DRPP Dutch Reverse Pulse Plating

USER MANUAL

REVERSE PULSE POWER SUPPLY

DPP-4_12

Author:	R. Kee.
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Dutch Plating Power B.V.
Meerheide 48-50, 5521 DZ, Eersel
The Netherlands

Sales Information and Customer Support:

Dutch Reverse Pulse Plating B.V.
Takkebijsters 41
4817 DL, Breda.
the Netherlands
Phone: +31 – (0)497 – 519499
Fax: +31 – (0)497 - 519498
E-mail: info@drpp.nl
Internet: www.drpp.nl

Technical Support:

Dutch Reverse Pulse Plating B.V.
Meerheide 48-50
5521 DZ Eersel
the Netherlands
Phone: +31 – (0)497 – 531753
Fax: +31 – (0)497 – 531754
E-mail: sales@dutchplating.com
Internet: www.dutchplating.com

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1. Introduction

The DRPP4 Reverse Pulse Power Supply is designed to produce four independent adjustable DC output currents with an adjustable reverse current pulse. The output currents can be set individually, so you can create four different output currents.

The supply can be controlled by the keyboard unit found at the front of the supply. This unit contains an LCD-display and 4 buttons which give you access to a menu structure to control the supply. (See chapter 3)

A more easier way to control the supply is to use a serial connection to a personal computer or a PLC. The supply contains one RS-232 connector and two RS-485 connectors to communicate with either a PC or a PLC. (See chapter 5)

2. Functional description

2.1. Output current wave form

As been described in the previous chapter, the supply produces two current wave forms. An example of a current wave form is shown in figure 2.1.

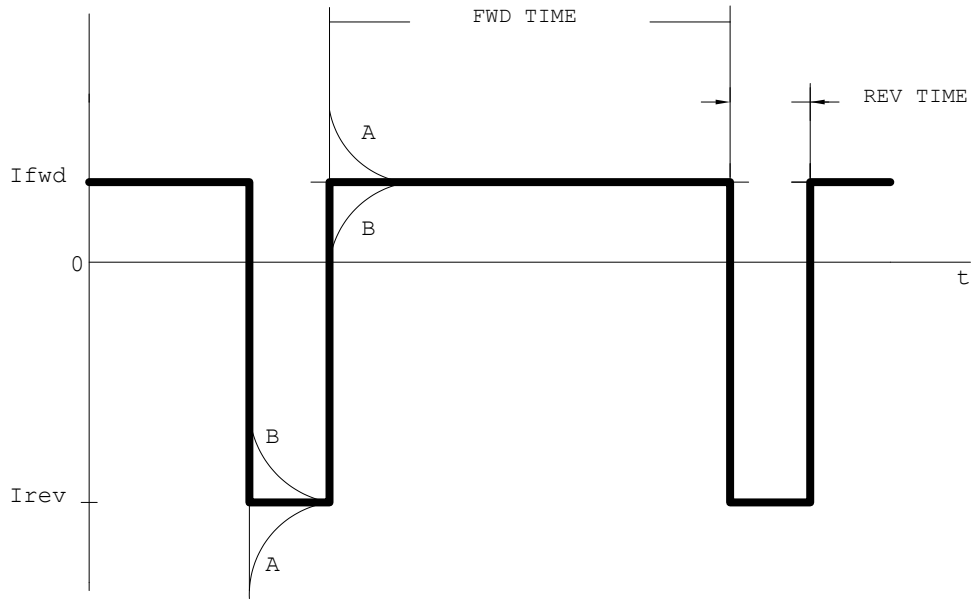


Figure 2.1 : Example of a current wave form

The wave form can be split into two parts: a forward current (Ifwd) and a reverse pulse current (Irev). So for each output current, you can set the forward current and the reverse current. Also, the forward time and the reverse time can be set. The forward time can be set from 2.00 to 500.00 msec, while the reverse time can be set from 0.10 to 6.50 msec.

