Rexroth
Bosch Group

# Rexroth PSQ 6000
# U/I Controller

**1070087072**
Edition 0a

**Commissioning, Operating instructions**

**Title** Adaptive controller and operation

**Type of documentation** Technical Information

**Document Typecode** DOK-PS6000-UIR-IB0x-EN-P

### Purpose of documentation

The present manual provides information on the:

- Installation
- functionality and
- operation

of the U/I controller XQR module.

### Purpose of documentation

The present information is meant to supplement the respective PSI 6000 manual on control and I/O level and the PSI 6000 manual on medium-frequency inverters.
**Please note that the safety instructions provided there are to be observed.**

Separate documentation is available for the ultrasonic system.

### Record of Revisions

| Previous editions | Status | Notes |
|---|---|---|
| DOK-PS6000-UIR-IB0x-EN-P | 05.2005 | provisional |
| DOK-PS6000-UIR-IB0x-EN-P | 10.2005 | provisional |
| | | |
| | | |

### Copyright



### Validity

The specified data is for product description purposes only and may not be deemed to be guaranteed unless expressly confirmed in the contract. All rights are reserved with respect to the content of this documentation and the availability of the product.

### Published by

Bosch Rexroth AG
Postfach 11 62
D-64701 Erbach
Berliner Straße 25
D-64711 Erbach
Tel.: +49 (0) 60 62/78-0
Fax: +49 (0) 60 62/78-4 28
Dept. BRC - WS/VTR

# 1 Contents

# 2 Safety Instructions

**The safety instructions given in the “PSI 6000 Control” and “PSI 6000 medium-frequency inverters” manuals are applicable!**

## 2.1 Proper use

The product described

- serves in connection with a suitable PS 6000 weld timer and a welding transformer suitable for the integrated power unit for the
  - Resistance welding of metals

  and
- is suitable for operation in industrial environments (emission class A, group 2) in accordance with the following standards:

- EN 50178
- EN 50081-2
- EN 50082-2
- EN 60204-1

Any other application is deemed improper use!

**DANGER**
**Risk of high-frequency interference!**
**This is a class A resistance welding device.**
**Class A resistance welding equipment is not intended for use in the public low-voltage network supplying, e.g., residential buildings, because it may interfere with other equipment in the environment.**

**For operation in residential environments, in trade and commercial applications and small enterprises, an individual permit of the national authority or test institution is required; in Germany, please contact the Regulierungsbehörde für Telekommunikation und Post (RegTP) or its local branch offices.**

**DANGER**
**The consequences of an improper use include personal damages of the user or of third parties as well as damages to property – the technical equipment, the workpiece to be processed, or environmental hazards.**
**Therefore, our products should only be used for their intended purpose!**

The faultless, safe functioning of the product requires proper transport, storage, erection and installation as well as careful operation.

## 2.2 Installation and retrofit

**CAUTION**
**Observe all precautions for ESD protection when handling modules and components! Avoid electrostatic discharge!**

The following protective measures must be observed for modules and components sensitive to electrostatic discharge (ESD)!

- Personnel responsible for storage, transport, and handling must have training in ESD protection.
- ESD–sensitive components must be stored and transported in the prescribed protective packaging.
- ESD-sensitive components may only be handled at special ESD workplaces.
- Personnel, working surfaces, as well as all equipment and tools which may come into contact with ESD–sensitive components must have the same potential (e.g. by grounding).
- Wear an approved grounding bracelet. The grounding bracelet must be connected with the working surface through a cable with an integrated 1MΩ resistor.
- ESD–sensitive components may by no means come into contact with chargeable objects, including most plastic materials.
- When inserting or removing ESD in/from other devices, the device must be safely disconnected from the supply.

# 3 Structure

## 3.1 General structure of the overall system

The U/I controller is a module in the European double-card format which is plugged into the PSI 6000 series of weld timers. It is closely connected to the weld timer via the internal bus coupling and is capable of exchanging information quickly. A 32-bit controller calculates the control algorithm and processes the communication with the weld timer and with the BQR user interface.

The BQR user interface supplements the BOS 5000 user interface for operating the U/I controller.

As of version 1.17, the BOS 6000 user interface already includes the U/I controller operation.

The BQR user interface for the U/I controller is a separate software program which is installed on PCs. The link to the system is performed via a V24/RS232 connection which is either connected to X3C on the controller card or to interface X1 on the weld timer. This user interface serves to input the controller parameters and display the curve characteristics of the weld.

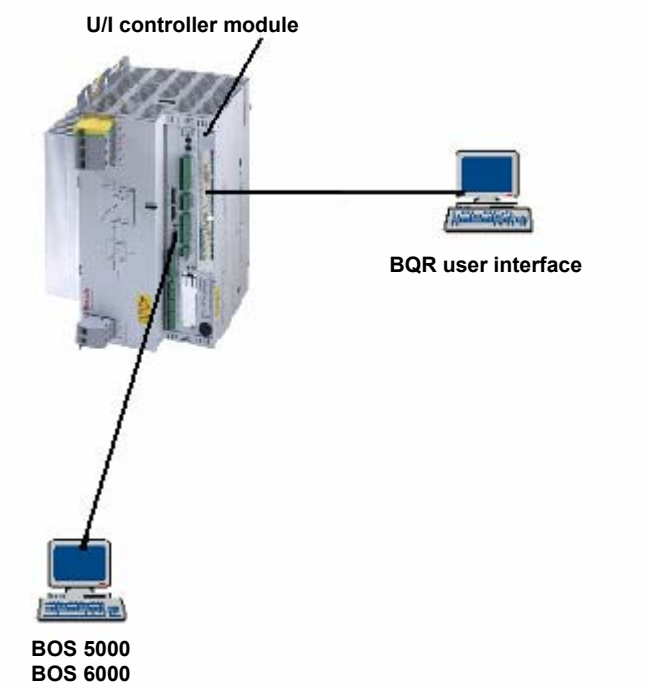
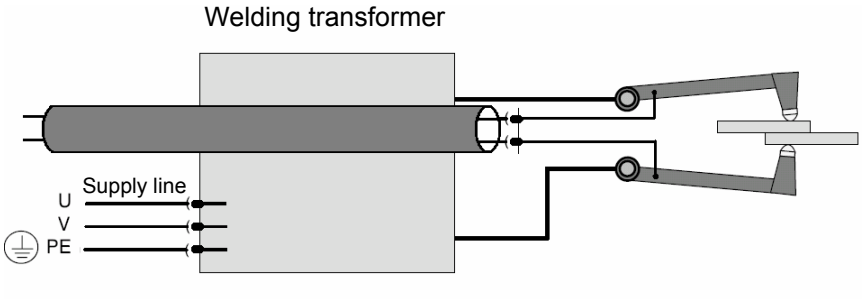
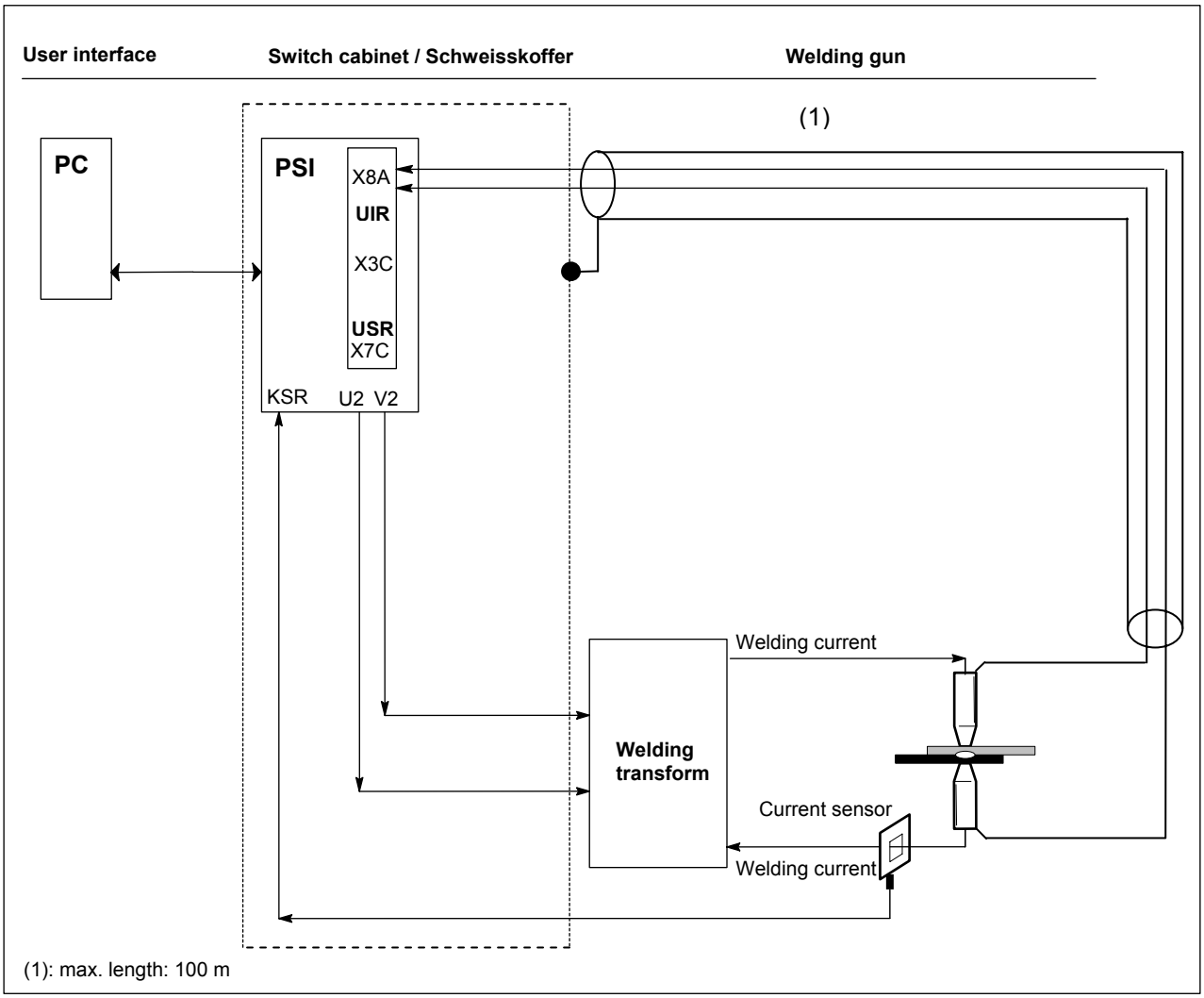



Figure:
BOS user interface of the weld timer at connector X1, BQR user interface for the U/I controller at connector X3C of the controller module

## 3.2 Connection

The electrode power cables must be connected in the closest possible vicinity of the electrodes. They may have electrical contact at the gun arms and must be routed so as to ensure that the gun movement is not obstructed. Voltage tapping must be behind the secondary cable or flexible links (looking towards the electrodes) in order to prevent wear or high temperatures from invalidating the measurement.






Wiring the system

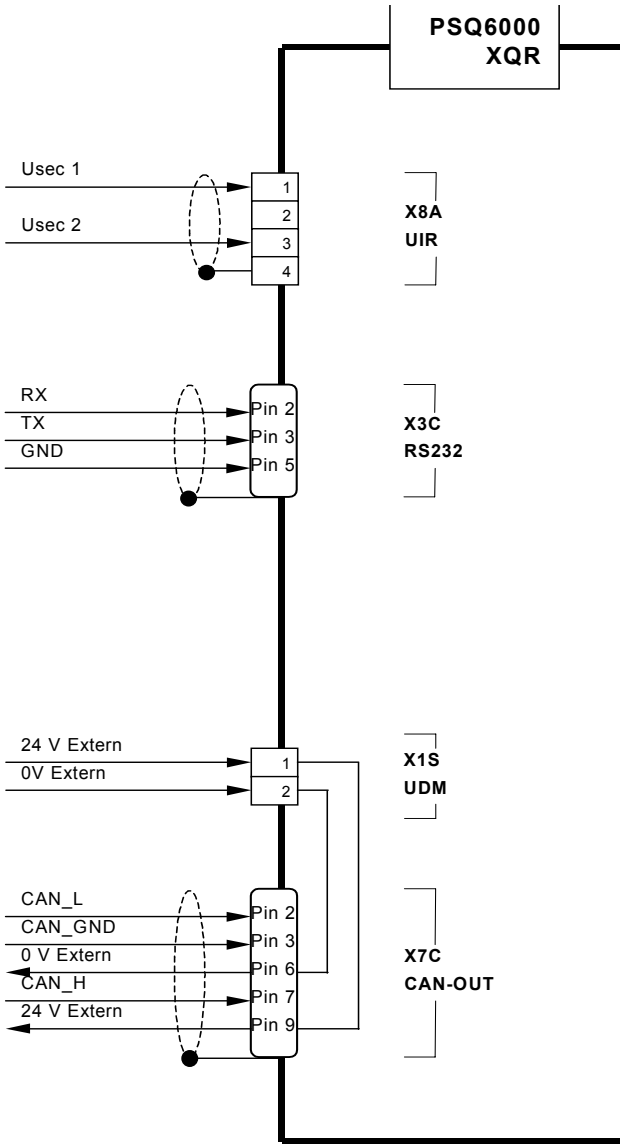
**Cable type for voltage measurement**

Shielded cable 2x0.75 mm², twisted pair,
corresponding to BOSCH part no.:1070 913494:
2x2x0.75 mm², LiYCY; 2 pairs of cores for electrode voltage and current sensor.

The maximum length of 100m must not be substantially exceeded.

Shield connected to ground on one side, preferably at the entrance to the control cabinet/Schweisskoffer.

**Note**
As the voltage measuring input has a low impedance (approx. 500 Ohm), no high-resistance cables, connectors or fuses may be used.




Connector X3C for V24/RS232 on the BQR user interface.

**Note:**
Connectors X7C and X1S are only used for the ultrasonic system.

## 3.3 Control unit integration

The U/I controller has been adapted to the PSI 6000 series of weld timers.
The controller is thus optimized for use with an inverter.

Implementations in the different types of control units require adjustments in the control unit's firmware and possibly in the controller module's firmware. The implementations using other control units from our series are carried out at the customer’s request or for specific projects.

## 3.4 Scope

The U/I controller can be used for the following welding tasks:

Single and multiple impulse welding
With and without slope (current slope)
Pre-heating time (1st WLD), post-heating time (3rd WLD) in KSR mode
The "repeat" operating mode is supported.
The "seam" operating mode is not supported.

**Interfering variables**

Mains voltage fluctuation
Bad fit
Shunt circuits
Different coatings
Adhesives, bad contacting properties
Bad caps
Third sheet
Different sheet thickness
Force changes
Electrode wear

## 3.5 Installation information and assembly

When delivered, the controller module is already installed into the control unit/inverter unit.

In case of retrofitting, the dummy plate has to be removed and the controller module inserted and screwed tight. For this purpose, the supply voltage must be switched off!
Retrofitting involves updating the firmware of the control unit in addition to the mechanical installation of the controller module. The control unit needs this new firmware to be able to address the controller module.

An updated version of the BOS user interface is necessary together with the new firmware because the timer firmware represents a new type of timer.

# 4 Commissioning with BOS6000

Basic knowledge of the operation of the BOS 6000 user interface is required for operating the U/I controller.

The BOS 6000 must have been prepared for operating the weld timer in order to perform all necessary functions, such as
- welding in KSR mode,
- scaling, if necessary, etc.

Then the system can be commissioned step-by-step.

## 4.1 Step 1

**Commissioning of the timer/inverter unit in constant current regulation mode (KSR).**

The functioning of the system in constant current control operation is an essential prerequisite. The U/I controller uses the same mechanisms as the KSR module (constant current regulation). This part of commissioning corresponds to the known procedures for a PSI6000 inverter system, therefore, spot welds can be produced in KSR mode.

For more details, also refer to the PS 6000 manuals on control and I/O level, medium-frequency inverters and welding transformers.

Any required pressure and current scaling are part of this step.

Please refer to the corresponding sections of the manuals.

**Note**
Scaling is not permitted if the U/I controller is active.

## 4.2 Step 2

**Conditions to be met by the gun and the electrodes**

The gun must be in perfect condition. The electrodes must be adjusted so that they are exactly parallel to each other and at right angle to the sheet.

The electrode tips must have been dressed and slightly worked in (approx. 20 - 25 spots). Dressing corrects the contact surface of the electrode caps. This creates ambient conditions which correspond to those of new caps. However, there may also be interference which is caused by dressing. First of all, dressing can create irregularities on the contact surface (e.g. chatter marks). Secondly, the plane of the contact surface may not coincide as well with the joining plane as in the used cap condition.

The squeeze time as well as the hold time must be long enough for the gun to build up the necessary pressure.

We recommend using a force measuring device.

## 4.3 Step 3

**Creating the reference curve**

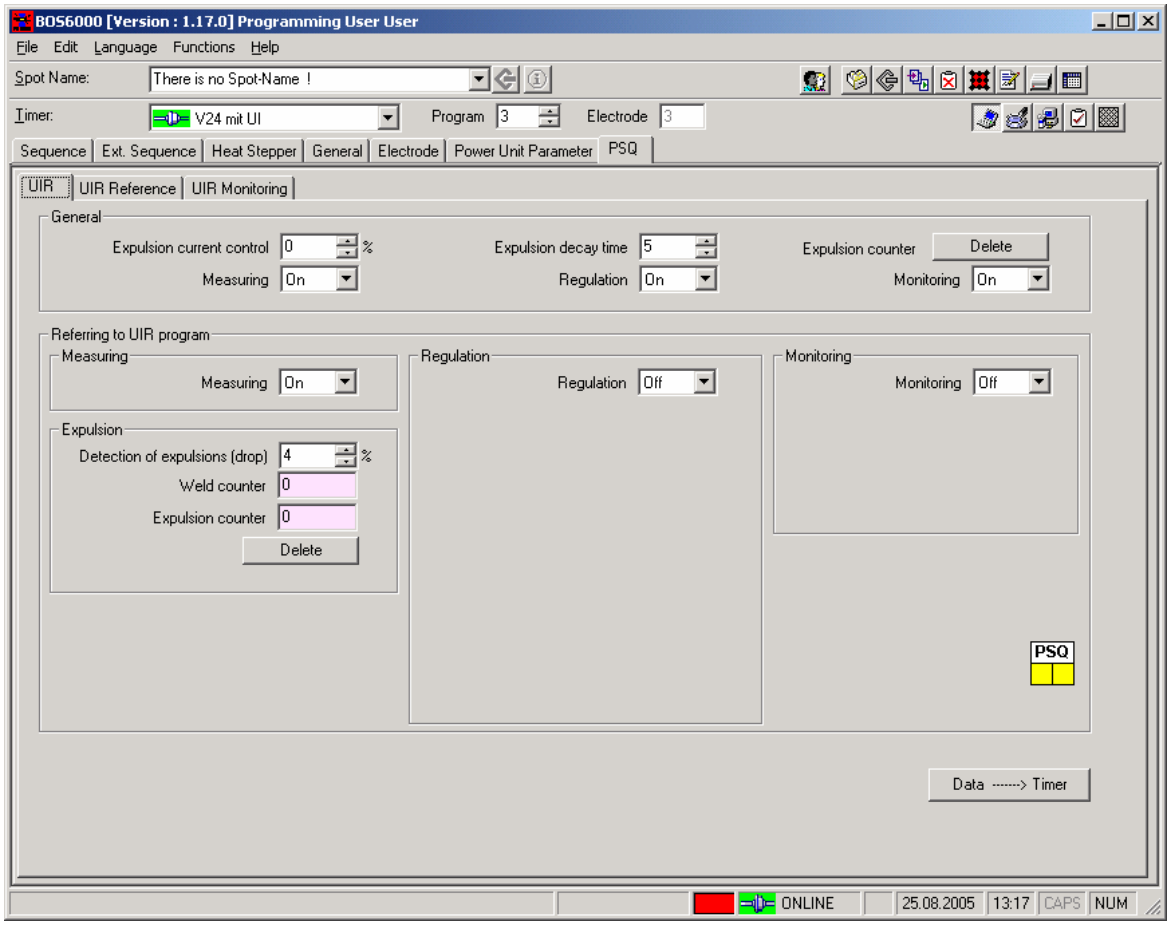
Select the spot weld or the program on the BOS 6000 user interface for the intended welding process.

To create a reference curve, welds are initially made using constant current mode until a sufficient spot size is reached.

| Parameters to be set or checked on the BOS6000 user interface | |
|---|---|
| Squeeze time | Sufficient for the actual welding task |
| Hold time | Sufficient for the actual welding task |
| 1st Weld time | Possibly as a preliminary impulse in KSR mode, refer to Sect. 8.4 |
| 2nd weld time and current | To be set for the actual welding task. Possibly upslope setting for 2nd weld time |
| 3rd weld time | Possibly for post-heating in KSR mode |
| Heat correction | 0% in order to provide for subsequent corrections |
| KSR mode | ON |
| Spot repetition | OFF |
| Monitoring stopped | ON |
| Stepping | Heat values to 100% |

**Programming of PSQ UIR**

| Settings for the U/I controller | |
|---|---|
| General | UIR measuring on |
| Program-specific UIR parameters | UIR measuring on<br>UIR regulation off<br>UIR monitoring off |



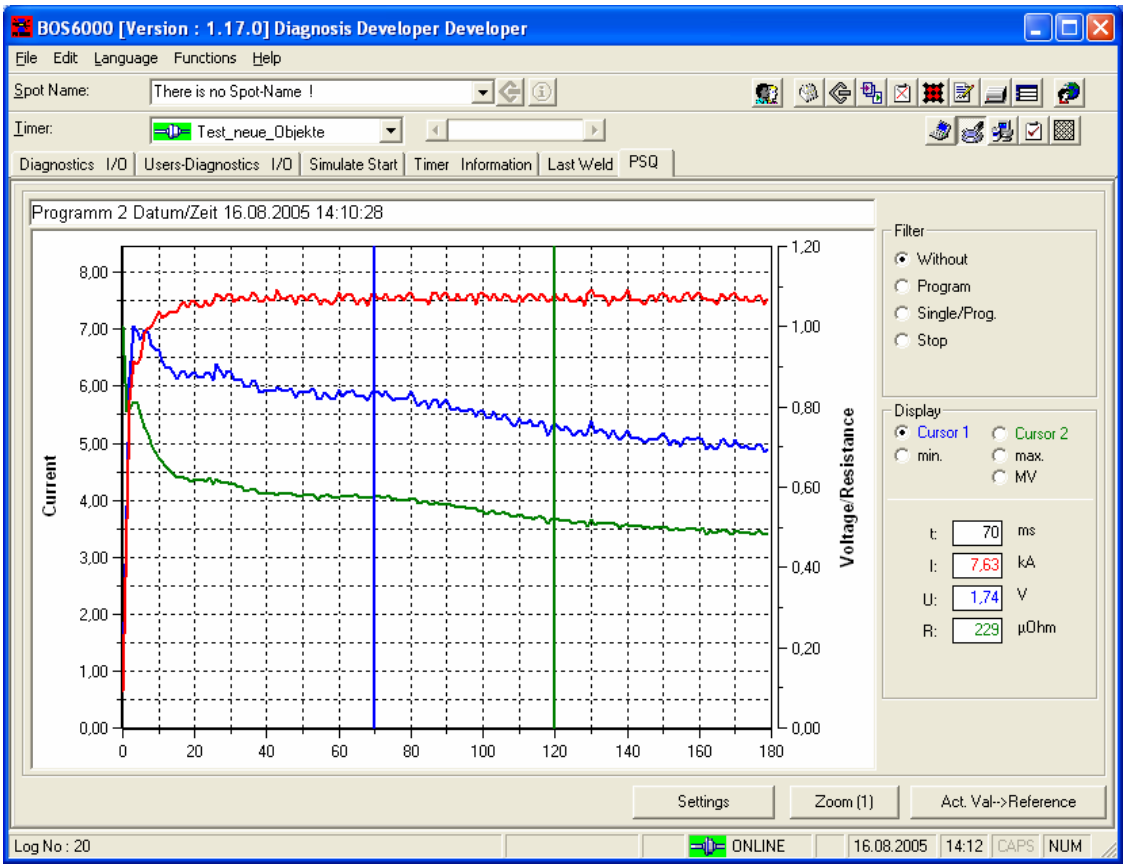

Data → Timer should not be forgotten

**For a detailed description of the operation, please refer to section 5, BOS 6000 with U/I controller**

### Creating the reference curve

The creation of the reference curves is supported in function 
*Diagnostics PSQ*.
Select the *Program* option under *Filter* and enter the program number.
This will start recording the data for this program.

