar

backward for actions taking a fixed period of time (e.g., flush for 3 minutes), thus showing the remaining time of the action. For procedures containing programmable actions (e.g., run), the clock runs forward, showing the time elapsed.

### Measurement Unit

The cassette with the detection unit is the core of the user interface and the instrument (see Fig. 5). In the center of the user interface, everything in direct connection with the capillary, and thus the separation, is displayed. One can see whether the lamp is switched on or off, whether voltage or pressure is applied to the capillary and which vials are in contact with the capillary. The temperature inside the capillary cassette can be read. The pressure bottle symbolizes the pressure system. The black connecting lines show the existing connections to the capillary or the vials. They change to red when power is applied, to blue when compressed air is supplied, and to pink for vacuum. The pressure applied is displayed in the pressure bottle. Thus, it is quickly visible what is switched on at a given point in time.

### Replenishment

The replenishment system display shows which vials are presently filled or emptied. For examples, see Fig. 6. Pressure on the lines is shown in blue, vacuum in pink.

### Runbar

The runbar (Fig. 7) is designed to provide an overview of the entire analysis. With its help, the user can see how far the analysis has proceeded. An analog bar displays the relative durations of the individual parts of the analysis in different colors.

The runbar gives the user the following information:

- Which step is presently in process (colored parts)
- What fraction of the total time is consumed by each individual step
- Completion of the analysis (overall time)
- Time since the start of the analysis (triangular arrow)
- Position of the current step in the analysis
- Individual steps executed
- Whether parallel replenishment is active.

This helps the user get a clear overview of the state of the analysis. A short glance at the analog display suffices for a qualitative impression.

### Detector and Electric State

The current values of the detector and the electrical unit are shown on the left side of the user interface. In the electrical parameter display (Fig. 8) voltage, current, and power are displayed and can be controlled. Whether voltage, current, or power control is enabled is indicated by a bold digital numerical value and a black bar (actual value) obscuring the corresponding green bar (reference value). The camera symbols show where data is being recorded. The display of the electrical values is located opposite the battery symbol.

The detector settings are shown in the user interface opposite the detector symbol (Fig. 9). Here, the settings for all channels can be read. Channels for which data is being recorded are indicated by camera symbols.

### Online Plot Area

In the online plot area (Fig. 10) are two signal windows in which the signals from the detector or the electrical unit can be displayed. The displays show the values presently measured.

Upon the click of a button, either plot window can be enlarged so that more precise values can be read and the curve

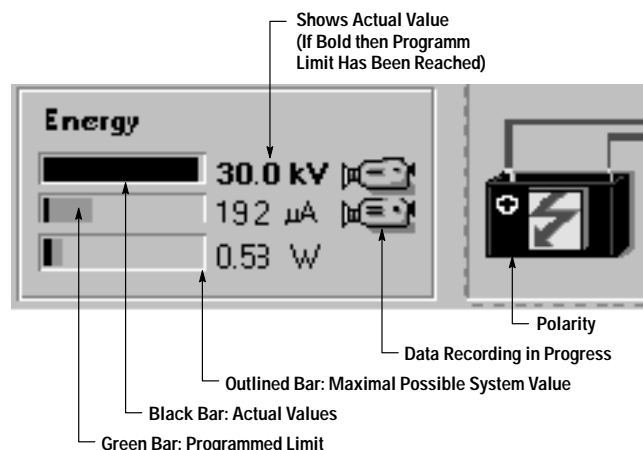


Fig. 8. Electrical parameter display.

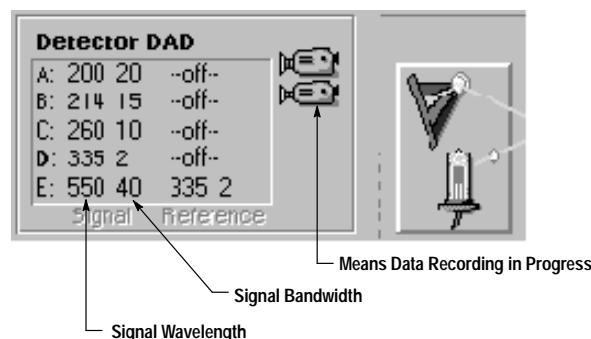
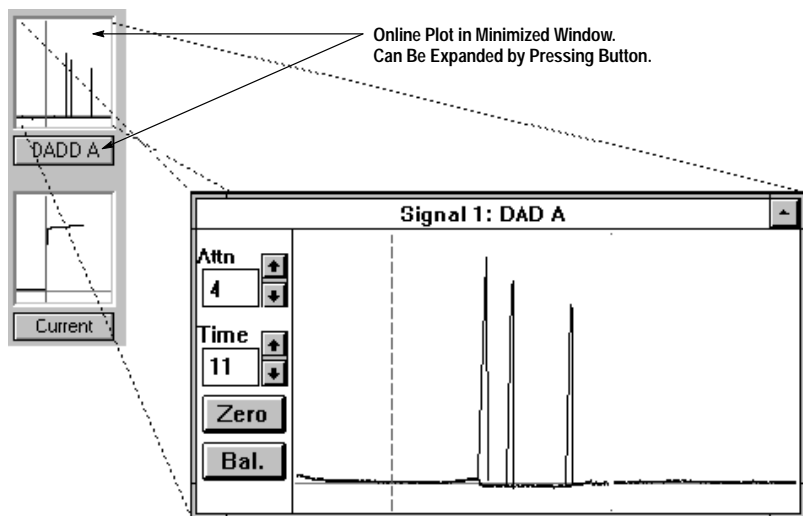


Fig. 9. Detector display.



**Fig. 10.** Online plots and enlarged plot.

trace can be better followed. Clicking on the enlarged signal enables tracking of the signal curve and precise determination of individual values.

### Simulation of a Method

Simulation is used for verification of a programmed method. The complete sequence of a method can be shown in the user interface. All actions are displayed as if the instrument were running. The simulation is software-based and does not require any hardware.

When the simulation is initiated, a control dialog appears which facilitates navigation through the simulation. Moving forward and backward in single steps is possible. With each step, the corresponding time at which the action is executed is displayed. The simulation only shows steps causing a change of state. A run button makes continuous stepping possible.

By simulation, the user can verify the complete sequence of a method before the actual run to make certain that the method is error-free. Especially in the case of methods with long run times, it makes sense to check in advance whether everything will go as planned or if program faults have slipped in. The user can also see in advance how long the analysis and the individual steps will take, and whether there are any conflicts.

### Acknowledgments

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