However, the maximum reverse time is limited by the following formula:

$$RevTime_{max} = \frac{(Irev_{max}/Irev)^2 * 20000\ \mu s}{2 * \text{output frequency}} \quad [\mu sec]$$

with a minimum of 0.10 msec and a maximum of 6.50 msec.
Also, the maximum RevTime is limited to FwdTime/2.

2.1.1. DC Mode

The supply is also able to generate a DC current instead of a pulse current. When the supply is in DC mode, only the forward current is generated.

2.2. Automatic setup correction

The supply contains an automatic wire inductance compensation. When you use long wires, the wave form will look like curve A or B (see figure 2.1). To approve the wave form, the supply measures the current at the begin and end of the reverse pulse. In this way, the inductance can be compensated by the supply by adjusting the wave form. So the supply makes sure that the output currents will be adjusted automatically, when the output current changes.

2.3. Setting the output currents/voltages

The supply can run in two modes : current controlled output or voltage controlled output. This means that you can select on what settings the output current will be controlled.

If you select a current controlled output, you can set the desired output currents. If you select a voltage controlled output, you can set the desired output voltages.

Once you've set the output settings, the supply will generate the output currents in a closed loop. This means that all output currents and voltages are measured. The supply will adjust the output wave form so that the measured values equals the output settings. This means that if the resistance of the output changes (like a short-cut), the supply will measure different values and they will be adjusted to the desired values again.
Acc. Time is the time that is necessary to ramp up from "0" to the maximum current.
So if the setting is 10 seconds, and the maximum current is 300 Amp, the ramp-up will be done with 300 / 10 = 30 Amperes per second.

2.4. "Supply off" conditions

The supply offers the possibility to set a different output setting, FwdTime and RevTime for the "off" condition. This means, that when you turn the supply off, the output wave form will be set to this "off" conditions, and not to zero! (Unless you enter 0 to these conditions).

Again, these settings are completely independent of the normal output current settings.

When you turn the supply back on, the normal output conditions will be set again.

When you turn the supply off, and the FwdTimeOff is set to zero, the FwdTimeOff will be set to the normal FwdTime. The same goes for the RevTimeOff. If the RevTimeOff is set to zero, it will be set to the normal RevTime.

2.5. Relay outputs

The supply has three programmable relay outputs. These can be used for feedback to external control devices. Each relay can be set into 4 modes: 0, 1, NO, NC.

- 0 : The relay output is always 0
- 1 : The relay output is always 1

- Normally open (NO). The relay is deactivated by the supply when its function is activated. So if an error occurs, the fault relay will be deactivated.
- Normally closed (NC). The relay is set by the supply when its function is activated. So if an error occurs, the fault relay will be activated.

There are three relays : FAULT, RUN and STOP. The fault relay is activated when an error occurred (like overvoltage). The run relay is activated when the supply is running and the stop relay is activated when the supply is turned off.

2.6. Fault handling

The supply can detect the following errors:
- *Phase-loss*. This error means that the input voltage of one or more lines is to low. To solve this problem, turn the supply off and check your input voltages.
- *Charging*. The supply is charging its DC link. As soon as the DC link has its correct voltage, charging disappears. (This code should only appear when you turn on the supply.)
- *Charging error*. The supply has a problem charging its DC link. Turn the supply off and contact DPP.
- *Overvoltage fwd1*. This error occurs if the measured forward voltage is higher than the forward trip level. So if you set the forward trip level to 6.50 V, and the measured value is 7.21 V, an overvoltage error occurs.
- *Overvoltage rev1,fwd2 and rev2*. Same as above.
- *Overcurrent fwd1*. This error occurs if the measured forward1 output current is too high. The current trip levels are set at about 130% of the maximum output current. So if the maximum output current is 900A, and the supply measures 1521A, an overcurrent error occurs.
- *Overcurrent rev1, fwd2 and rev2*. Same as above.
- *Temperature error*. The temperature in the supply is too high.
- *SupplyType error*. Error with the supplytype selection.
- *Internal comm error*. Communication with front board failed.