A weld was recorded.

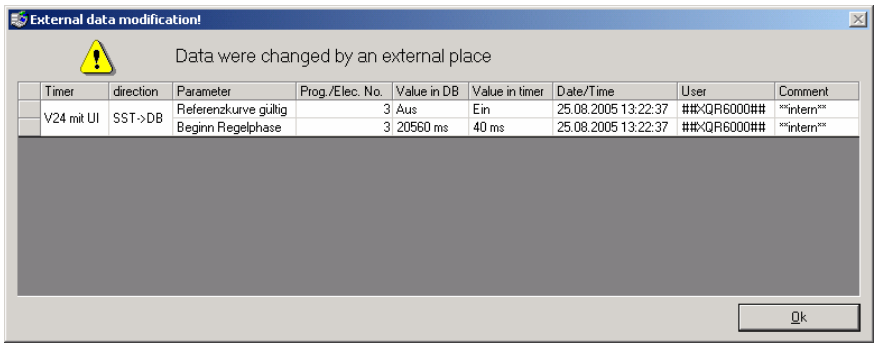



### Accepting the reference curve

Once a weld has been recorded which is to be used for creating the reference curve, data recording is halted by selecting Stop to prevent the curves on the display from being overwritten by a new sequence.

Pressing 

will store the curve currently displayed as the reference curve for this program in the U/I controller. Please enter the program number and confirm the next message by hitting OK.




The reference curve will be valid as soon as the data map performed by BOS6000 afterwards has been completed.

**Notes**

It is recommended to use a separate program for each combination of different sheet thicknesses and to determine separate reference curves. Advantage: when using separate programs, all welding parameters can be optimally set for the welding task in question, the weld time will not become longer than necessary based on the different sheet thicknesses.

However, if a single program is to be used to weld different combinations of sheet thicknesses, the reference curve should be determined using the thinnest sheet combination offering the lowest amount of resistance. For coated sheets, the thinnest sheets with the thickest coating should be used.

In order to determine the reference curves, welding may be carried out on the component. However, if sheet strips are used, the following is to be noted:
- The curve of the first spot on a sheet must not be used as reference curve.
- The spots must be welded at a distance of approx. 20mm (shunt circuit).

If the spot diameter is not sufficient, the current must be increased from one spot to the next up to the expulsion limit.
If expulsion occurs, the current must be reduced to the last value without expulsion and the weld must be repeated.
Afterwards, the sequence can be stored as reference curve, provided that the quality of the weld is satisfactory. For this purpose, for example, the spot diameter has to be measured.

The quality of the weld cannot be determined by an interpretation of the curve characteristics. Controlling the curve characteristics must be limited to the following assessment:

- Resistance characteristic: typical characteristic showing a strong decline in resistance at the beginning (when making contact) and a continuous decline in resistance towards the end.
- Voltage signal: whether a voltage signal is present and whether its characteristic is similar to that of the resistance.

Expulsion can also be detected by a sudden downward slope of the resistance characteristic.

See also Section 8.

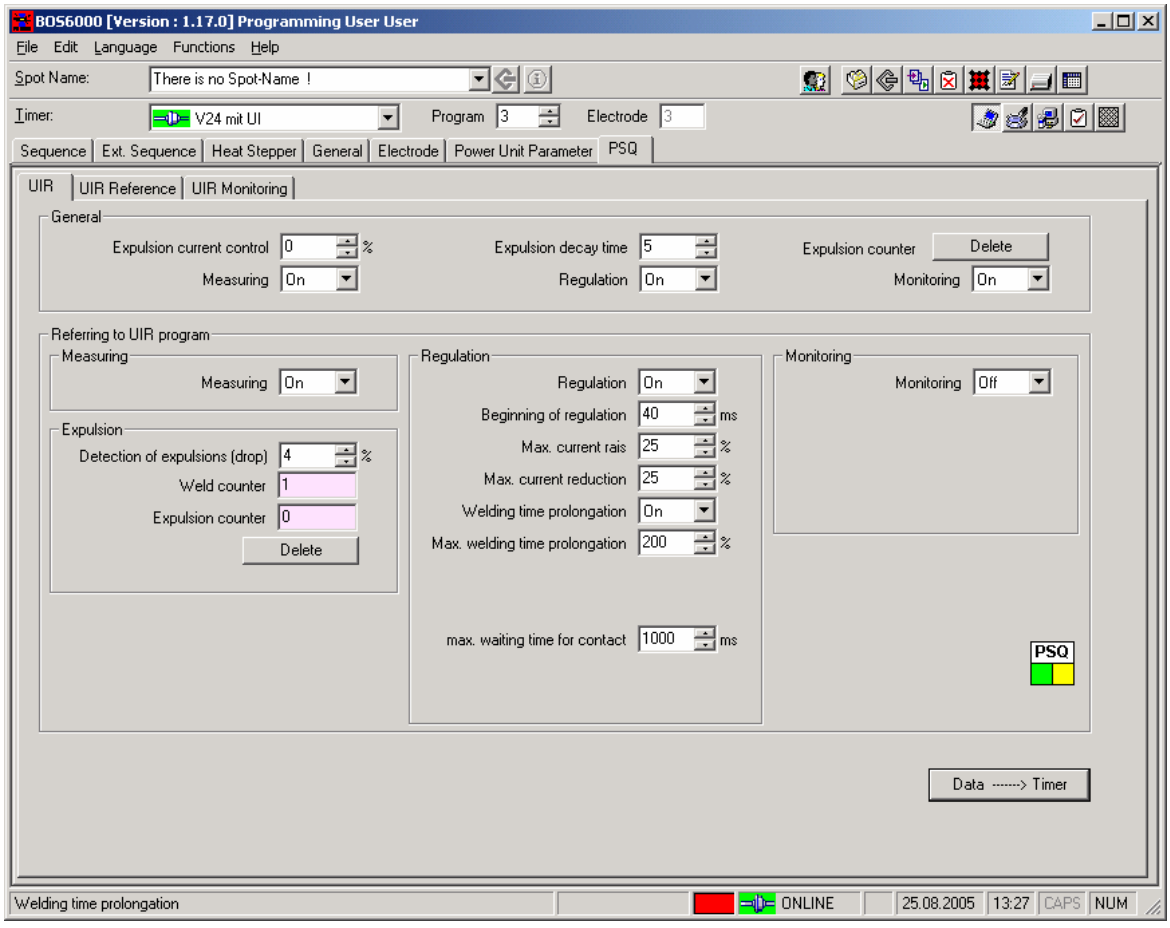
The cap wear condition should be between 10 and 100 welds.

## 4.4 Step 4

**Activating the controller for this program:**

Use option  Programming PSQ UIR

| Settings for the U/I controller | |
|---|---|
| General | UIR regulation on |
| Program-specific UIR parameters | UIR regulation on |




**WLD prolongation**

Activating *Welding time* prolongation will allow the U/I controller to prolong the weld time for this program.
The *maximum welding time prolongation* limits the prolonged weld time required by the U/I controller in order to compensate interfering variables.
In automatic mode, extremely long weld times may be undesirable.
If this time is exceeded, a fault message is output
”Maximum weld time reached”.

**Note**
The *General* section may be used to deactivate measuring, monitoring and regulation for all programs of the weld timer.

Steps 2 to 4 should be repeated for every spot weld which is to be made with U/I control.

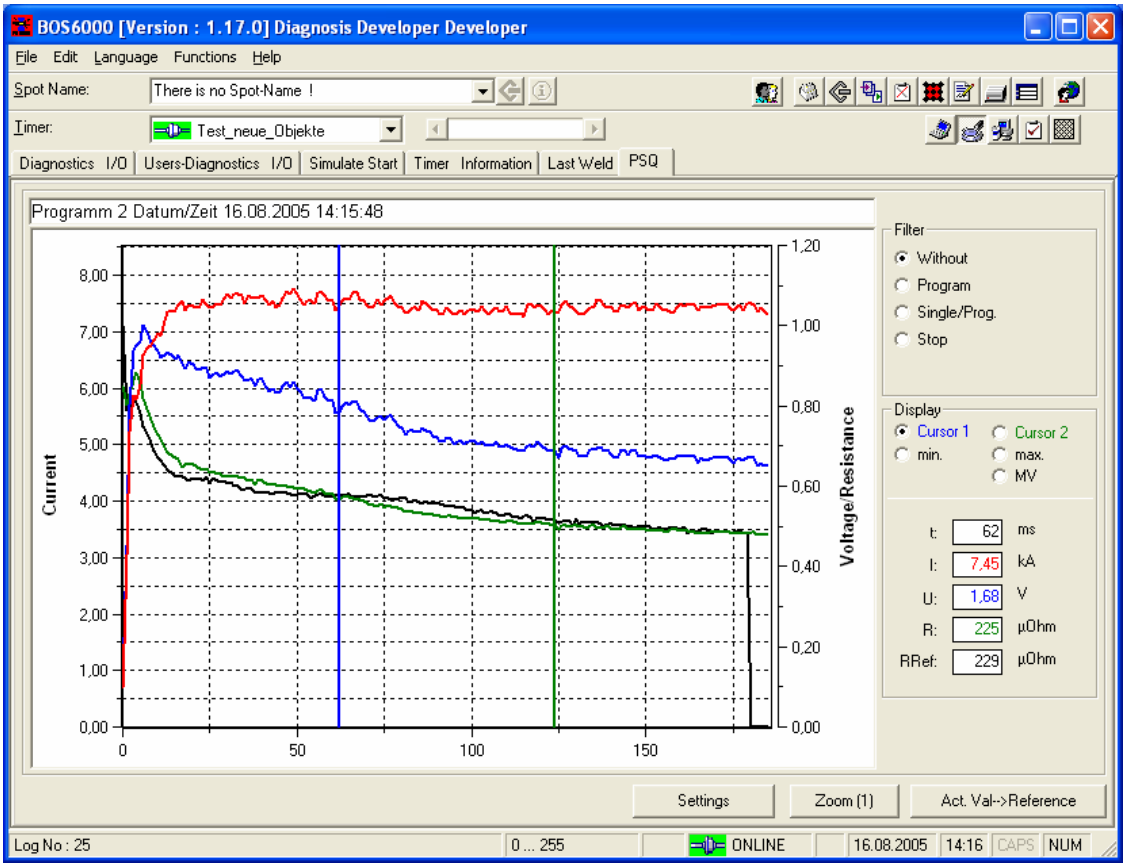
The creation of reference curves has now been completed.

Afterwards, the reference curve can be corrected - increased/decreased - using the Heat correction function of BOS 6000 only. The weld time and the amount of current can no longer be changed because they are now controlled by the U/I controller.

For this reason, when activating current monitoring at BOS 6000, it must be ensured that the tolerance bands are wide enough for the U/I controller to respond accordingly without reporting errors.

For a description of monitoring with tolerances, refer to section 5.7.

The curve characteristics of the current weld can be displayed in  *Diagnostics PSQ*.




Visualization of the curve characteristics

**For a detailed description of the operation, please refer to section 5, BOS 6000 with U/I controller**

# 5 BOS 6000 with U/I controller

## 5.1 Preconditions

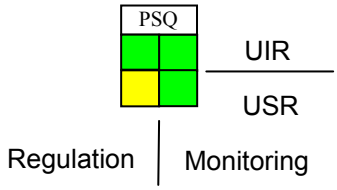
BOS6000 user interface version 1.17 or above

**Note**

For the general operation and set-up procedures, please refer to the BOS6000 online help function.

## 5.2 PSQ status display

On some screens, the PSQ status display informs about the status of U/I regulation and monitoring and, if equipped accordingly, about US regulation and monitoring.




Green: Active
Yellow: Inactive

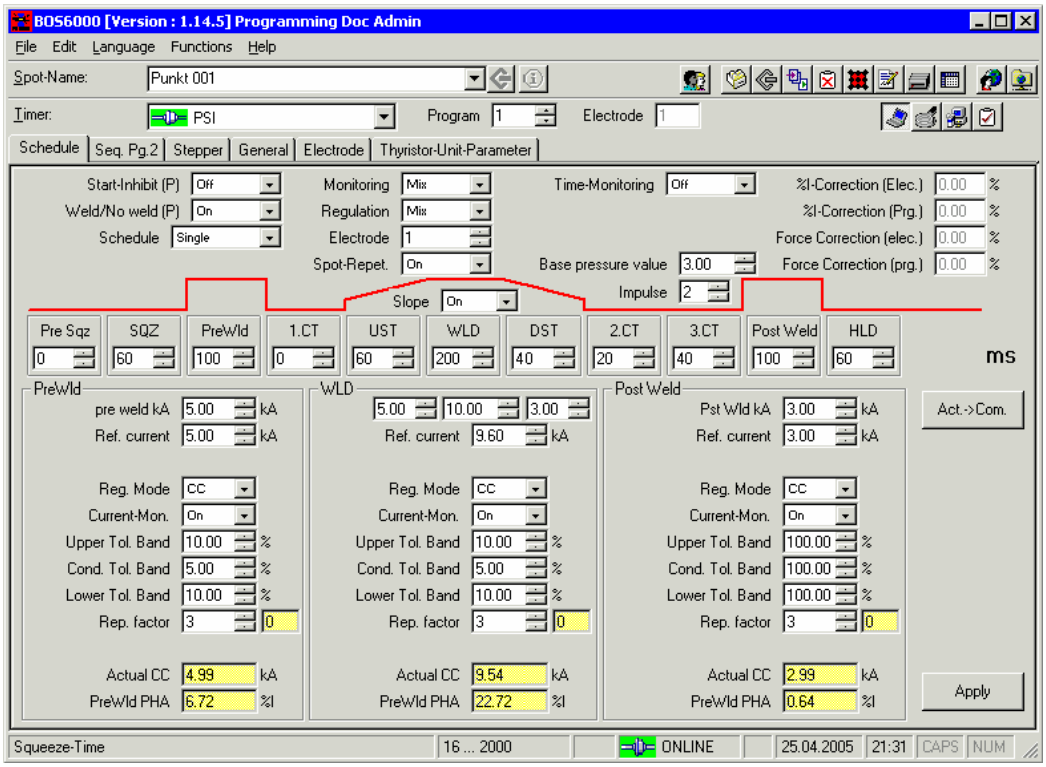
## 5.3 Overview of the U/I operating functions

| Programming of PSQ | |
|---|---|
| UIR | Parameter settings for the U/I controller |
| UIR Reference | Display/read/store actual and reference curves |
| UIR Monitoring | Monitoring and historical values |

| Diagnostics | |
|---|---|
| Last sequence | Actual values of the last welding sequence |
| PSQ | Current curve characteristic |

# 5.4 Programming of sequence

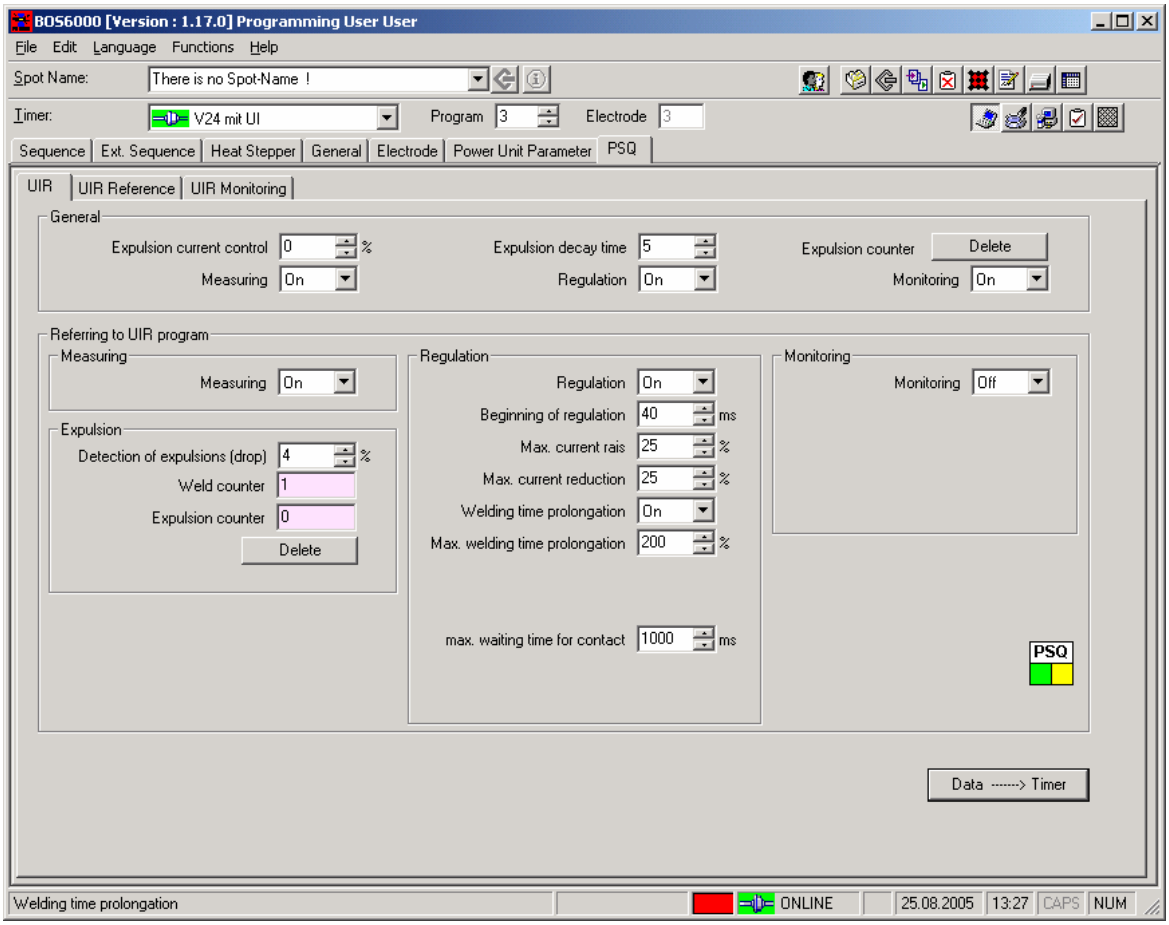
In order to prepare the timer for U/I control mode, all basic settings must be programmed for a welding program.




**Note**

If the U/I control and monitoring functions are active, certain parameters/functions may be dimmed or illegible in Programming-Sequence because they are not needed for the selected mode.

# 5.5 Programming of PSQ - UIR




## General: Global UIR parameters

These parameters apply to all electrodes and programs assigned to the weld timer.

A global activation of *measuring, regulation* and *monitoring* for the entire weld timer is available here.
In order to use these functions, they must be activated for the respective program in option *Referring to UIR program*.
Refer to section 5.5, *Program-specific UIR parameters* Measurement, control and monitoring.

### Expulsion detection

#### Expulsion current change

This parameter is used to determine how the controller responds to expulsion. The controller changes the current at the time of expulsion by the programmed percentage. The value with a positive sign effects a current increase, the value with a negative sign a current reduction.

### Expulsion counter

Pressing *Delete* will reset the expulsion counter and the weld counter for all programs.

For more information on expulsion, refer to *Program-specific UIR parameters - expulsion* in section 8.2.

## Program-specific UIR parameters

### Measuring

*Measuring* will turn U/I measurement on/off.
An electrode voltage cable must be connected to the gun in order to use the voltage measurement function. U/I measurement must also be activated in *General* to use it at this point.

### Regulation

#### Regulation

Turns the U/I controller on/off for the selected program.

The following preconditions must be fulfilled to activate the U/I controller:

- Measuring must be activated in *General* and in *Referring to UIR program*.
- U/I regulation must have been activated in *General*
- the reference curve of the selected program must have been stored and the corresponding parameters set

#### Beginning of regulation

This value is automatically calculated when creating the reference curve.

Changing this value may affect the efficiency of the U/I controller!
Therefore, you should not change this value without good reason.

#### Max. current raise

The *Maximum current raise* parameter allows the U/I controller to raise the current by the specified percentage compared to the reference current when balancing interfering variables.

#### Max. current reduction

The *Maximum current reduction* parameter allows the U/I controller to reduce the current by the specified percentage compared to the reference current when balancing interfering variables.

**CAUTION**

Changing these limit values may affect the efficiency of the U/I controller in the event of interfering variables!
Therefore, you should not change this value without good reason.

### Welding time prolongation

Activating *Welding time* prolongation will allow the U/I controller to prolong the weld time for this program.
The *maximum welding time prolongation* limits the prolonged weld time required by the U/I controller in order to compensate interfering variables. In automatic mode, extremely long weld times may be undesirable.
If this time is exceeded, a fault message is output
”Maximum weld time reached”.

Example:
A welding time prolongation of 100% will allow the U/I controller to maximally double the programmed weld time, if necessary.

## Monitoring

*Monitoring* will turn the monitoring function of the U/I controller on/off.
Refer to section 5.7, *UIR monitoring*

## Expulsion

### Detection of expulsions (drop)

Has been assigned a default value. Should not be changed unless specifically requested.