The voltage trip levels can be set by the menu. This means that you can enter at which measured forward voltage, the supply will generate an overvoltage error. The supply also contains a function to disable the overvoltage checking.

All other error checks are always active.

2.7. Parameters storage into memory

The supply contains a memory to store all parameters into. Each time a parameter is changed (for example: any current, address etc), this parameter is stored into the memory. Next time you switch the supply on, all last parameters are read from the memory and are set. So when you change the address, voltage trip levels, output currents etc, they will be hold in the memory.

The supply has a “Load Defaults” command to clear the memory chip and set all parameters to their default values. This will be done for all parameters, except the communication address and the service parameters.

2.8. Locking/Unlocking the front panel

Like explained in the first chapter, the supply can be controlled by a keyboard unit at the front of the supply and through a serial port. The supply offers the possibility to disable all front keyboard controls (The LED displays are not disabled). So this means that from than on, the supply can only be controlled through the serial port, until the front keyboard is enabled again. When the front is disabled, this setting will be stored into the memory chip.

This option can be useful if the supply is controlled by a PLC or PC system, and nobody else should be able to change a setting.

2.9. AmpHour calculation

The supply contains a counter which tells you how many AmpHour the supply has made. This counter is continuously updated when you are making any output currents and is stored in the internal memory of the supply. So the counter is NOT reset when you turn the supply on again.

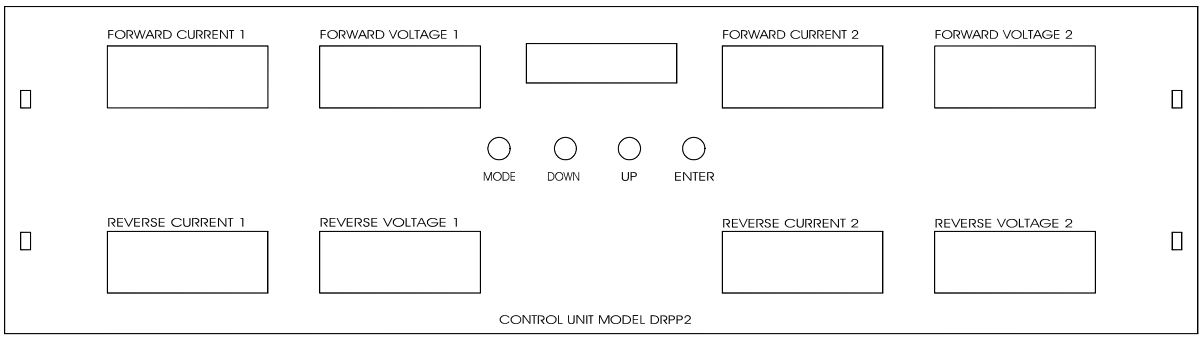
The counter value can be accessed through the serial communication port or the keyboard unit.

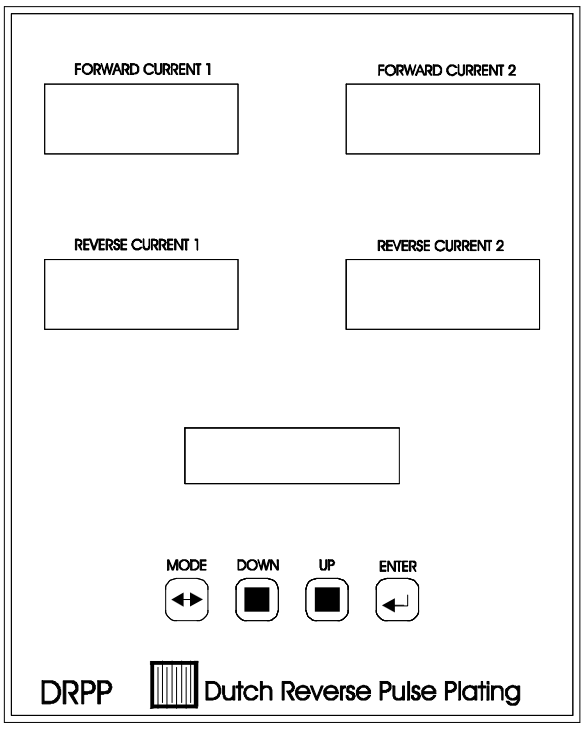
3. Keyboard control

3.1. Keyboard functions

The supply can be controlled by the keyboard unit found at the front of the supply. The control unit has a keyboard unit and some LED display units to show the measured values.