### Weld counter

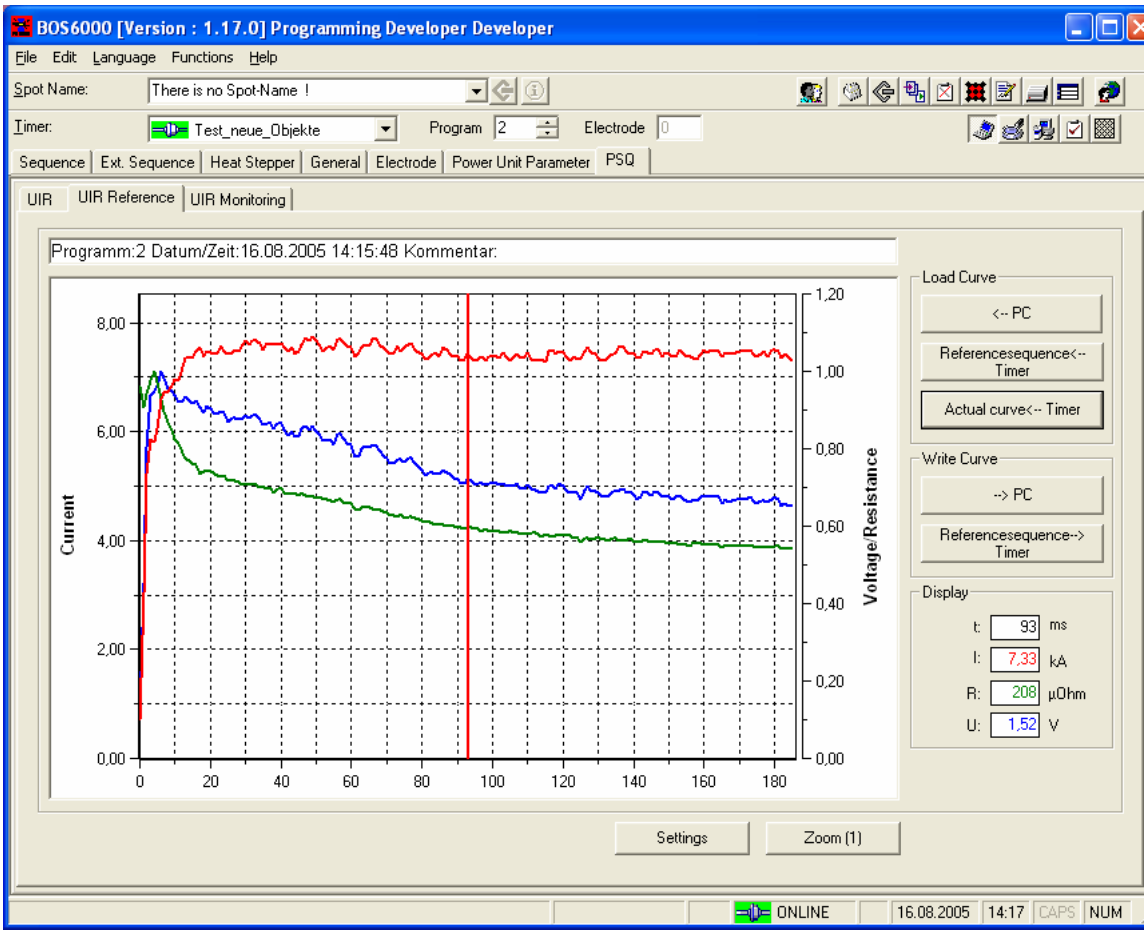
The weld counter shows the current number of welds (since deletion of the weld counter) for the selected program.

### Expulsion counter

If the system detects expulsion, the expulsion counter is incremented. The frequency of expulsions can thus be compared to the weld counter.

Pressing *Delete* will reset the expulsion counter and the weld counter for the selected program.

# 5.6 Programming of PSQ - UIR reference




Display showing the characteristics of the current, voltage and resistance of the selected curve in a diagram. Including the possibility to read and store actual and reference curves.

## Load curve

### ← PC

Retrieves a curve stored in the PC to the display. A window is displayed for selecting the file.
The filename extension is *rui*.

### Reference sequence ← Timer

Retrieves the reference curve for this program from the weld timer to the display.
Condition: a reference curve has been stored for this program in the weld timer.

### Actual curve ← Timer

Retrieves the actual curve of the last sequence from the weld timer to the display, regardless of the program that was last executed. The relevant program data, such as number and date/time, are displayed in the diagram header.

Condition: U/I measuring has been activated globally and for this program, and the weld timer has performed a welding sequence.

## Write curve

### → PC

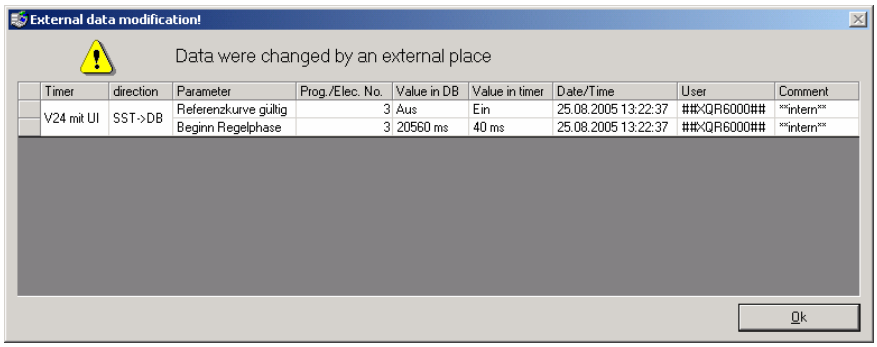
Stores the curve on the display in the PC. A window is displayed for selecting the folder and file name.
The filename extension is *rui*.

### Reference sequence → Timer

Stores the curve displayed for this program as reference curve in the weld timer.
An existing reference curve will be replaced.

Therefore, you should not use this function without good reason.

Please confirm the next message by hitting OK.




The reference curve will be valid as soon as the data map performed by BOS6000 afterwards has been completed.

## Settings

This option is provided for the color settings of the background, grid, letters, channel and cursor in this window.

## Zoom

Zoom function of the x axis for magnifying the curves displayed 2, 5 and 10 times.
Furthermore, the x and y axis can be shifted in order to view a certain magnified section by holding down the left mouse button when the cursor shape changes to a hand.

## Display

Displays the curve values at the movable cursor line:

t Point of time on curve
I Current at the cursor position
R Resistance at the cursor position
U Voltage at the cursor position

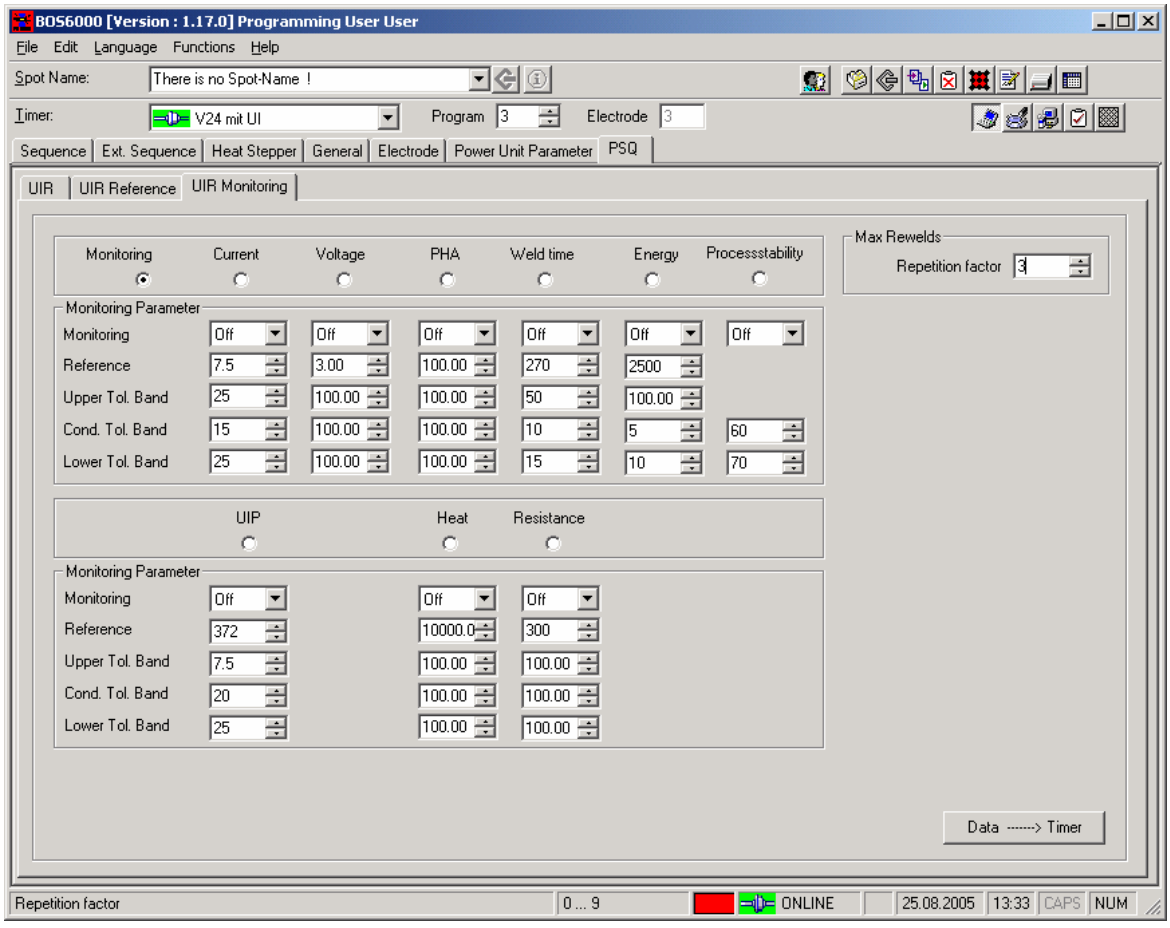
# 5.7 Programming of PSQ - UIR Monitoring

Monitoring can be activated separately for each of the parameters to be monitored for optimum adjustment to the welding task and monitoring its quality. Depending on the welding task, it may be useful to monitor different quantities.

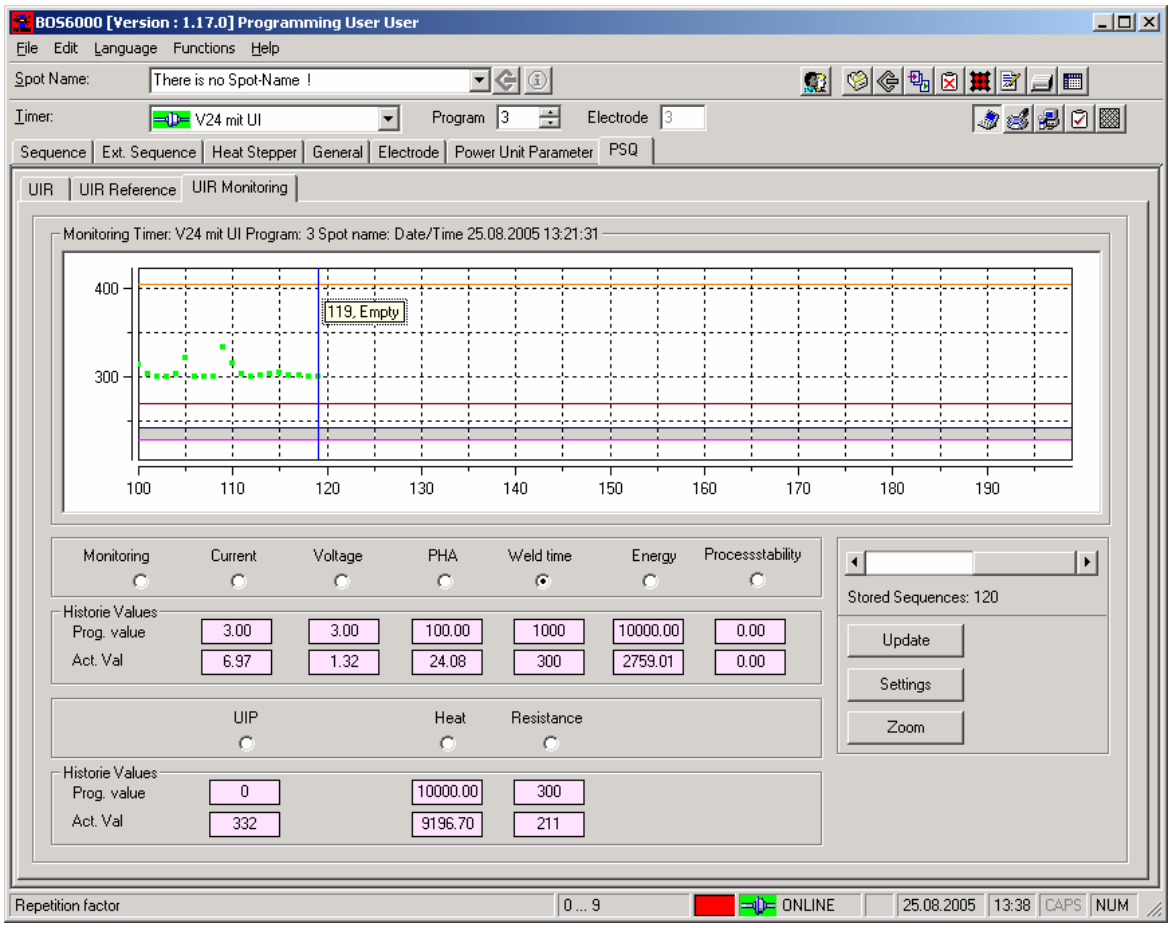
The monitoring result is displayed and logged by BOS6000 and can be used for evaluation such as the Statistical Process Control (SPC).

The *UIR Monitoring* window is subdivided into two major areas:

1.) The *Monitoring* radio button has been activated → programming the monitoring function with tolerance bands, etc.



2.) The radio button of a monitored parameter has been activated → the characteristic of the monitored quantity is displayed including tolerance bands, etc.




## Programming monitoring

Here, monitoring can be turned on/off separately for each parameter to be monitored..

The *Reference* parameters serve as command values for monitoring the individual parameters and quantities.

The weld timer compares the measured actual values (shown in the *Act Val.* fields) with these programmed values and interprets them

• as “good“ or “bad“, taking the *Upper Tolerance Band* and *Lower Tolerance Band* parameters into account.

• for a continuous decrease based on the parameters *Conditional Tolerance Band* and *Repetition factor*.

Unacceptable actual values result in a warning or fault message if the relevant monitoring function has been activated.

## Upper tolerance band

Specifies the maximum permitted positive tolerance as a % value of the reference value.

Actual values above this tolerance limit generate the message type ”… too large”.

## Lower tolerance band

Specifies the maximum permitted lower tolerance as a % value of the reference value.

Actual values below this tolerance limit generate the message type "... too low” or “no … detected”

## Conditional tolerance band

Input as a percentage of the reference value. Must be less than parameter

Lower tolerance band.

This parameter is used in connection with the *Repetition factor* in order to determine “creeping” faults of the system that cause a gradual yet continuous “decline” in actual values.

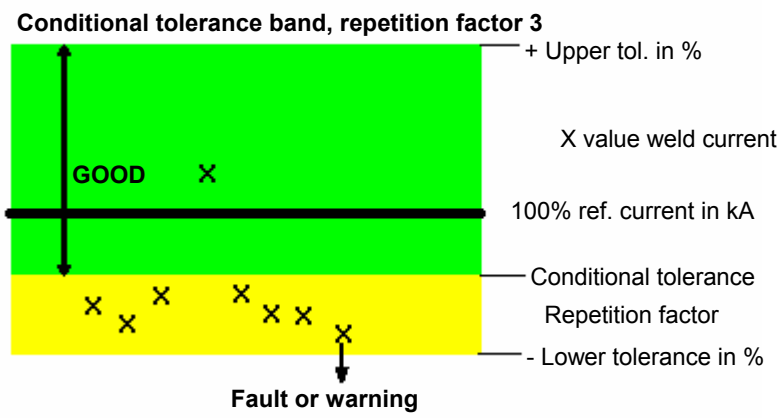
Together with the *Lower tolerance band*, it defines a range of values in the lower section of monitoring.

## Repetition factor

The *Repetition factor* determines the number of consecutive welds that may be within the conditional tolerance band.

If this value is exceeded, a message of the following type will be output by the timer

“Repetition fault … “.




**Note**

The counter of the repetition factor is incremented regardless of the monitored quantity that is in the conditional tolerance band. The repetition counter will be reset after a faultless weld.

# Display of the characteristic

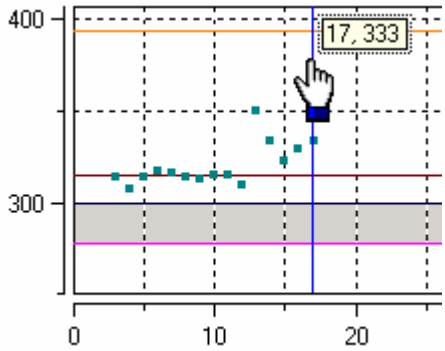
This display shows the characteristic of the value measured for a monitored parameter of a program.

One of the monitoring parameters available is selected by activating a radio button. The *Monitoring* radio button returns to programming of the tolerances.

The last 100 welds are shown in the chart as a default. If a higher number of welds exists in the log memory, the display can be browsed forward and backward. Refer to *Welding sequences stored.*
Use the *Zoom* function to display the last 200, 500 or 1000 welds in the chart. Refer to *Zoom*.

The currently valid reference value and the currently valid tolerance bands are represented as lines.

In order to view the monitoring values of a specific weld, the cursor line can be moved with the mouse when the cursor symbol changes to a hand. The programmed and actual values of the selected sequence are

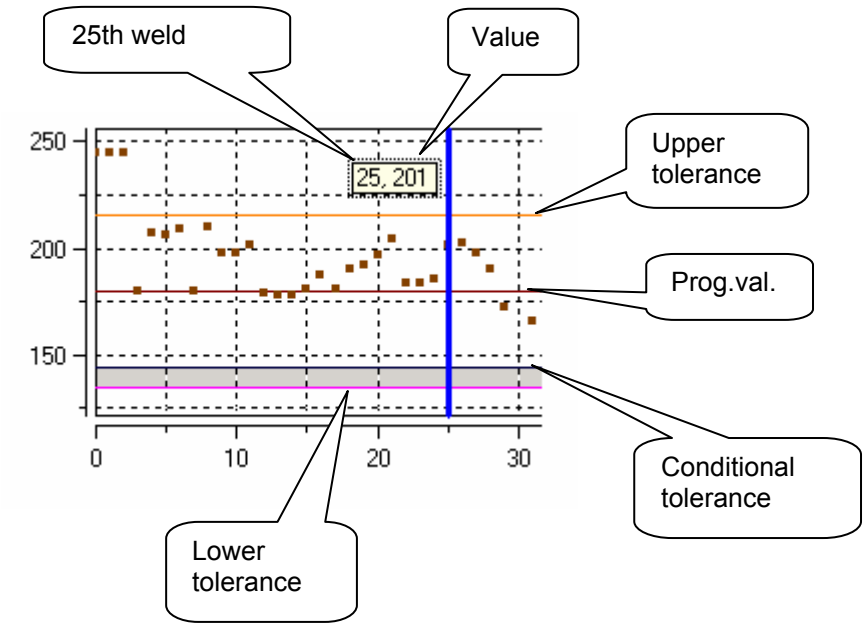



additionally displayed in the parameter fields. Furthermore, the spot name, its date and time are shown at the upper border of the chart.

**Display of the programmed and command values in field “Historie values”**

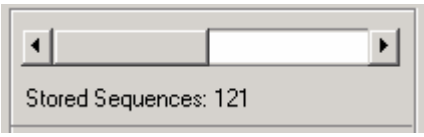
- Mean programmed current and actual current
- Mean programmed and actual value of the electrode voltage
- PHA: Mean programmed and actual value of the pulse width (phase angle)
- Programmed and actual value of the weld time
- Programmed and actual value of the energy
- Process stability: The programmed value is always 100%. The actual value is composed of several physical quantities, each providing meaningful information about the process by returning a number. This number corresponds to the process status compared to the stable initial situation.
- UIP: Programmed and actual value of the quality factor. The UIP is composed of several physical quantities, each providing meaningful information about the quality by returning a number. This parameter provides a welding quality assessment based on the measured curve characteristics.

- Programmed and actual value of the heat
- Mean programmed and actual value of the resistance.




## Stored sequences

100 welds are shown in the chart as a default. If a higher number of welds exists in the log memory, the display can be browsed forward and backward. Refer to *Zoom*.




The number of stored welds will be displayed.

## Update

Refreshes the display so that the last welds performed are also represented in the chart.

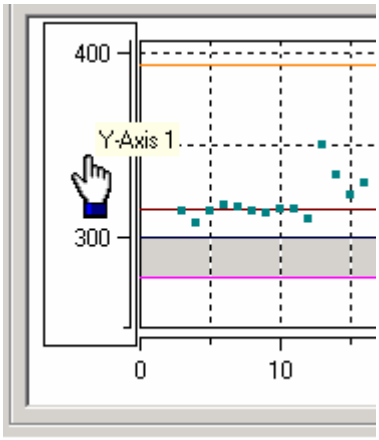
## Settings

This option is provided for the color settings of the background, grid, letters, channel and cursor in this window.

## Zoom

Use the Zoom function to display the last 200, 500 or 1000 welds in the chart.

Furthermore, the x and y axis can be shifted in order to view a certain section by holding down the left mouse button when the cursor shape changes to a hand.




## Notes on monitoring

### Current

The smallest possible tolerance used for the KSR controller does not make sense here because the U/I controller must change the current in order to balance interfering variables. The “max. current raise/reduction” limit values must be noted in this case which specify the compensation limits to the controller.

### PHA (pulse width)

Again, close tolerance limits do not make sense because the pulse width is changed in order to achieve a higher/lower current.

### Weld time

The lower tolerance (weld time too short) may be small because the weld time will not be shorter than the reference weld time. An exception is a termination of weld as a result of the “No current” fault, or an external weld time termination. A weld time prolongation may be necessary, depending on the type and size of the influencing variables. For this reason, the “Upper tolerance” should be defined large enough so as to ensure that no message is output even if the weld time is prolonged during operation.

### Energy

Since the weld time is part of the energy balance sheet, the lower tolerance (energy too low) can be defined within close limits because the energy applied will not drop below the energy for the reference weld. An

exception is a termination of weld as a result of the “No current” fault, or an external weld time termination. Increasing the energy may be necessary, depending on the type and size of the influencing variables. For this reason, the “Upper tolerance” should be defined large enough so as to ensure that no message is output even if the energy is increased during operation.

## Process stability

In order to determine the stability of the process, a process map is calculated from the signal characteristics.

A process stability value of 100 means full consistency with the process of the reference weld, and thus a stable process.

A 30% tolerance band means that a 30% deviation from a stable process is still acceptable, i.e. the process matches the process of the reference weld by 70%.

If influencing variables have to be compensated by a weld time prolongation, this process change is reflected by a negative trend of the process stability value. At the same time, the weld time monitoring parameter shows a higher value.

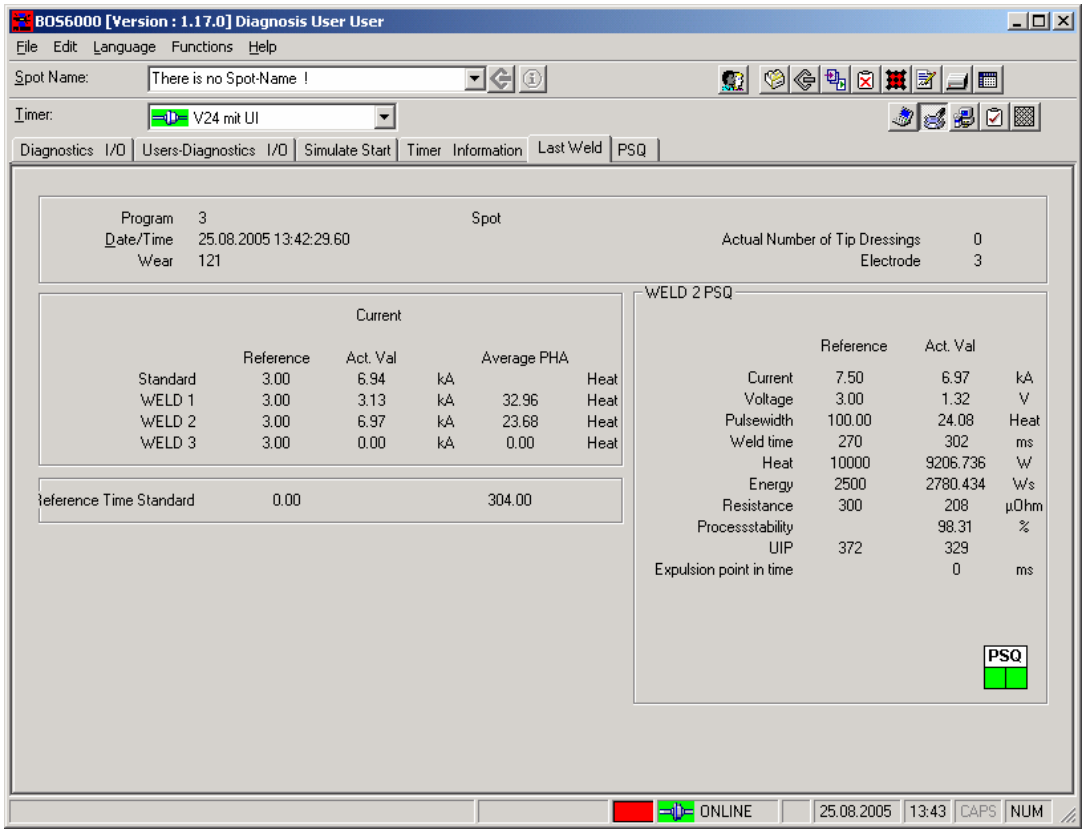
In KSR/PHA mode, the process stability is displayed as 0.

## UIP (process quality)

The UIP quality value provides a welding quality assessment based on the measured curve characteristics. A cold weld results in a low UIP value, a hot weld in a high UIP value. For this reason, the highest possible UIP value should be striven for, however, this will become closer to the expulsion limit. The UIP value from the reference weld is probably the optimal reference for monitoring because it has been derived from an optimal weld.

# 5.8 Diagnostics - Last weld

Using  Diagnostics *Last weld*, you can display the measured values of the last welding sequence actually performed. The display will be refreshed by every new sequence. The values are also stored in the logbook memory and can be tracked later weld by weld using *Programming-UIR Monitoring*.




The following information will be displayed for the relevant weld timer:

- welding program that was started last and spot name
- Date and time of the last weld
- Wear counter status of the electrode in question
- Actual number of tip dressings of the electrode in question
- Reference current and actual current, separately for each WLD, or as an average value for all WLD in *Standard* line.
- Reference time and time actually needed
- the necessary phase value, separately for each WLD

**PSQ values from the U/I controller for 2.WLD**

- Reference current and actual current
- Electrode voltage reference and actual values
- Pulse width (phase angle) reference and actual values
- Weld time reference and actual values
- Heat reference and actual values
- Energy reference and actual values
- Resistance reference and actual values
- Process stability actual value
- Reference and actual values of the UIP quality factor
- Expulsion point in time

**Note**

Slightly different values displayed for Average PHA, current and weld time between *2.WLD* and *2.WLD PSQ* result from the fact that the current controller only measures the weld time without trail current.

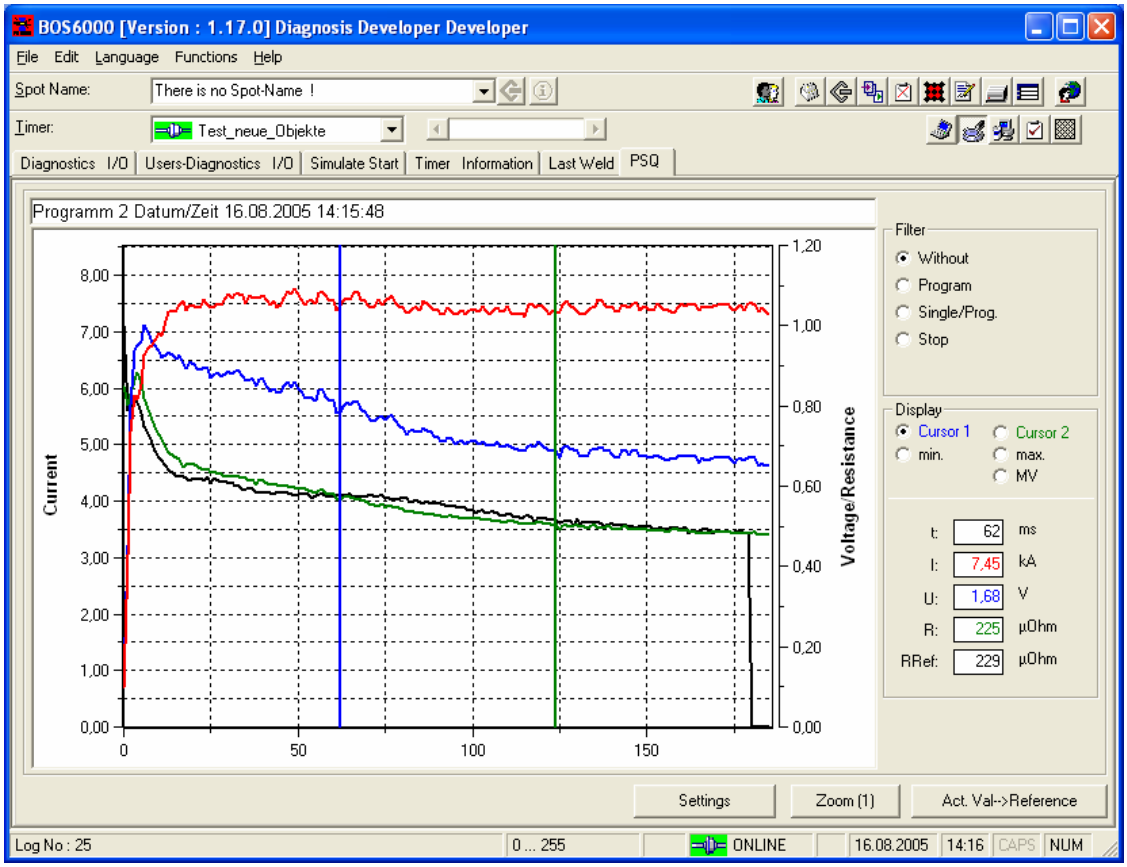
**Note**

The reference value is the value specified in UIR Monitoring. The U/I Monitoring function compares the actual value to this reference value, taking the programmed tolerances into account, and infers warnings or fault messages from this comparison.

Condition: U/I measuring has been activated globally and for this program, and the weld timer has performed a welding sequence.

# 5.9 Diagnostics - PSQ

Using  Diagnostics *PSQ*, you can display the curve characteristics of the last welding sequence actually performed. The creation of the reference curves is supported by the *Filter* function.
Condition: U/I measuring has been activated globally and for this program, and the weld timer has performed a welding sequence.




The program data pertaining to the displayed curves, such as number and date/time, are displayed in the diagram header.

The temporal characteristic of current, voltage and resistance is shown. There is a possibility of storing the actual curve as the reference curve.

## Filter

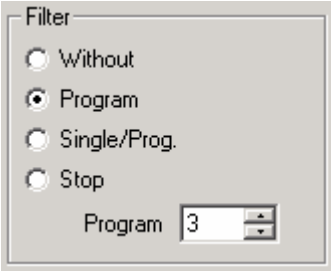
### Without

Retrieves the actual curve of the last sequence from the weld timer to the display, regardless of the program that was last executed. The display is refreshed by each welding sequence.

### Program

If the *Program* option has been selected, a program number can be chosen. This starts the data display for this program only which is

refreshed whenever the program is executed.
In automatic systems, a specific program can be monitored in this way.




### Single/Prog.

If the *Single/Prog* option has been selected, a program number can be specified. This starts the data display for this specific program, and a single execution of this program is recorded.
In order to restart the data display, you have to select *Stop* and then *Single/Prog* again.

In automatic systems, this function prevents the curves displayed from being overwritten by a new sequence.

### Stop

This will stop the data display until it is enabled again by one of the other filter functions.

In automatic systems, this function prevents the curves displayed from being overwritten by a new sequence.

This may be necessary, for example, when storing the reference curve using Actual curve → Ref. curve.

## Display

Displays the curve values at the movable cursor line:

| | |
|---|---|
| t | Point of time on curve |
| I | Current at the cursor position |
| U | Voltage at the cursor position |
| R | Resistance at the cursor position |
| Rref | Resistance of the reference curve at the cursor position |

### Cursor 1

Cursor 1 is active as a default. That means, the curve values are displayed at the position of cursor 1.

### Cursor 2

If cursor 2 is selected, the curve values are displayed at the position of cursor 2.

### Min.

If this radio button is selected, the lowest value between the two cursors is displayed.

### Max.

If this radio button is selected, the highest value between the two cursors is displayed.

### Solenoid

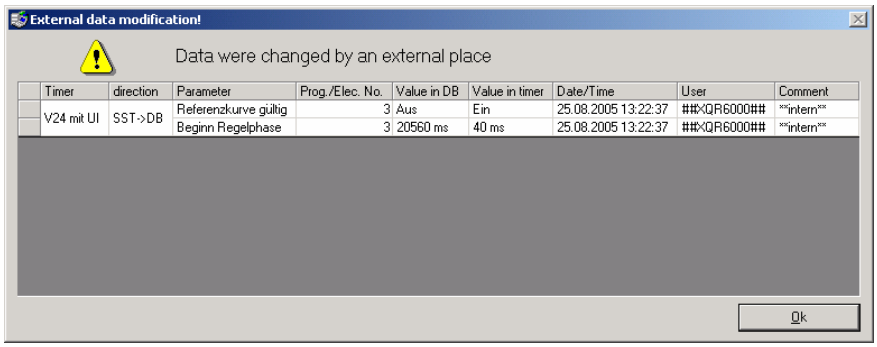
If this radio button is selected, the mean value between the two cursors is displayed.

## Actual curve → Ref. curve

Once a weld has been recorded which is to be used for creating the reference curve, data recording can be halted by selecting *Stop* to prevent the curves on the display from being overwritten by a new sequence.

Pressing 

will store the curve currently displayed as the reference curve in the U/I controller. Please enter the program number and confirm the next message by hitting OK.




The reference curve will be valid as soon as the subsequent data match has been completed.

## Settings

This option is provided for the color settings of the background, grid, letters, channel and cursor in this window.

## Zoom

Zoom function (magnification) of the time axis of the curves displayed: 2, 5 and 10 times.
Furthermore, the x and y axis can be shifted in order to view a certain magnified section by holding down the left mouse button when the cursor shape changes to a hand.

# 6 Commissioning with BQR

Following the installation of all components, the system can be commissioned step by step.

## 6.1 Step 1

**Commissioning of the timer/inverter unit in constant current regulation mode (KSR).**

The functioning of the system in constant current control operation is an essential prerequisite. The U/I controller uses the same mechanisms as the KSR module (constant current regulation). This part of commissioning corresponds to the known procedures for a PSI6000 inverter system, therefore, spot welds can be produced in KSR mode.

For more details, also refer to the PS 6000 manuals on control and I/O level, medium-frequency inverters and welding transformers.

Any required pressure and current scaling are part of this step.

Please refer to the corresponding sections of the manuals.

**Note**
Scaling is not permitted if the U/I controller is active.

## 6.2 Step 2

**Conditions to be met by the gun and the electrodes**

The gun must be in perfect condition. The electrodes must be adjusted so that they are exactly parallel to each other and at right angle to the sheet.

The electrode tips must have been dressed and slightly worked in (approx. 20 - 25 spots). Dressing corrects the contact surface of the electrode caps. This creates ambient conditions which correspond to those of new caps. However, there may also be interference which is caused by dressing. First of all, dressing can create irregularities on the contact surface (e.g. chatter marks). Secondly, the plane of the contact surface may not coincide as well with the joining plane as in the used cap condition.

The squeeze time as well as the hold time must be long enough for the gun to build up the necessary pressure.

We recommend using a force measuring device.

## 6.3 Step 3

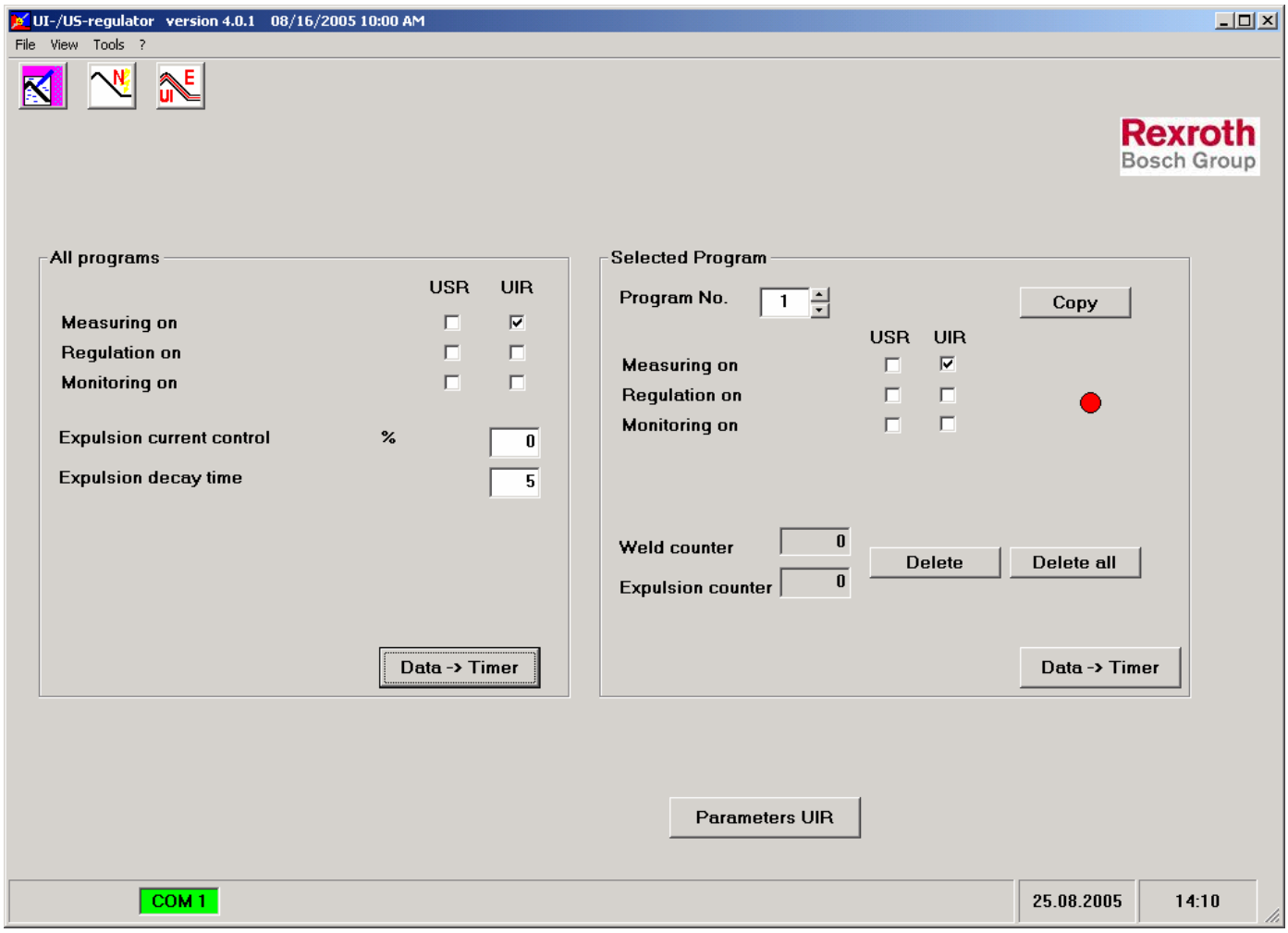
**Creating the reference curve**

Select the program on the BOS 5000/6000 user interface for the intended welding process.

To create a reference curve, welds are initially made using constant current mode until a sufficient spot size is reached.

| Parameters to be set or checked on the BOS5000/6000 user interface | |
|---|---|
| Squeeze time | Sufficient for the actual welding task |
| Hold time | Sufficient for the actual welding task |
| 1st Weld time | Possibly as a preliminary impulse in KSR mode, refer to Sect. 8.4 |
| 2nd weld time and current | To be set for the actual welding task. Possibly upslope setting for 2nd weld time |
| 3rd weld time | Possibly for post-heating in KSR mode |
| Heat correction | 0% for subsequent corrections |
| KSR mode | ON |
| Spot repetition | OFF |
| Monitoring stopped | ON |
| Stepping | Heat values to 100% |

| U/I controller settings in the BQR user interface | |
|---|---|
| All programs | UIR measuring on |
| Selected program | UIR measuring on<br>UIR regulation off<br>UIR monitoring off |



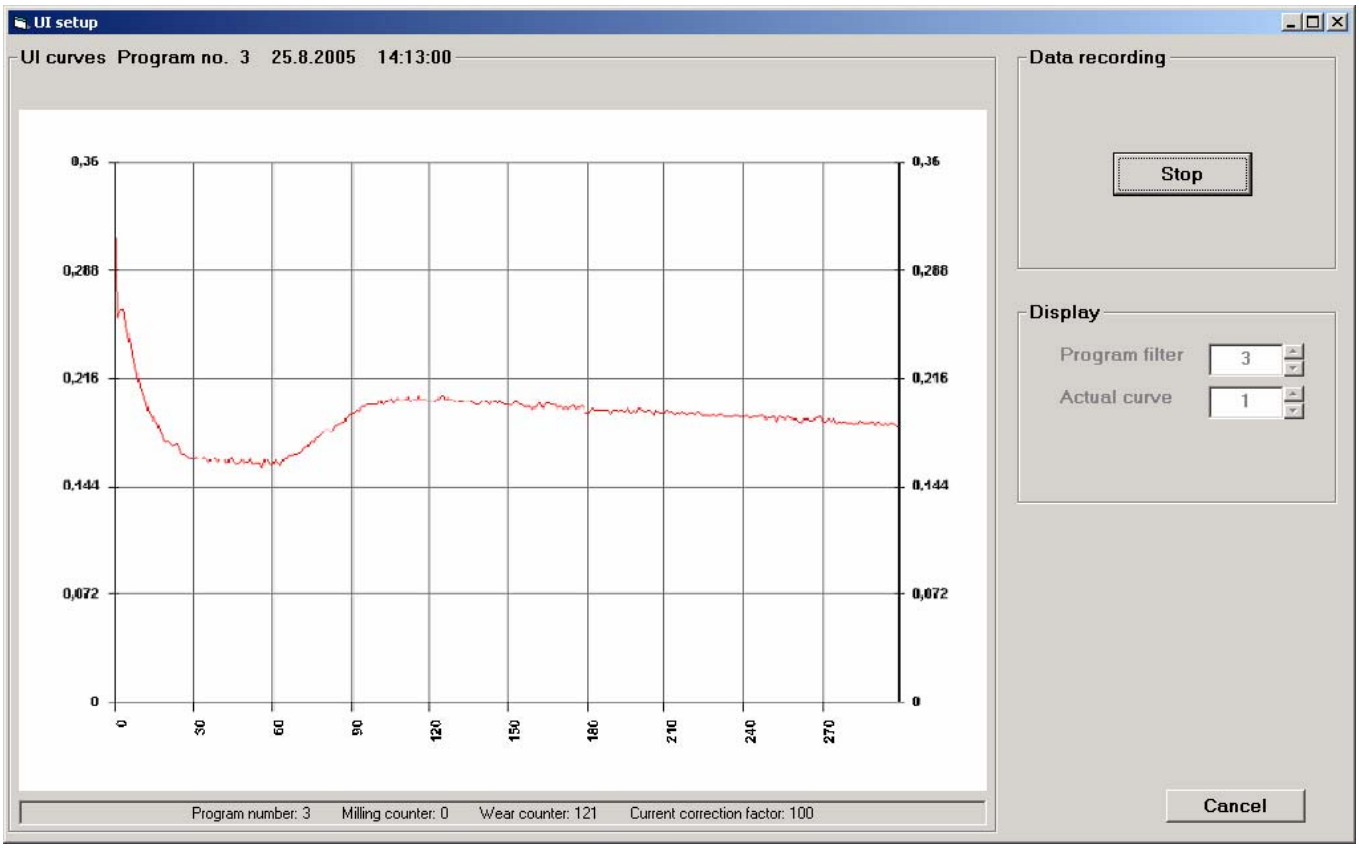

Data → Timer should not be forgotten

**For a detailed description of the BQR operation, please refer to section 7, BQR user interface with U/I controller**

### Creating the reference curve

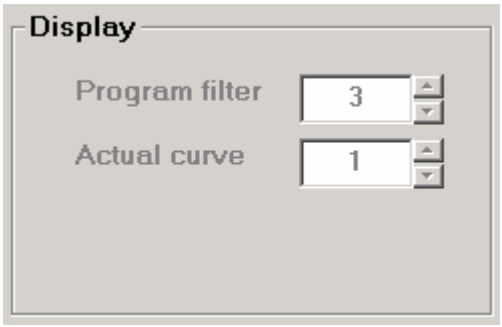
The creation of the reference curves is supported in *Tools - UI Setup*. Advantage: several welds performed by a program can be included, regardless of the sequence in which the programs are executed. This feature considerably simplifies the creation of the reference curve in practice.

Start recording by hitting the *New* button in the Data recording field.