Each supply has one of the following two front units. Each unit contains an LCD-display and 4 push buttons:





This unit gives access to a menu to control the supply. When the menu is not activated, the LCD-display shows the status of the supply. The keyboard unit is controlled by 4 buttons:

MODE The MODE button activates/deactivates the menu. When you press the MODE button, the menu will be activated. If you press the MODE button while you are in the menu, the display will return to its original state and will show the status of the

supply.

DOWN The DOWN button can be used to step one item down in the menu structure or to decrease the value of a menu parameter.

UP The UP button can be used to step one item up in the menu structure or to increase the value of a menu parameter.

ENTER When you are in the menu, and you have selected the menu item you like with the UP/DOWN buttons, you can press the ENTER button to enter the selected menu item. After you've changed the value, you can press the ENTER key to send this new value to the supply. (If you press the MODE button, the display will return to its original state, and the new value will NOT be send to the supply!)

3.2. Keyboard menu structure

The keyboard gives access to most parameters. The keyboard has a menu structure, which contains several sub-menus. The complete menu structure (including sub-menus) contains the following items:

1. Current Menu
    - I Forward 1
    - I Reverse 1
    - I Forward 2
    - I Reverse 2
2. Pulse Menu
    - Fwd Time
    - Rev Time
    - DC Mode
    - Fwd Time Off
    - Rev Time Off
3. Supply ON/OFF
4. Voltage Menu
    - V Forward 1
    - V Reverse 1
    - V Forward 2
    - V Reverse 2
5. Relay menu
    - Run Relay
    - Stop Relay
    - Fault Relay
6. Off Cur Menu
    - I Forward 1 Off
    - I Reverse 1 Off
    - I Forward 2 Off
    - I Reverse 2 Off
7. Off Volt Menu
    - V Forward 1 Off
    - V Reverse 1 Off
    - V Forward 2 Off
    - V Reverse 2 Off
8. Misc Menu
    - RS 485 Address
    - VTrip Enable
    - VFwd1 Trip Level
    - VFwd2 Trip Level
    - Loop Type
9. AH Count
10. Load Defaults
11. Reset Supply

4. Communication program

The communication program controls the supply by a RS-485 connection. The communication program can view/change all settings of the supply.

4.1. Installation

Never use the original distribution disk as your working disk. Make a backup copy of the supply communication diskette using the DOS **DISKCOPY** program, then label the new copy and store the original disk in a safe place.

If you have a hard disk, create a new directory for the supply software and copy all files from the distribution disk to that directory:
For example (store the program in c:\DPP2)

```
CD \
MD DPP2
CD DPP2
COPY A:*.* C:
```

For information on using the DOS commands, refer to your *DOS User's Guide*.

4.2. Starting the program

The supply software command line has the following form:

```
SUPPLY [options]
```

As you can see, the program can be started with some commandline options:

Option	Description
/? or /H	Show these commandline options
/DEMO	Bypass all communication (for demonstration mode)
/HEAP	Shows free memory at lower right corner. This options is mostly used for debugging the program and probably won't be used by any user.
/LICENSE	Display program conditions

You can specify these options in any order, and in any combination.

After you type SUPPLY, the program shows the about window, showing the version, date and copyright information about the program. This window can be closed by pressing the ENTER or ESC key, or by pressing the OK button.

Then, the serial setup window appears, in which you can enter your serial communication settings, such as the COM-port and address.