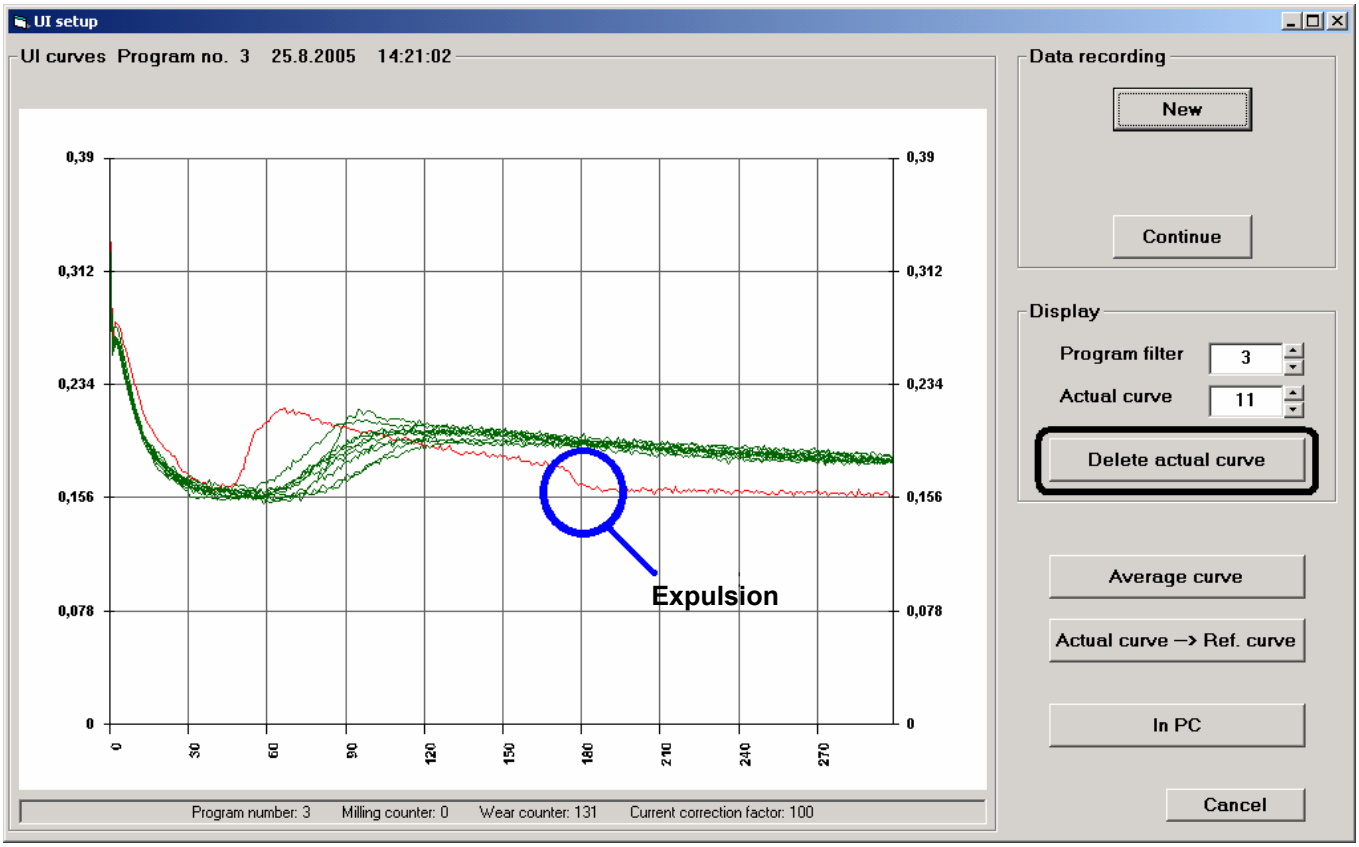

A weld was recorded.

Now, all welds will be displayed that are being executed. The *Display - Program filter* field shows the program number of the last program executed, and *Display - Actual curve* returns the current number of the last weld.



Once the welds have been recorded which are to be used for creating the reference curve, data recording can be stopped.


Now, a program can be selected in *Display - Program filter* whose curves are to be displayed. A curve can be selected from this range in *Display - Actual curve* which is shown in red color for evaluation.
This specific curve can be deleted by hitting *Delete actual curve*.

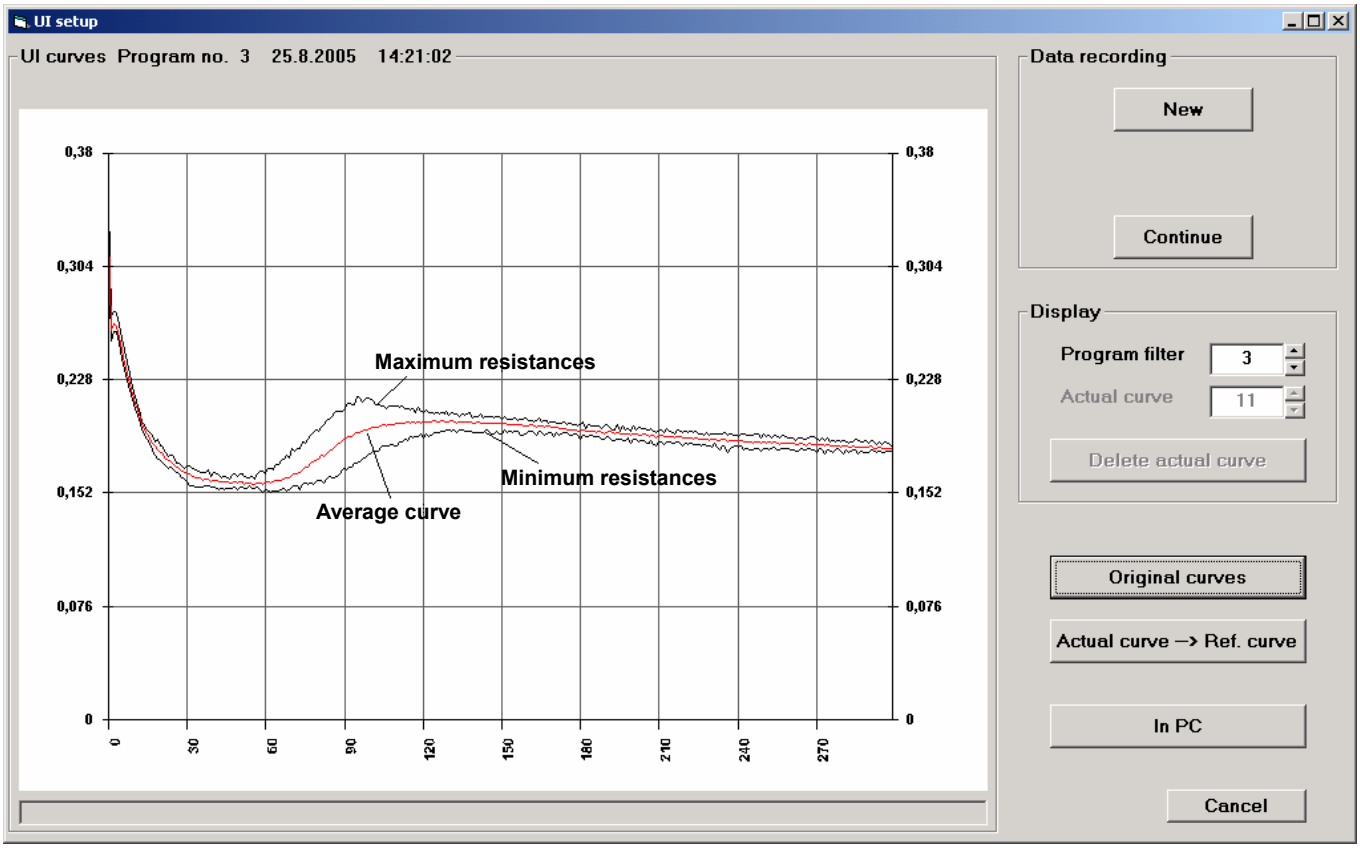



Before the reference curve can be calculated from this curve, it is possible to delete anomalies.

In any case, welds with expulsion must be deleted from the curves.

Expulsion can be detected by a sudden downward slope of the resistance characteristic.

By pressing *Average curve* the reference curve will be calculated for a program and displayed in red color. The black curves show the minimal and maximal resistance characteristics.




By hitting 

, you can return from the average curve display to the original curve represented.

**Accepting the reference curve**

Pressing 

will store the red curve as the reference curve in the U/I controller.

**Notes**

It is recommended to use a separate program for each combination of different sheet thicknesses and to determine separate reference curves. Advantage: when using separate programs, all welding parameters can be optimally set for the welding task in question, the weld time will not become longer than necessary based on the different sheet thicknesses.

However, if a single program is to be used to weld different combinations of sheet thicknesses, the reference curve should be determined using the thinnest sheet combination offering the lowest amount of resistance. For coated sheets, the thinnest sheets with the thickest coating should be used.

In order to determine the reference curves, welding may be carried out on the component. However, if sheet strips are used, the following is to be noted:
- The curve of the first spot on a sheet must not be used as reference curve.
- The spots must be welded at a distance of approx. 20mm (shunt circuit).

If the spot diameter is not sufficient, the current must be increased from one spot to the next up to the expulsion limit.
If expulsion occurs, the current must be reduced to the last value without expulsion and the weld must be repeated.
Afterwards, the sequence can be stored as reference curve,
provided that the quality of the weld is satisfactory. For this purpose, for example, the spot diameter has to be measured.

The quality of the weld cannot be determined by an interpretation of the curve characteristics. Controlling the curve characteristics must be limited to the following assessment:

- Resistance characteristic: typical characteristic showing a strong decline in resistance at the beginning (when making contact) and a continuous decline in resistance towards the end.
- Voltage signal: whether a voltage signal is present and whether its characteristic is similar to that of the resistance.

Expulsion can also be detected by a sudden downward slope of the resistance characteristic.

Also refer to Section 8

The cap wear condition should be between 10 and 100 welds.

## 6.4 Step 4

**Activating the controller for this program:**

| U/I controller settings in the BQR user interface | |
|---|---|
| All programs | UIR regulation on |
| Selected program | UIR regulation on |

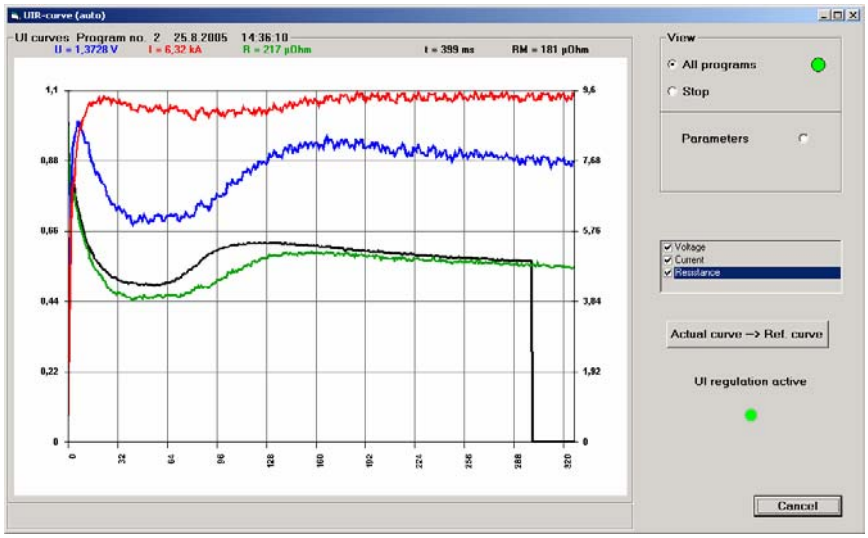
**Note**
The *All programs* option may be used to deactivate measurement and regulation for all programs of the weld timer.

Steps 2 to 4 should be repeated for every spot weld which is to be made with active controller.

The creation of reference curves has now been completed.

Afterwards, the reference curve can be corrected - increased/decreased - using the Heat correction function of the BOS 5000/6000 only. The weld time and the amount of current can no longer be changed because they are now controlled by the U/I controller. For this reason, when activating current monitoring at BOS 5000/6000, it must be ensured that the tolerance bands are wide enough for the U/I controller to respond accordingly without reporting errors.

The curve characteristics of the current weld can be displayed in  .




Visualization of the curve characteristics

**For a detailed description of the operation, please refer to section 7, BQR user interface with U/I controller**

# 7 BQR user interface with U/I controller

The BQR user interface is used for parameter input and diagnosis of the U/I controller on location or to supplement BOS 5000.The more recent versions of the BOS 6000 user interface also include the functions of the separate BQR operating software. The BQR user interface for the U/I controller is exclusively operated via the V24/RS232 interface on the X3C controller board or via weld timer X1. It automatically adjusts to one of the baud rates 19,200 Bd or 57,600 Bd. The user interface is designed for a fixed screen resolution of 1024 * 768 pixels.

In the same manner as in BOS5000/BOS6000, up to 256 weld programs (0-255) and 32 electrodes (0-31) are supported.

## 7.1 Installation and connection

### Preconditions

- Operating system Windows 2000/NT/XP
- Screen resolution: 1024 x 768
- Serial interfaces COM1 / COM2 (with at least 57,600 baud)
- Min. Pentium II 233 MHz
- Min. 1 GB hard-disk storage
- Min. 64 MB random access memory
- CD-ROM drive

### Connection

A suitable V24/RS232 connecting cord is to be provided for linking the PC and the controller module, e.g., BOSCH part number 1070 0067 49. For more information on the connecting cord, please refer to manuals Rexroth PSI 6xxx.000, Control and I/O level, Technical Information, keywords "Programming terminal" or "X1".

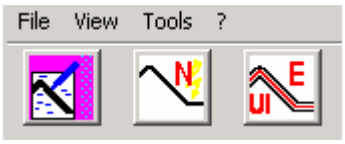
### Installation

Load the installation CD into the CD-ROM drive and start the Setup program. Then follow the instructions on the screen.

The user interface of the controller is needed for commissioning or diagnostics only. Once it has been set up, the controller works independently.

## 7.2 Overview of the operating functions

Operation of the U/I controller is subdivided into the following areas. These areas are reflected in the menu structure.




**Note**
If ultrasonic measurement has been globally deactivated, the ultrasonic functions are hidden.

| File | View | Tools | ? |
|---|---|---|---|
| Backup | UI / US Curves (auto)  | Comport | Help |
| Restore | Reference curve (program)  | Select language | Info |
| Exit | | System info | |
| | | PSI | |
| | | Expert mode | |
| | | Initialize (reset) | |
| | | Load firmware | |
| | | UI setup | |

**Table : Menu structure of the user interface**

## 7.3 Parameter settings for the U/I controller

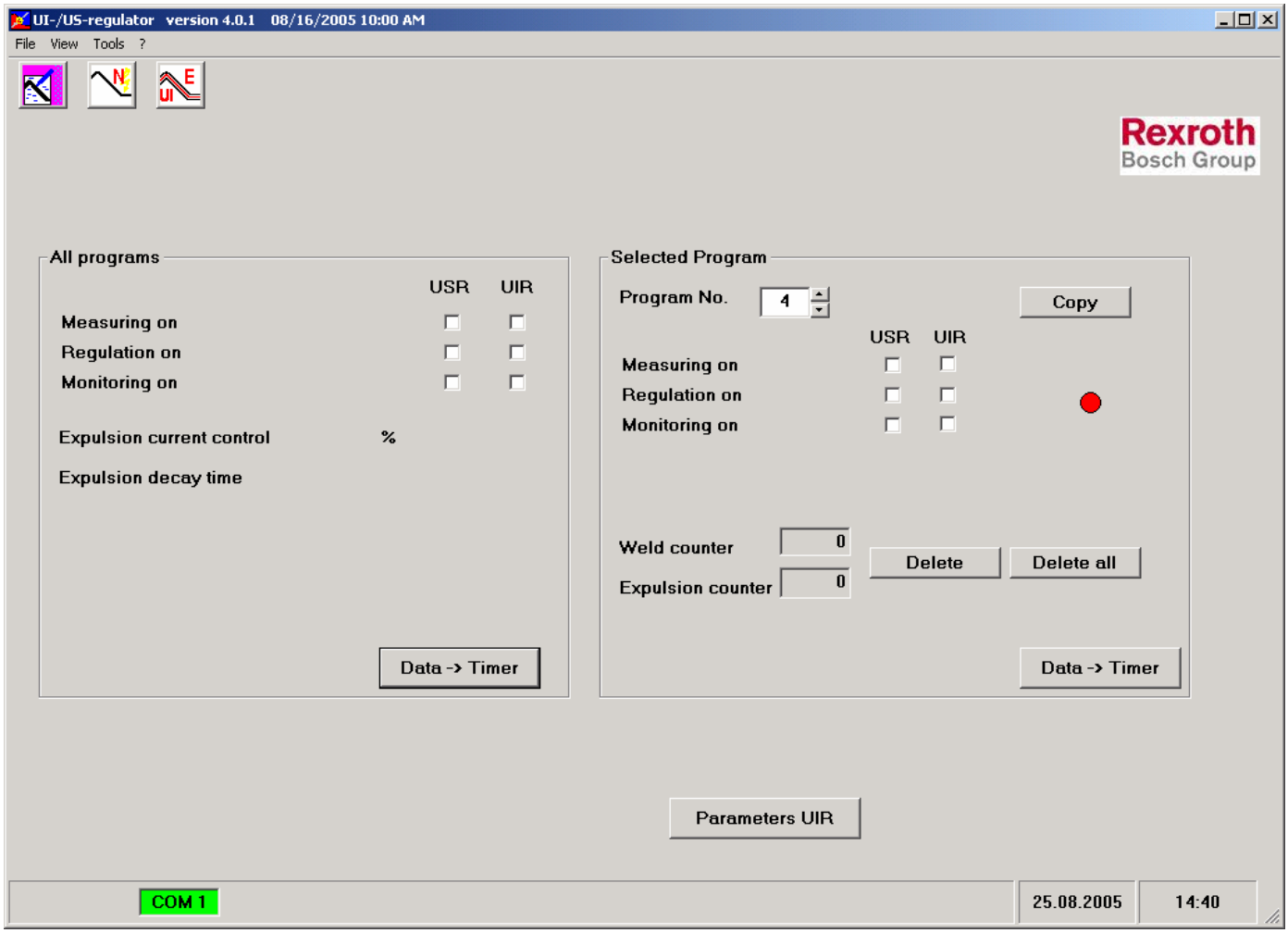
All parameters for U/I regulation are stored on the controller board. A distinction is made between parameters for:

- "All programs": applicable to all electrodes and all programs
- “Selected program”: applicable to program numbers 0 through 255

To achieve the desired welding result it is necessary to set all parameters correctly. To ensure simple application, all parameters are preset with default values that will generate a functioning weld in most cases.

All parameters are monitored with regard to a permissible entry range, or the entry is limited to the permissible range. Before a parameter set is loaded, the default values are displayed.

## Basic display




### All programs

The activation of measuring, regulation and monitoring for USR and UIR is available here.
All programs means that these parameters apply to all electrodes and programs assigned to the weld timer.

This information applies to the U/I controller module only.

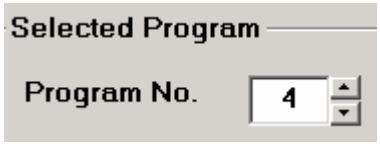
## Expulsion detection

**Expulsion current control**
This parameter is used to determine how the controller responds to expulsion. The controller changes the current at the time of expulsion by the programmed percentage. The value with a positive sign effects a current increase, the value with a negative sign a current reduction.

**Expulsion decay time**
Has been assigned a default value. Should not be changed unless specifically requested.

## Selected program

First, a program has to be selected by




Activation of measuring, regulation and monitoring for a selected program is available here.

“Measuring on” in column UIR will turn U/I measurement on/off.
An electrode voltage cable must be connected to the gun in order to use the voltage measurement function. U/I measurement must also be activated in “All programs” in order to use it at this point!

“Regulation on” in column UIR will turn the U/I controller on/off.
The following preconditions must be fulfilled to activate the U/I controller:
a) U/I regulation must have been activated in “All programs”
b) the reference curve of the selected program must have been stored and the corresponding parameters set

**U/I regulation ready**

The operating condition of the controller is displayed here.

U/I controller ready 

U/I controller not ready 

A welding sequence with U/I regulation can take place only if a valid reference curve has been loaded for the selected program and the U/I controller has been activated globally as well as for the selected program.

### Weld time prolongation

Activating *Welding time* prolongation will allow the U/I controller to prolong the weld time for this program.
The *maximum* parameter limits the prolonged weld time required by the U/I controller in order to balance interfering variables. In automatic mode, extremely long weld times may be undesirable.
If this time is exceeded, a fault message is output
”Maximum weld time reached”.

Example:
A welding time prolongation of 100% will allow the U/I controller to maximally double the programmed weld time, if necessary.

**Note**
When the U/I controller is switched off, Welding time prolongation will also be deactivated.

### Expulsion counter

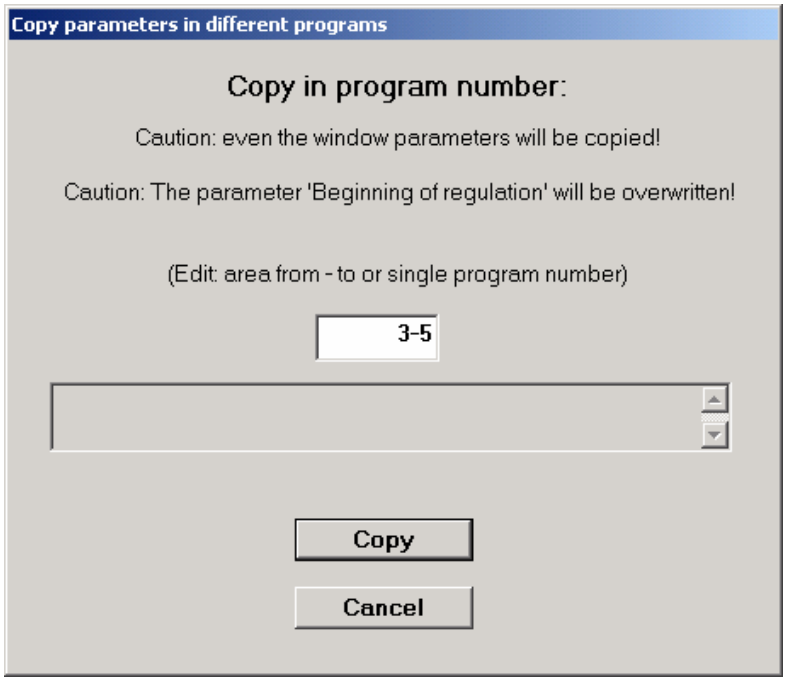
If the system detects expulsion, the expulsion counter is incremented. The weld counter shows the current number of welds (since deletion of the weld counter) for the selected program.

The frequency of expulsions can thus be determined.

Pressing *Delete* will reset the expulsion counter and the weld counter for the selected program.