4.2.1. Starting the program in DEMO mode

The following command starts the software in demonstration mode:

```
SUPPLY /DEMO
```

In the demonstration mode, all communication is bypassed. This means that the communication won't work. The program will simulate a DRPP2/1800 supply. So you can demonstrate the functions of the software, without connecting a supply.

4.3. Using the menu bar

The menu bar at the top of the screen is the gateway to the menus:

There are three ways to select a menu command:

F10 — Press F10, then use the arrow keys to go to the menu you want and use them again to select a command. Press Enter to choose the selected command.

Alt — Press Alt and the highlighted letter of the menu you want (such as Alt+F for the File menu), use the arrow keys to select a command, then press Enter to choose that command.

You can also press the highlighted letter of a menu name of command instead of using the arrow keys.

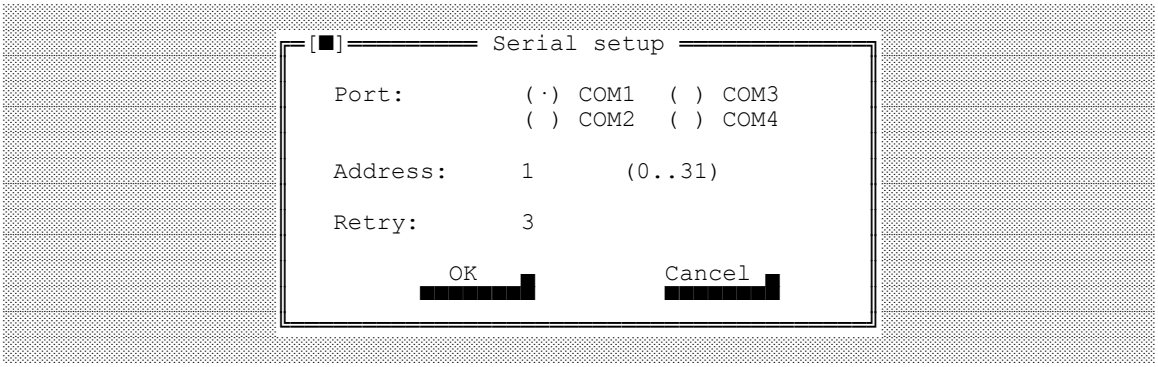
[≡) Mouse — Click the title of the menu you want to pull down, then click the menu command you want to choose.

The highlighted menu title is the currently selected menu.

Some commands are followed by a hot key. A hot key is a two key combination you can press to enact a menu command directly, without pulling down any menus. (Such as Alt+X stands for the Exit command).

4.4. Using the windows

Most windows contain one or more edit fields, and mostly one or two buttons. As an example, we show the Serial setup window:



You can select an item by pressing Alt and its highlighted letter (if there is one). Another way to select an item is to use the TAB key. The TAB key selects the next item in the list of items. The third way to select an item is to use the mouse: click on the item you want.

This window contains 2 text fields (Address, Retry), and one selection field (Port).

The edit field is used to enter a value. It is a normal input field, where you can use the backspace, del, insert and arrow keys.

The selection field is a field where you can select one of the given items. So for the com-port field, you can select your desired com port. So only one item can be selected! You can select an item by pressing the space bar or a mouse click. To select another item, use the arrow keys or the mouse.

The window also contains two buttons. If a window contains an OK button, this means that the window will be closed and all settings are stored into memory or are send to the supply. Pressing the Enter key has the same effect as pressing the OK button.

If the window contains a CANCEL button, this means that the window is closed, but the settings in the window are NOT stored into memory and are not send to the supply. This means that the old settings stay in memory. Pressing the escape key has the same effect as pressing the CANCEL button.