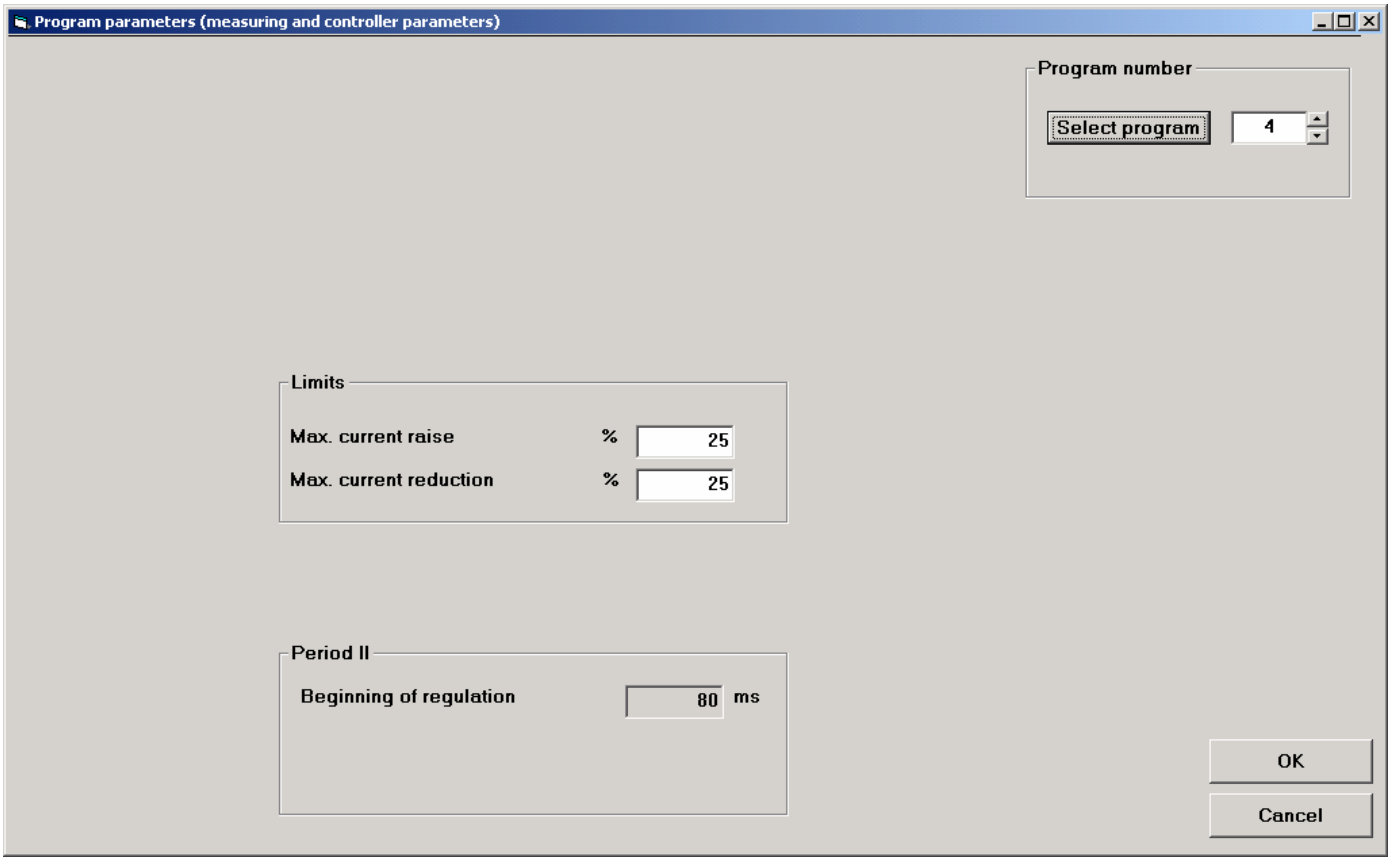
Pressing *Delete all* will reset the expulsion counter and the weld counter for all programs.

**Copy**
Using this button, the parameters of the selected program can be copied to other programs.




**Note**
By double clicking (left mouse button) a parameter field, you can transfer the selected parameter to several programs.

## UIR Parameters




### Limit values

The *Maximum current raise* parameter allows the U/I controller to raise the current by the specified percentage compared to the reference current when balancing interfering variables.

The *Maximum current reduction* parameter allows the U/I controller to reduce the current by the specified percentage compared to the reference current when balancing interfering variables.

### CAUTION

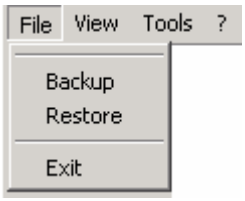
Changing these limit values may affect the efficiency of the U/I controller in the event of interfering variables!
Therefore, you should not change this value without good reason.

### Period II

This value is automatically calculated when creating the reference curve.

Changing this value may affect the efficiency of the U/I controller in the event of interfering variables!
Therefore, you should not change this value without good reason.

# Backup/Restore




In the *File* menu item, you will find the "Backup" and "Restore" functions.

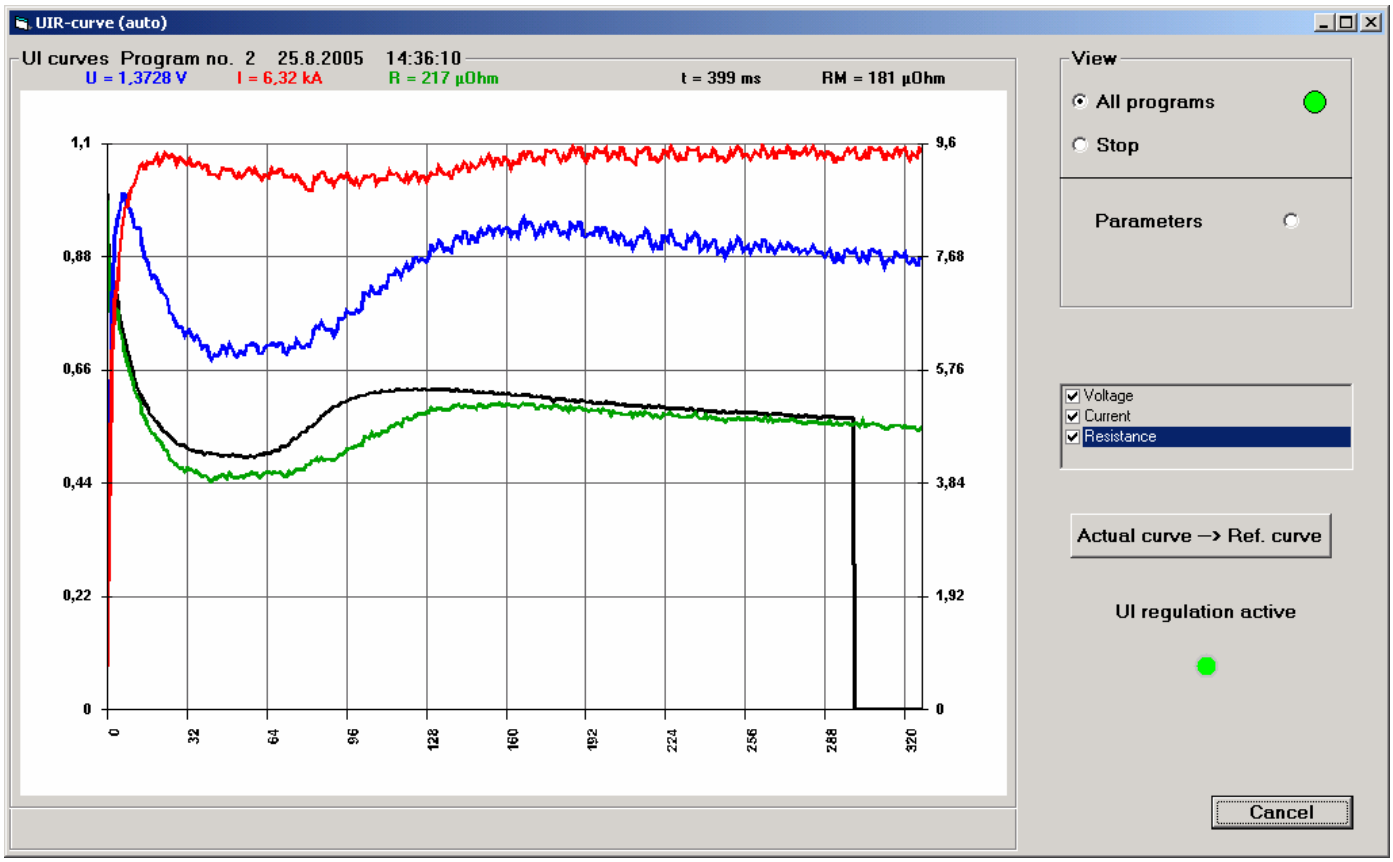
The *Backup* function can be used to backup the controller board data on the PC (or network).

Having selected the data source “Regulation card”, a directory and file name have to be determined. Press *Start* to backup the parameters and the reference curves of the individual programs stored on the controller board.

Using the *Restore* function, backed-up data is transferred back to the controller board.

Having selected “Regulation card”, a directory and file name have to be selected. Press *Start* to restore the parameters and the reference curves of the individual programs from the backup file to the controller board.

# View UI/US curves (auto)




When the window has been opened, the curve characteristics of the last weld are be displayed including the program number, date and time of the last weld.

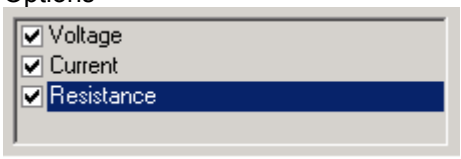
The applicable curve characteristic is shown in the diagram:

- Voltage blue
- Current red
- Resistance green
- Reference resistance black

The weld time is plotted in milliseconds on the x axis.

Individual points of time (in milliseconds) on the curve can be selected via mouse click. The frame of the diagram will then show the related measured values of the selected point.

Options




can be used to select the individual curves.

## All programs

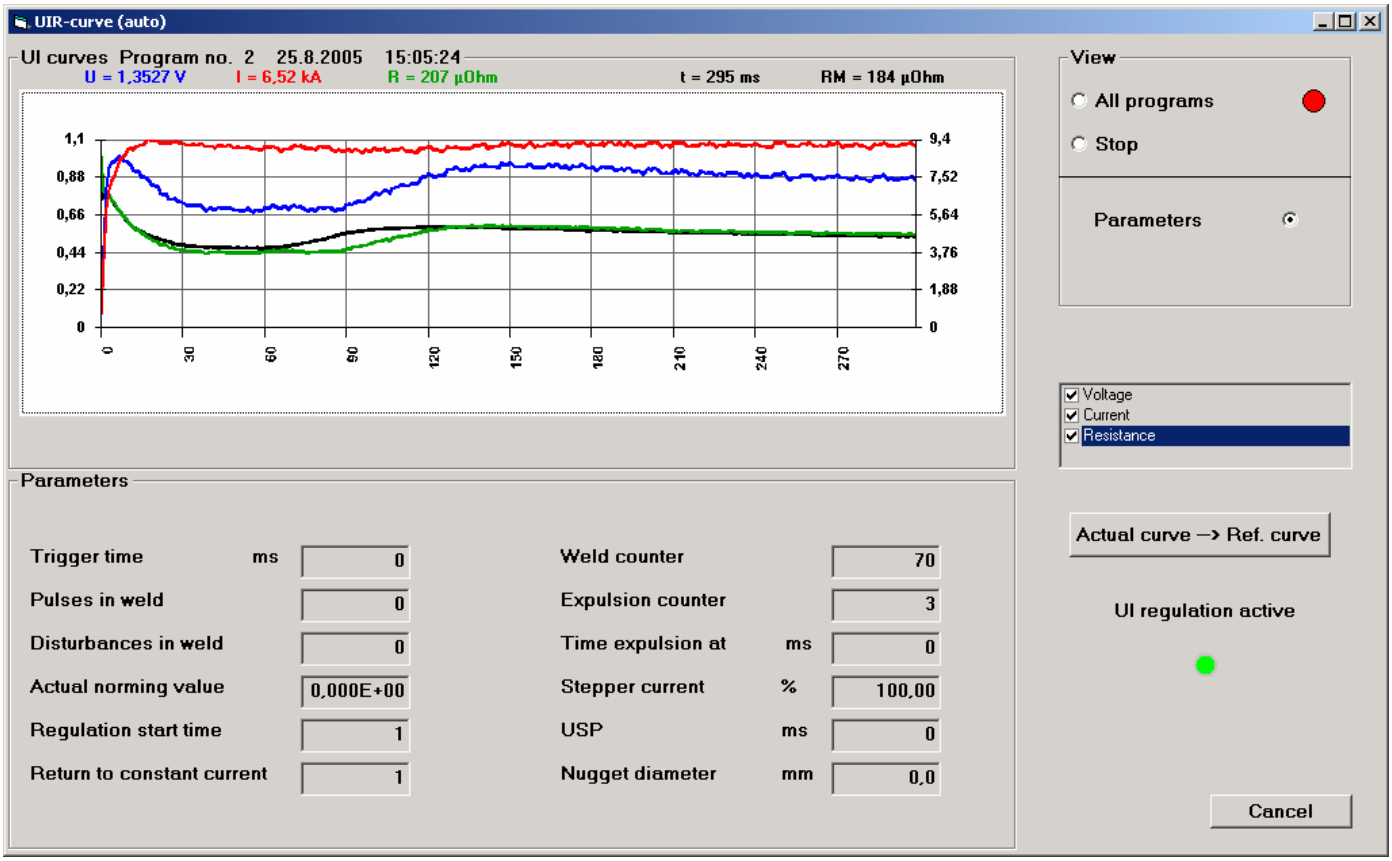
This button in the View window starts the query of the controller board, the signal indicator turns green.

If a new welding sequence has occurred, the current parameters and curve characteristics are automatically loaded and displayed. A new sequence is recognized by the time stamp.

## Stop

The *Stop* button halts the data transmission, the signal indicator turns red.

## Parameter



In the View field, it is possible to switch over between the actual value curve and an additional parameter display of the last welding sequence.

Press *All programs* to return to the previous screen

## Meaning of the U/I parameters

### Weld counter

The weld counter shows the current number of welds (since deletion of the weld counter) for the selected program.

### Expulsion counter

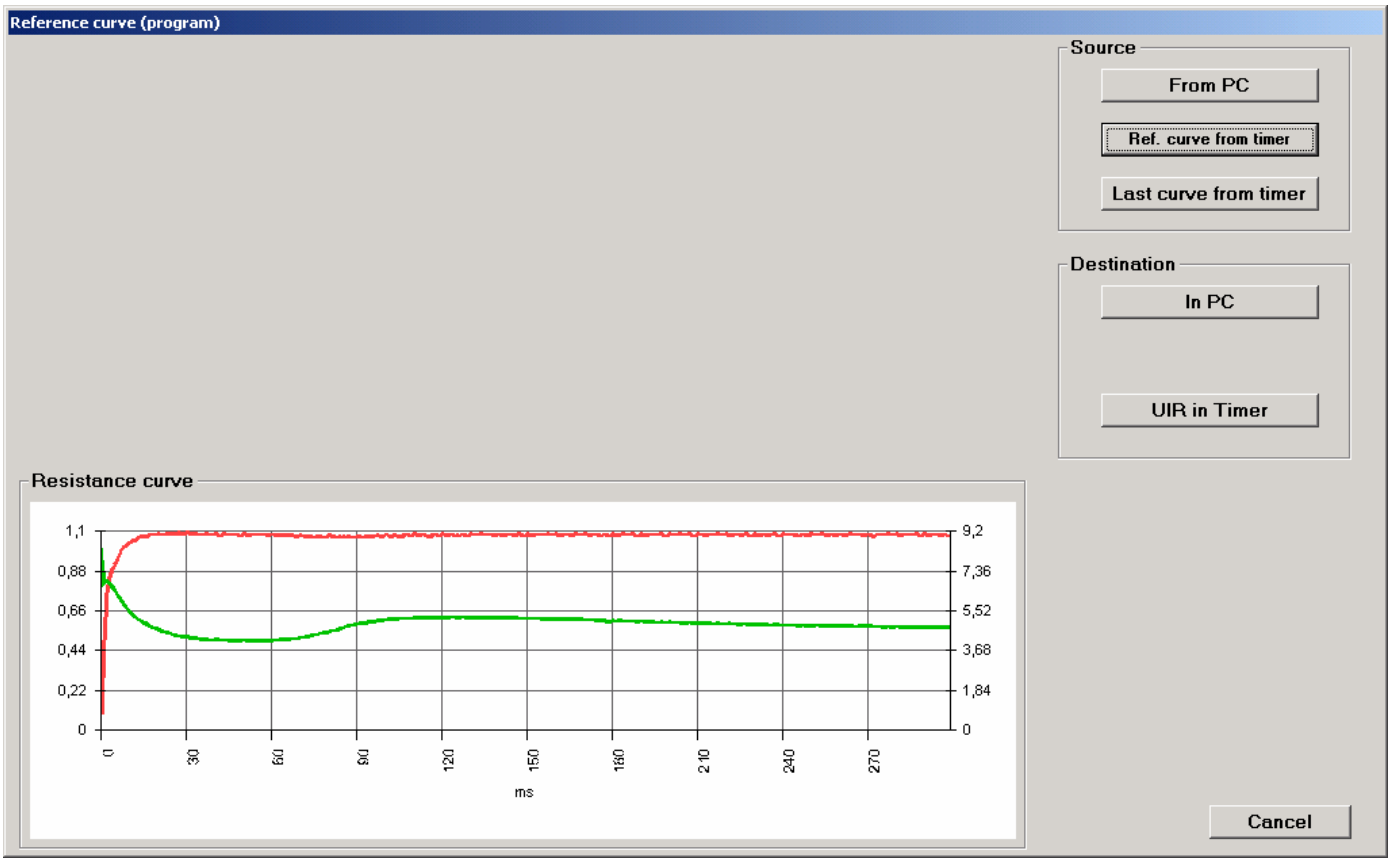
If the system detects expulsion, the expulsion counter is incremented.

### Expulsion point in time

This field shows the moment within the weld time in which expulsion occurred.

**Note**
In the basic display, it is possible to delete the expulsion counter for the selected program or for all programs. The weld counter is also deleted in the process.

# View Reference curve (program)




This option offers the possibility of retrieving reference and actual curves to the display and of storing them as reference curves.

## Source - From PC

Retrieves a reference curve stored in the PC to the display. For this purpose, the directory (the default is *C:\Einrichten\Referenzkurven*) and the file on the PC must be selected.
The curve may be stored in one of the destinations.

## Source - Reference curve from timer

Retrieves a curve stored in the timer to the display. A program number has to be entered for this purpose.

The curve may be stored in one of the destinations.

## Source - Last curve from timer


Retrieves the last curve (for the last welds) from the weld timer to the display. A program number has to be entered for this purpose.

The curve may be stored as a reference curve in one of the destinations.

## Destination - In PC

The curve currently displayed is stored as a reference curve in a directory (the default is *C:\Einrichten\Referenzkurven*) of the PC. For this purpose, the a file name must be entered.

## Destination - UIR in Timer

Stores the curve currently displayed as reference curve in the weld timer. A program number has to be entered for this purpose.

**CAUTION**

Changing the reference curves may affect the functioning of the U/I controller!
Therefore, you should not use these functions without good reason.

# Tools, UI Setup

## Comport

Specification of the comport number of the computer to which the V24/RS232 serial interface is connected. Having entered a new port number, a new initialization of the interface is performed. If it is successful, the comport number is displayed on green background in the lower left corner of the screen. A red field indicates that the interface is not ready.

## Select language

German and English can be selected here.

## System info

To identify the timer and / or the controller module, the version identification of the device to which the BQR user interface is connected via the serial interface can be displayed.

If the BQR user interface is connected to the controller module, the version identification of the controller module is displayed.

If the BQR user interface is connected to the timer unit (X1 port), the timer type and its version number are additionally displayed.

## Load Firmware

Using this function, new firmware can be loaded into the controller module.
- Select “Regulation card”
- Open file: the filename extension is “hex”
- note the messages on the screen

The firmware version can be viewed in *Tools - System info*.

**CAUTION**
Welding is not possible during a firmware download!

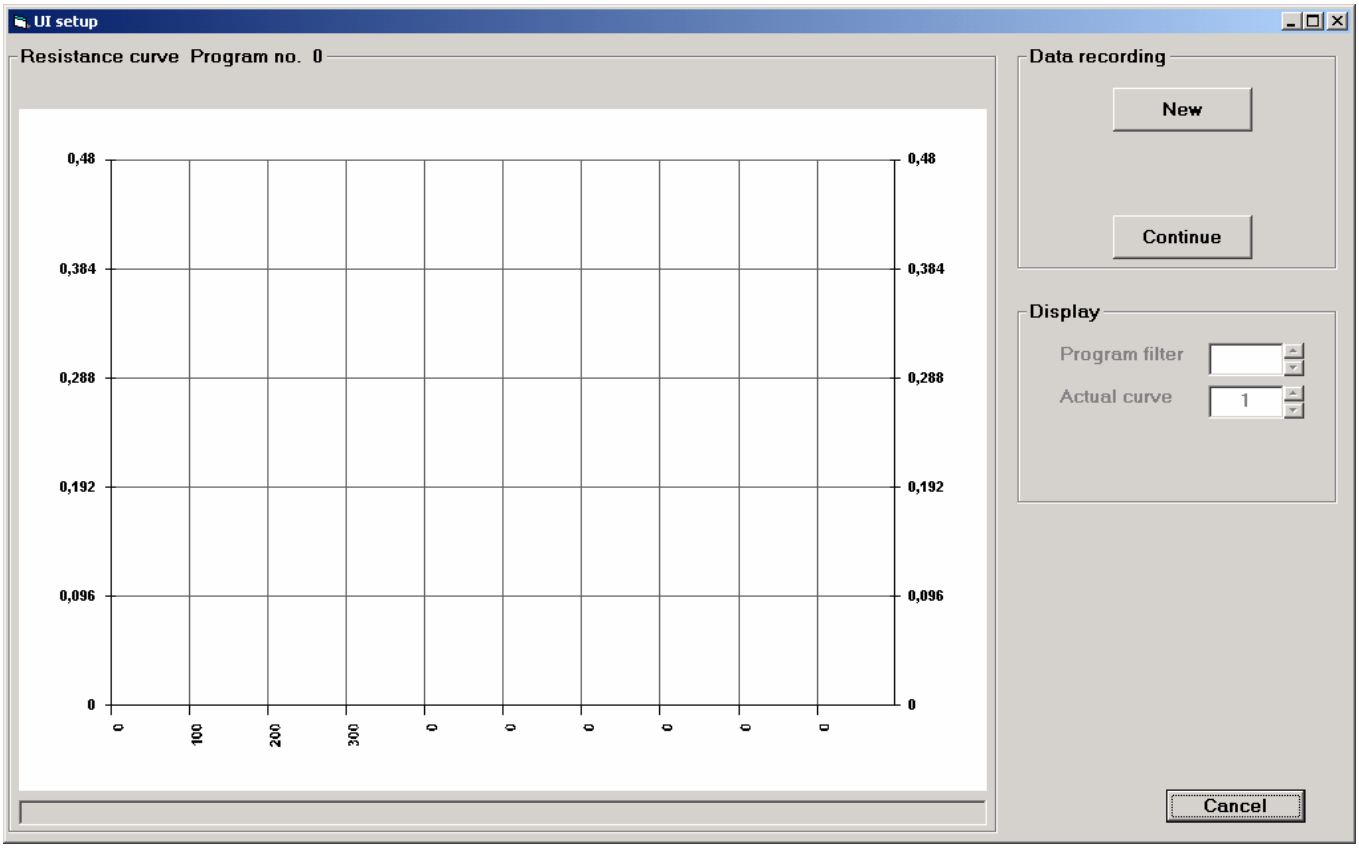
## UI Setup


Serves for the convenient setup of reference curves, in particular, in an automatic production process.

First, recording must be started. From now on, the resistance characteristics of all welds are recorded and assigned to the relevant program. The order in which the programs are executed is of no importance here. It is practical to weld some components and then to terminate data recording. Now, several resistance curves are available for each program executed. From these curves, an average curve can be calculated and stored as a reference curve for this program in the U/I controller.
This feature considerably simplifies the creation of the reference curve in practice. provided that the quality of the weld is satisfactory. For this purpose, for example, the spot diameter has to be measured.

Anomalies in the curve characteristics, e.g. in the event of expulsion, can be deleted prior to the calculation

The amplitude of the curves can be zoomed with the right mouse button.




Start recording by hitting *New*.

**New**
This starts a new data recording. In the event that any curves exist that have been recorded previously, these curves are deleted, and the resistance characteristics of the current program being welded will be shown.
As soon as this function has been called, the resistance characteristics of

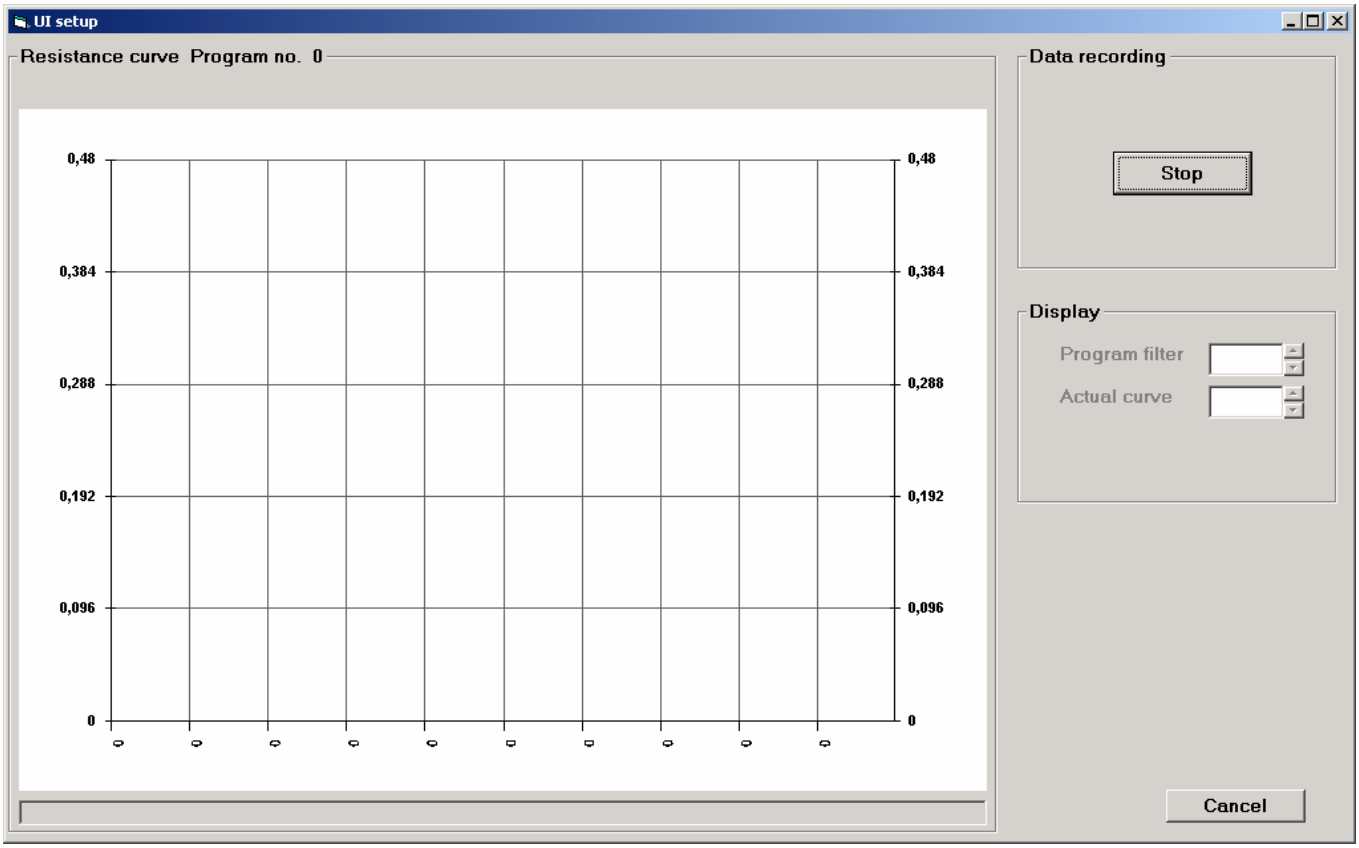
the currently welded program will be displayed. The chart will show the current curve as well as any curves that were previously welded with this program.

Each weld that is performed now will be stored in the BQR and displayed specifically for each program.

**Continue**
If you exited the window on purpose or by mistake, the recordings made so far will not be lost. Hit *Continue* to resume recording at the point of interruption.
The recorded curves will be stored in C:\EinrichtenUI\P001, …\P002, etc. on the PC.

**Program filter**
If other curves were recorded before, they may be viewed individually for each program. Only the curves relating to the selected program will be displayed.

**Actual curve**
You may change over between the individual curves of the currently selected program and select one of them.




**Recording has been started.**

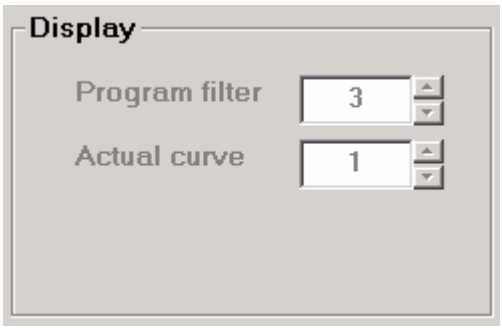
The program is now ready for recording and waits for the first welding sequence.

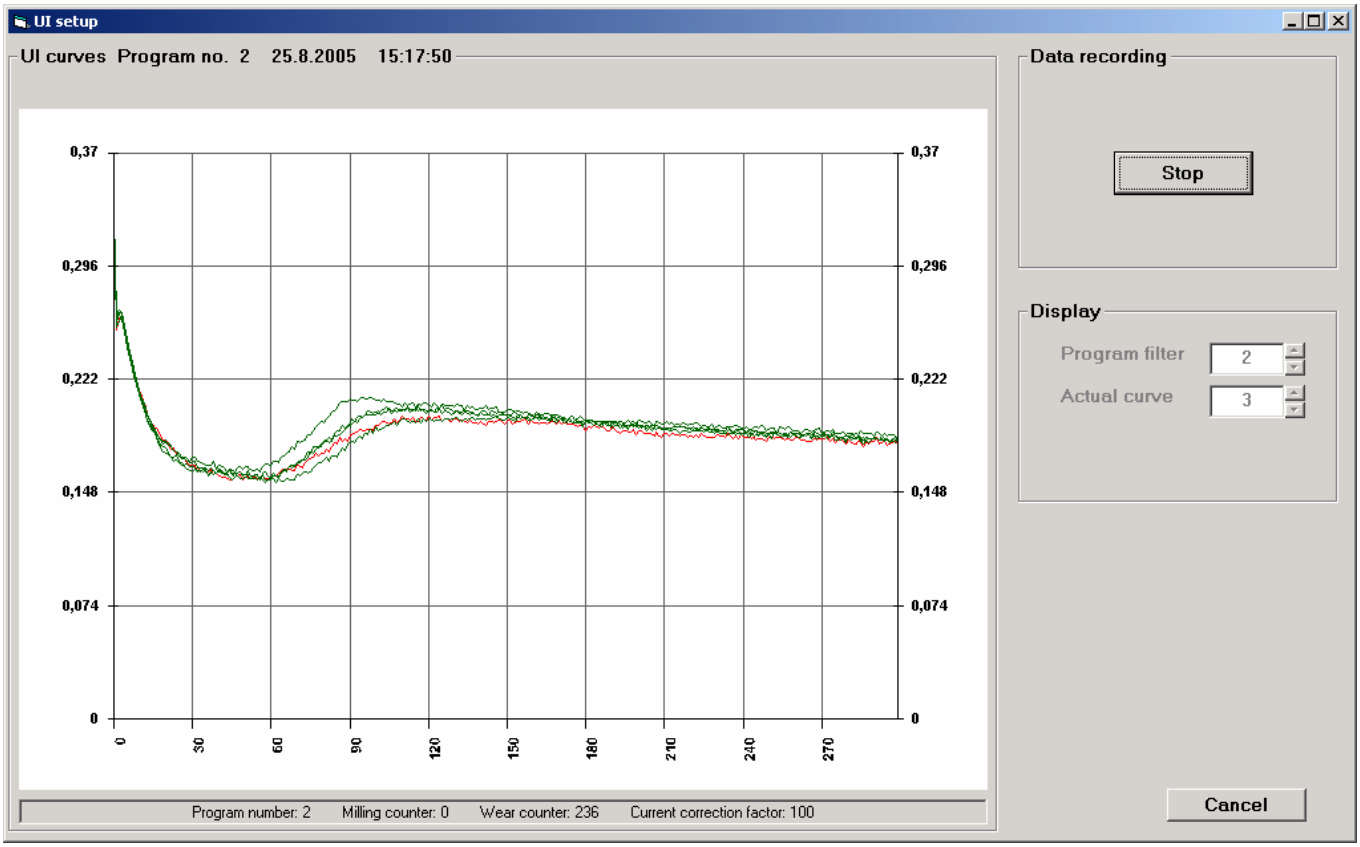
Recording is halted by hitting *Stop*.

While recording curves, no program selection can be made.

Likewise, no sequence can be selected using *Actual curve*.

The *Display - Program filter* field shows the program number of the last program executed, and *Display - Actual curve* returns the current number of the last weld.






**Recording mode**

The welds being performed will be represented as a resistance characteristic. The last sequence added will be shown in red color.

Important: The order in which the programs are executed is of no importance here - an “arbitrary” order is possible (e.g. Prog. 15, Prog. 4, Prog 6, …).

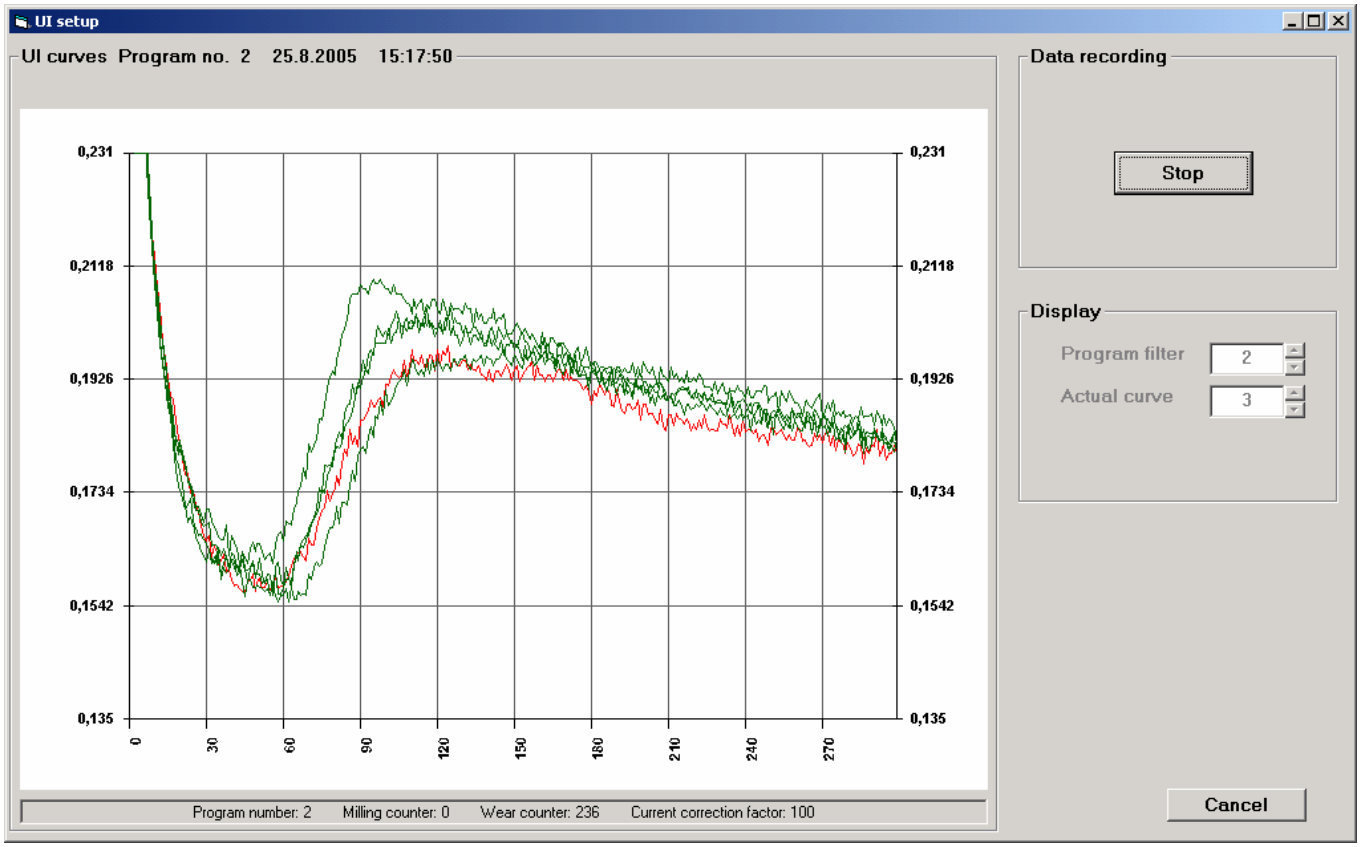
Nevertheless, all previous curves and the curve pertaining to the last weld (program) will be displayed in any case.

The *Actual curve* field shows the number of sequences welded with the current program.

The program number, date and time of the last sequence will be indicated in the header bar.

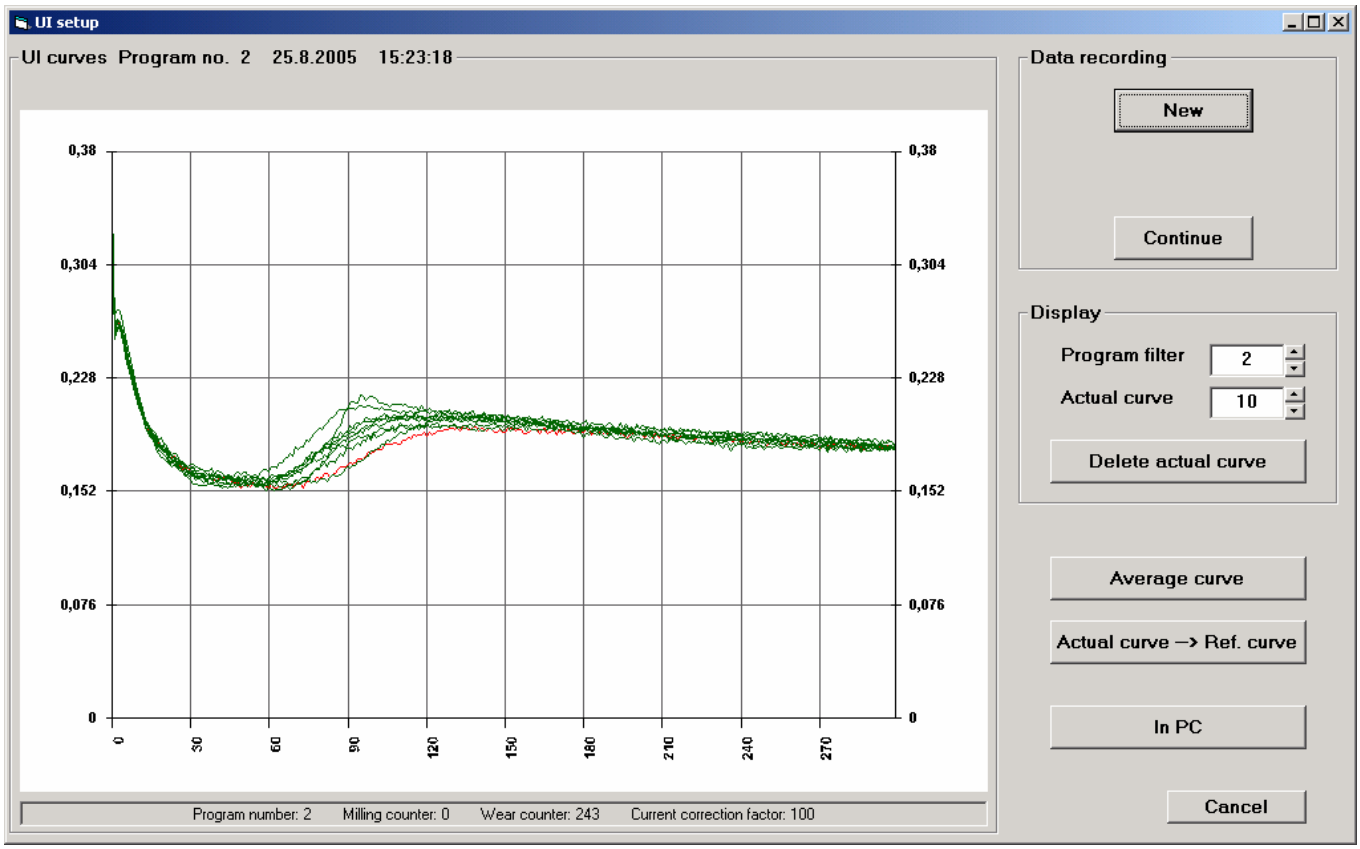
The footer bar contains more information on stepping and the electrode status:

- Milling counter
- Wear counter
- Current correction factor: shows the currently active stepper value as a percentage of the base heat.




**Zooming curves.**

The amplitude of the curves can be zoomed with the right mouse button. With the left mouse button, the normal display of the curves is restored.



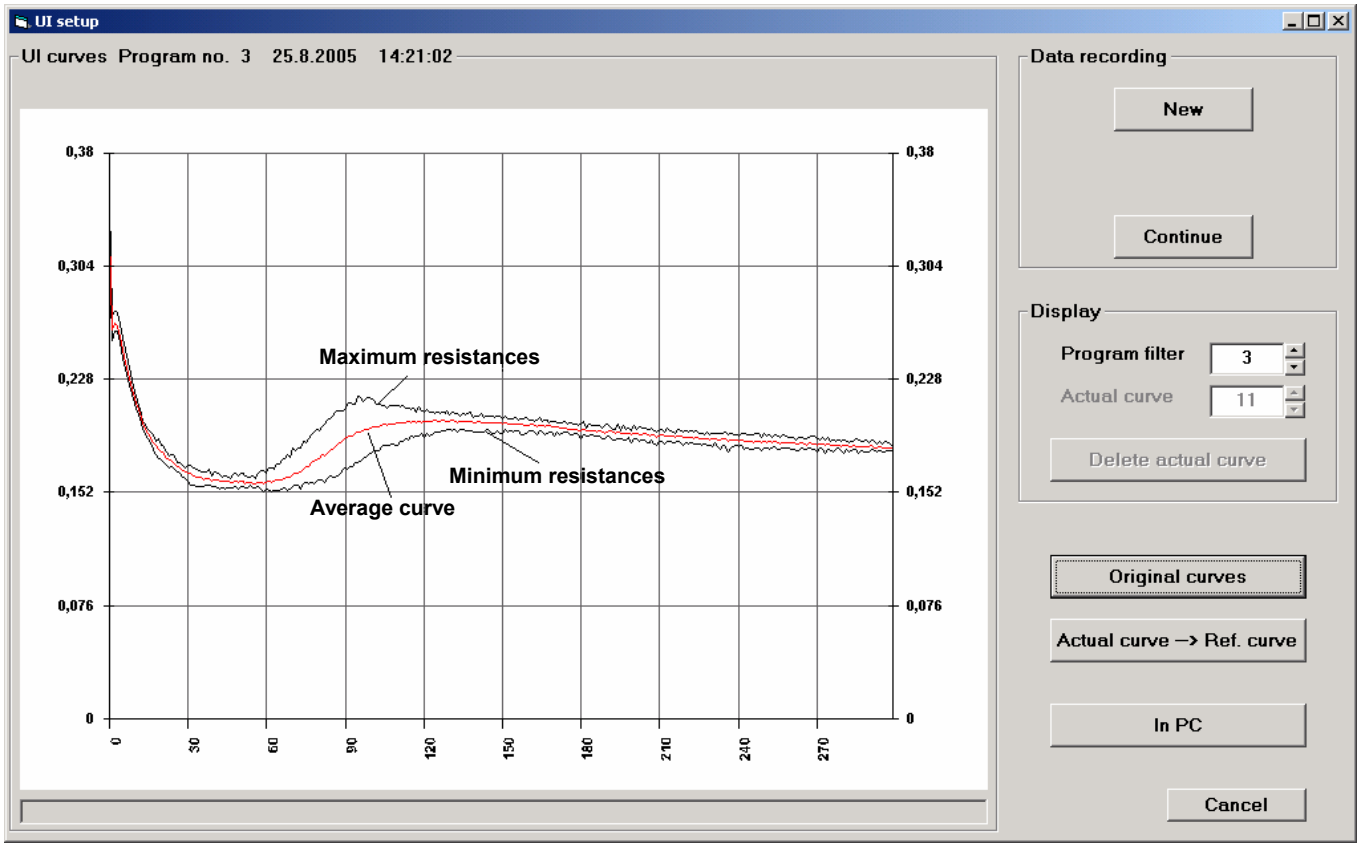

**Recording completed.**

When recording has been completed, the curves of the desired program can be selected using the *Program filter* option. All curves that were recorded for the selected program will be displayed.

You may change over between the individual curves of a program and select one of them using the *Actual curve* option. The currently selected curve will be displayed in red color.

The selected curve can be deleted by hitting *Delete actual curve*.

In the figure shown above, Program 2 was selected using the *Program filter* option. Ten curves were recorded for this program, which can be selected using *Actual curve* so that they will change to a red color display. The individual curves can be better displayed and evaluated by this function.




**Average reference curve**

By pressing *Average curve* the reference curve will be calculated for a program and displayed in red color. The black curves show the minimal and maximal resistance characteristics of this program.

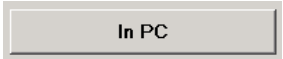
By hitting 

, you can return from the average curve display to the original curve represented.

**Accepting the reference curve**

If the red curve is to be accepted as the reference curve, it can be stored in the U/I controller by hitting 

.

Hit 

to store the red curve as the reference curve in directory *C:\Einrichten\Referenzkurven* on the PC.

Afterwards, the reference curve can be corrected - increased/decreased - using the Heat correction function of the BOS 5000/6000 only. The weld time and the amount of current can no longer be changed because they are now controlled by the U/I controller. For this reason, when activating current monitoring at BOS 5000/6000, it must be ensured that the tolerance bands are wide enough for the U/I controller to respond accordingly without reporting errors.

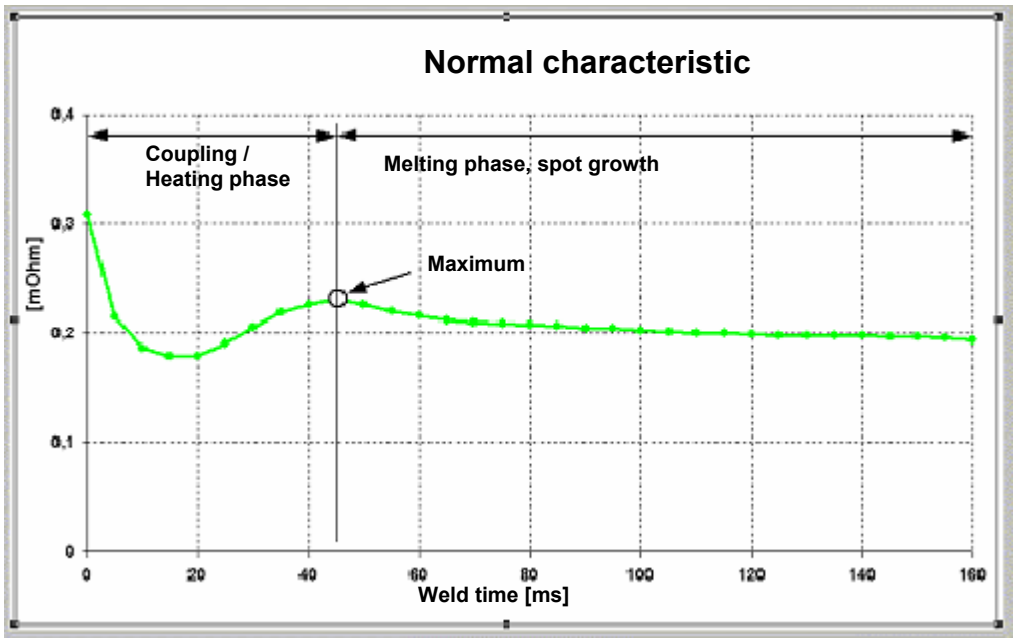
# 8 Explanation of the resistance characteristics

The U/I controller uses very different types of information from the welding process to perform its regulation tasks. At various times during the welding process, it scans different measured quantities to calculate the current and weld time as influencing variables. Thus, it considers not only the current, but also the energy and the resistance. Furthermore, it considers information concerning expulsion and the temporal relationship of the individual quantities.

For a better understanding of the process of a welding task, it is helpful to know more about the resistance characteristics. These characteristics are visualized together with the current characteristics in the user interface. In constant-current regulation mode (KSR), this visualization may be used to monitor process changes after a variation of the welding parameters and use these findings for further optimization. In controlled operation using the U/I controller, understanding the resistance characteristics will assist the user in detecting controller interventions and changes in the process situation.

## 8.1 Normal curve

The following figure illustrates the “normal” characteristic of a resistance curve. The resistance drops from relatively high values at the beginning of the weld because the sheets warm up and are therefore closer connected. This phase is referred to as the coupling or heating phase. After a relative minimum, the resistance rises again to a relative maximum due to the beginning liquefaction of the steel in the spot to be welded. When the maximum is reached, the material in the spot to be welded is liquid. The resistance value drops continuously until the end of the weld time. During this phase, the spot to be welded grows to the spot diameter to be reached.

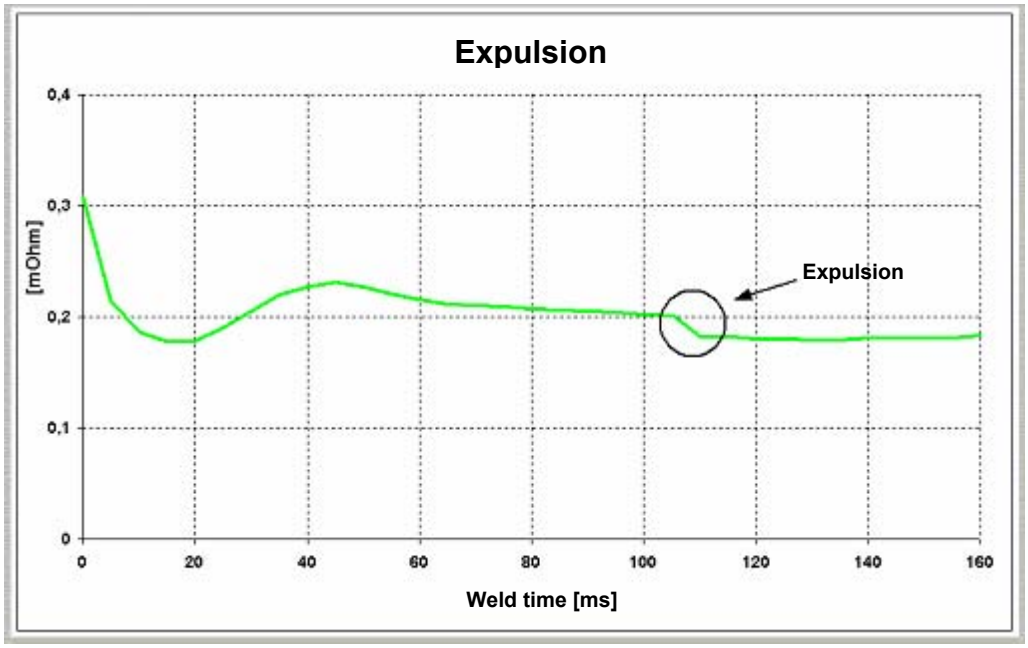



Resistance characteristic of an undisturbed weld

At this point, it must be pointed out that the characteristic shown above represents an ideal curve. There may certainly be some sheet combinations where minimums and maximums are not too distinct, therefore, the curve has a very flat characteristic. This is the case, e.g., with very thin sheet combinations. It is even possible that the resistance characteristic starts with a high initial value and then simply declines without any detectable extremes until the end of the weld time. This phenomenon can be observed with thin electrogalvanized sheets. The controller can work with these characteristics, however, they are more difficult to interpret. Dynamic resistance characteristics, i.e. resistance changes of approx. 100 µOhm, are usually obtained with thick sheet combinations.

## 8.2 Expulsion

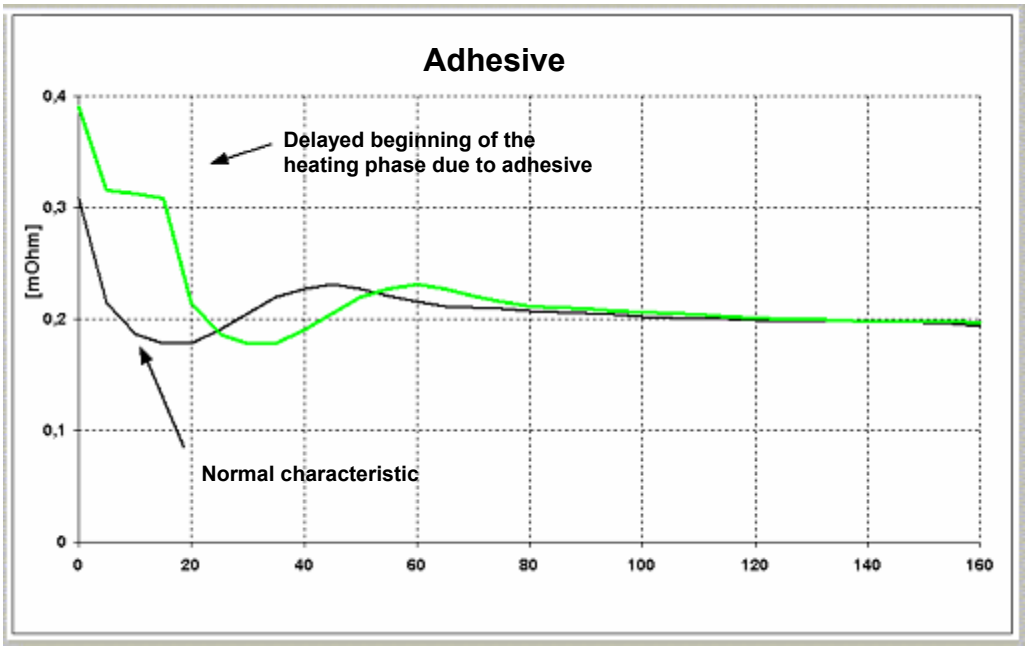
Expulsion can be detected by a sudden change towards lower resistance values in the resistance characteristic. In the example below, expulsion occurs at 105 ms of the weld time. The measures for eliminating expulsion strongly depend on the time the expulsion occurs, as explained in detail further below.




Resistance characteristic with expulsion at 105 ms

## 8.3 Insulating materials

Especially when using adhesives for car body production, insulating layers are encountered between the sheets to be welded. When used properly, these materials do not present an obstruction to the weld. However, their insulating effect first has to be overcome before welding can start. The following figure illustrates the change by the resistance characteristic. At the beginning of the weld time, resistance remains high until the insulating layer is driven out or has been burnt off. The duration of this phase depends on the material used and the forces at the electrode gun, among others. When the insulation has been removed, the weld will be executed as normal, and the resistance characteristics will be determined by the sheet combination.




Resistance characteristic of welds with an adhesive

# 8.4 Steps for optimizing the weld

Based on the curves of the process parameters as visualized by the user interface, it is easy to optimize the welding parameters.

## General rules

- The special features of the relevant welding task must always be included in the optimization (material, coating, adhesives etc.)
- You must always check that the welding equipment and parts to be joined are suitable for the welding task (forces, positioning, cooling, flange width, etc.)
- The interfering variables of the welding equipment must be minimized
- Using the scales on the graphs, a coarse verification of the voltage and resistance properties of the machine / gun can be carried out.
- Before performing the reference weld, defined initial conditions must be created at the electrode cap, refer to sections 4.2 and 6.2.
- Dynamic resistance characteristics with relatively large resistance changes are to be striven for. They indicate a stable process status and must be well observed.

## Measures to eliminate expulsion

First, it must be determined at which point of time the expulsion occurred.

### Early expulsion

Early expulsion is defined as expulsion that occurs before approx. 2/3 of the weld time have elapsed. In the event of early expulsion, most likely the relationship between current and force is not correct. If a verification shows that the force is within the desired range, the current must be reduced.

Other interfering variables in the welding process may also cause expulsion. If the spot position results in an edge weld, the position must be corrected. In many cases, expulsion is caused by problems with the fit. In addition to a correction of the cause, using a current upslope may help in this case in order to improve the coupling behavior.

### Late expulsion

Late expulsion is defined as expulsion that occurs during the last third of the weld time. In the case of late expulsion, it is also necessary to minimize the interfering variables within the welding process. Known problems include a bad repositioning behavior of the welding equipment.

If expulsion occurs shortly before the end of the weld time, shortening the weld time slightly will often be sufficient. This applies, in particular, to hot-galvanized material.

### Expulsion in controlled operation

Although the controller largely balances interference caused by interfering variables, expulsion may also occur in controlled operation. This can be explained by the fact that the interfering variable may be too strong to be balanced, or by several interfering variables acting simultaneously.

The controller response to expulsion can be adjusted in terms of the welding current, refer to sections 7.3 and 5.5. In the event of expulsion, the active controller automatically extends the weld time to a certain extent in order to make up for the energy lost in the material.

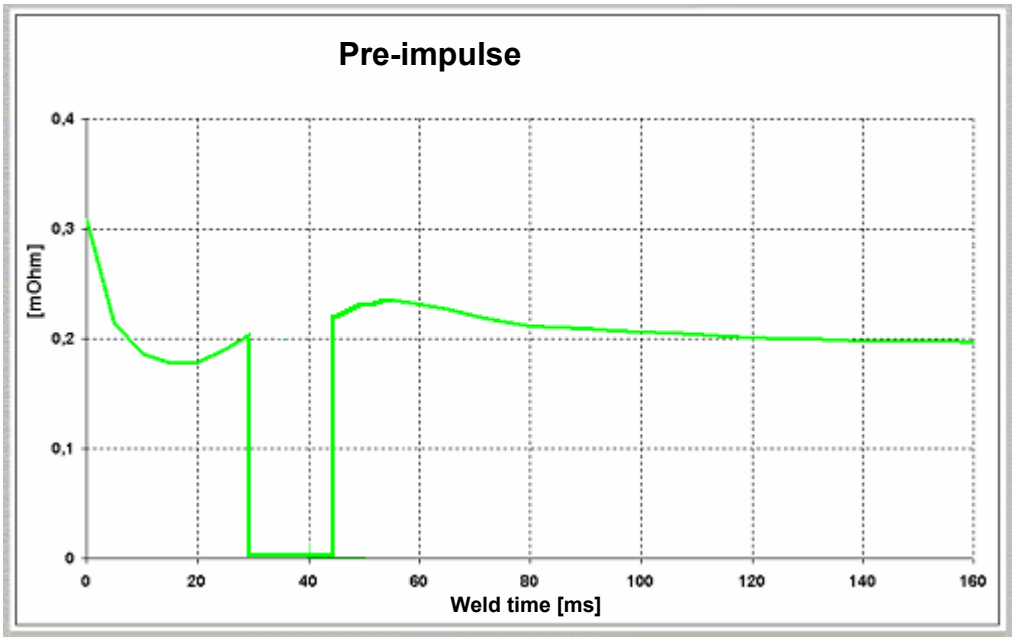
Furthermore, the controller offers the possibility of varying the energy input through “heat correction”. Lowering the heat may also help to eliminate expulsion.

## Optimization of single-pulse welding

The current and the weld time as well as the force must be chosen so as to ensure that the relative maximum of the resistance characteristic occurs before one-half of the weld time has elapsed. With hot-galvanized material, the coupling phase is longer, therefore, the maximum resistance characteristic may also be in the 2nd third of the weld time.

# Optimization of welds with a preliminary impulse

For welds with a preliminary impulse, the most important principle to be applied is that no melting takes place during the preliminary impulse. This is achieved by the corresponding amount of current and impulse duration and a possible cool time. During the preliminary impulse, the resistance characteristic must not yet reach its maximum. The falling edge of the resistance curve must be completely within the main impulse.




Design of a preliminary impulse

# 9 Fault messages

You are informed by the timer of all control-relevant events that might occur during operation.

In principle, distinction is made between

- Faults, and
- warnings.

**In the event of faults**

- no welding sequence can be started
- the READY LED on the timer front panel goes off (refer to timer documentation)
- the "Timer ready" output signal on PSI 6000 is reset.

**In the event of warnings**

- more welding sequences are permitted.

☞ **Whether or not an event is interpreted as a fault or a warning depends on the parameter setting in the timer (BOS, fault allocation).**

Both faults and warnings may be “self-resetting”.

“Self-resetting” means that these events are automatically reset by the timer when the cause of the fault or the warning has been corrected. Therefore, they do not require a manual “Fault reset”.

Examples of self-resetting faults include:

- Stop / No 24V

- Power voltage off/too low

The timer only uses code numbers for signaling faults and warnings. These code numbers are supplemented by plain text in the programming terminal or the line PC. This is designed to save memory resources of the timer and to reduce communication times.

## 9.1 Faults in the welding process

**Fault code** Fault text

**80 – PSQ measuring error in sequence:**

General fault during weld time

*Cause:*

Error in US/UI measurement

*Corrective action:*

Refer to additional PSQ fault message (code 115)

Note: This fault message signals a fault of the controller module and occurs together with an additional fault message.

**81 – PSQ controller error in sequence:**

General fault during weld time.

*Cause:*

Error in US/UI regulation

*Corrective action:*

Refer to additional PSQ fault message (code 115)

Note: This fault message signals a fault of the controller module and occurs together with an additional fault message.

**85 - Reweld:**

The spot weld was automatically repeated. Refer to “Maximum number of repetitions” parameter in BOS.

The spot weld was repeated after “Fault Reset with Reweld”.

*Cause:*

US/UI measurement/regulation not possible

*Corrective action:*

- Check programmable parameter “Maximum number of repetitions” in BOS.
- Check spot weld.

Note: In this case, it is not possible to record a meaningful curve characteristic.

**135 – PSQ sequence aborted:**

Sequence aborted because of error in controller module

*Cause:*

US/UI measurement/regulation not possible

*Corrective action:*

Refer to additional PSQ fault message (code 115)

## 9.2 General errors

Error code 115

**Additional code** - error text

**1 - PSQ hardware fault:**

Initialization fault when switching the timer on or hardware fault of the controller module

*Cause:*

Error during initialization or DPRAM access

*Corrective action:*

- Check firmware version of the controller module and the timer
- Cycle power or Reset timer

**2 - PSQ internal communication fault:**

General error (self-resetting)

*Cause:*

Communication error between the timer and the controller module

*Corrective action:*

If error is permanently present: Check the firmware version

Cycle power or Reset timer

**3 - PSQ temperature fault:**

Temperature fault on controller module (resettable)

*Cause:*

Temperature on controller module > 60 °C

*Corrective action:*

- Cool down, reset fault

**6 - PSQ Watchdog:**

Watchdog fault (can be reset)

*Cause:*

Controller module no longer serves watchdog counter (>100ms)

*Corrective action:*

- Reset fault
- Cycle power or Reset timer

**7 - PSQ not ready:**

Controller module is not ready for new welding sequence (resettable)

*Cause:*

Controller module has not completed processing of previous sequence at program start

*Corrective action:*

- Reset fault
- select longer spot interval, if necessary

**8 - PSQ sequence fault:**

Error during welding sequence (resettable)

*Cause:*

Controller module detects abort or undefined status of timer

*Corrective action:*

- Reset fault
- Reduce load on controller module, if necessary

**11 - PSQ memory deleted**

Memory on controller module deleted (resettable)

*Cause:*

New board was installed in weld timer, or modified memory structure following firmware update

*Corrective action:*

- Reset fault
- Reprogram parameters
- Retrieve parameters with Restore

**12 - PSQ status fault:**

Inadmissible sequence status input from the controller module

*Cause:*

The timer cannot execute the input from the controller module.

*Corrective action:*

- If error is permanently present: Check the firmware version
- Cycle power or Reset timer

**13 - PSQ maximum weld time reached:**

The maximum weld time demanded by the controller was limited

*Cause:*

The weld time must be extended in order to obtain a good spot weld

*Corrective action:*

- Check weld time prolongation and select longer time, if necessary.
- Check spot weld.

**14 - PSQ software fault:**

No new command values from the controller module

*Cause:*

The timer waits for new command values

*Corrective action:*

- If error is permanently present: Check the firmware version
- Cycle power or Reset timer

**15 - Electrode contact fault:**

U/I controller contact fault

*Cause:*

The maximum contact time was reached

*Corrective action:*

- Check maximum contact time and select longer time, if necessary.
- Correct contact problems (adhesive, sealant)

**16 - Electrode voltage measuring loop error:**

U/I controller measuring loop error

*Cause:*

The programmed electrode voltage was not reached during the programmed time

*Corrective action:*

- Check values programmed for the measuring loop test and change values, if necessary.
- Check voltage measuring cable
- Check controller module

☞ **For more fault and status messages of PS 6000, please refer to “Error list PS 5000 / PS6000” (no. 1070 087 001).**

# 10 Accessories

| *Component* | *Part number* |
|---|---|
| **V24/RS232: female 9-pole sub D connector** | 1070 912981 |
| **V24/RS232: cover for female 9-pole sub D connector** | 1070 313723 |
| **V24/RS232: prefabricated cable, length 1.5m** | 1070 066749 |
| **Sensor cable: 2 x 2 x 0.75mm$^2$ LiYCY** | 1070 913494 |
| | |

**Table : List of accessories with part numbers**

# 11 Abbreviations, terms

| | |
|---|---|
| **BOS** | Welding GUI |
| **BQR** | User interface for U/I controller |
| **CAN** | **C**ontroller **A**rea **N**etwork: data bus |
| **CT** | Cool time, time between the current impulses/blocks (1., 2., 3. CT) |
| **ED** | Duty cycle: Ratio between weld time and time without current flow |
| **EST** | End slope time, current slope at the end of the 2.WLD |
| **Ext** | External, e.g. +24V voltage for signal transmitters (switches) and actuators (valves) outside the timer |
| **HT/%I** | Heat in SKT (scale values/pulse width) or kA |
| **I/O** | Input / Output |
| **Ignition** | Ignition, firing pulses for triggering the power unit are switched on and off |
| **kA** | Kilo-Ampere (amount of current) |
| **kN** | Kilo-Newton (pressure) |
| **KSR** | Constant-Current Regulation, i.e. the current in the secondary circuit is kept at a constant level by this control mechanism |
| **KUR** | Constant-Voltage Regulation, line fluctuations are balanced |
| **LAN** | Local Area Network: General network |
| **LT** | Power unit (thyristor or inverter) |
| **PG** | Programming terminal/welding computer |
| **PHA** | Heat value |
| **PSG** | Transformer-rectifier unit for the PSU/PSI inverter |
| **PSI** | Medium-frequency power unit (1000 Hz) |
| **PSL** | PS power unit |
| **PSQ** | Quality assurance system |
| **PSS** | PS timer unit |
| **PST** | Thyristor power unit (50/60 Hz) |
| **PSU** | Welding current inverter (medium-frequency) |
| **SKT** | Scale divisions, represent an electrical heat value or pulse width |
| **Slope** | Current increase from an initial to a final heat value |
| **Solenoid** | Solenoid valve, drives the cylinders for closing the electrodes |
| **SQZ** | Squeeze time that runs before the weld time. The electrodes squeeze the parts to be welded together. |
| **SST** | Start slope time, current slope at the beginning of the 2.WLD |
| **Stepper** | Heat stepping in order to compensate for electrode wear |
| **Temp** | Temperature |
| **UDM** | Ultrasonic data processing module (front-end) |
| **UIR** | U/I controller |
| **ÜK** | Monitoring contact |

| | |
|---|---|
| | e.g. for monitoring the pressure inside the cylinder that closes the electrodes or monitoring of the electrode position, e.g. gun closed |
| **US** | **U**ltra**s**onic |
| **USE** | Ultrasonic sensors |
| **USP** | Lower intersection |
| **USR** | Ultrasonic controller |
| **USW** | NEXUM operating data and statistics management software |
| **WLD** | Weld time |
| **2.WLD** | 2. Weld time, main welding time, may consist of a block comprising individual impulses; only the 2nd WLD can be programmed with an upward and downward slope. |
| **WT** | Weld timer, also referred to as resistance weld timer |
| **XQR** | Controller module |

Rexroth
Bosch Group

Bosch Rexroth AG
Electric Drives and Controls
Bgm.-Dr.-Nebel-Str. 2
97816 Lohr a. Main, Germany
info@boschrexroth.de
www.boschrexroth.de