4.5. The help function

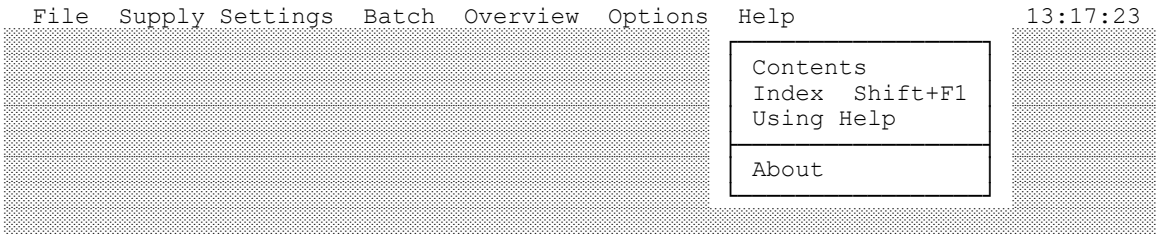
The communication program contains a help function to get help about the menu options, error messages etc.

There are two types of help provided by the program. The first is a single line text at the bottom of the screen (the status-line). This status line contains a few commands and a text help line about the currently active window/menu-item.

For example, if you select the “open file” command, the status line should look like this:

```
F1 Help │ View/Edit a text file
```


The help menu at the menu bar contains four menu items :



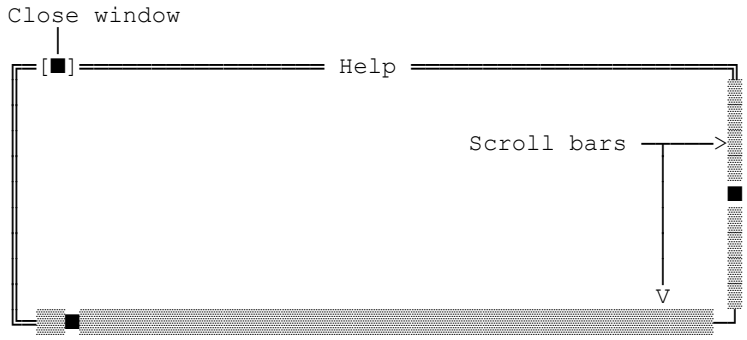
1. **Contents**. By choosing this item, a help-window will appear with the contents of the help function.
2. **Index**. This menu item shows a list of all help items of the help function in alphabetical order.
3. **Using help**. This menu item shows a window which tells you how to use the help function. It contains about the same text as described in this paragraph.
4. **About**. The about function shows copyright and version information about the program.

4.6. Using the help function

F1

Wherever you are, you can press the F1 key to view a help screen about the menu command or window that's currently active.

This context-sensitive help (and many other windows) comes up in the following window-style:



You can read all of the screen by using the cursor keys, page up/down keys or the scroll bars. This window (and many other windows) can be closed by pressing the ESC key or by clicking the "close" button at the top-left of the window.

F1 F1

Once you're in the help system, press F1 again to pop up the How to Use Help screen.

If you're not in the help system, you can also choose Using Help from the help menu.

ALT+F1

When you're in the help system, you can press ALT+F1 to go back to a previous Help screen.

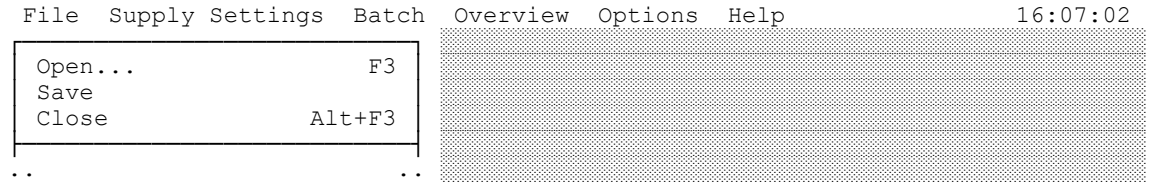
Most help screens have some highlighted items ("Help keywords") on them that lead to another help screen. (These highlighted items are colored yellow).

Tab — You can press the tab key to jump to the help keyword you like, and then press enter to view the help screen attached to the keyword.

[≡) Mouse — If you're using a mouse, just click the help keyword you're interested in.

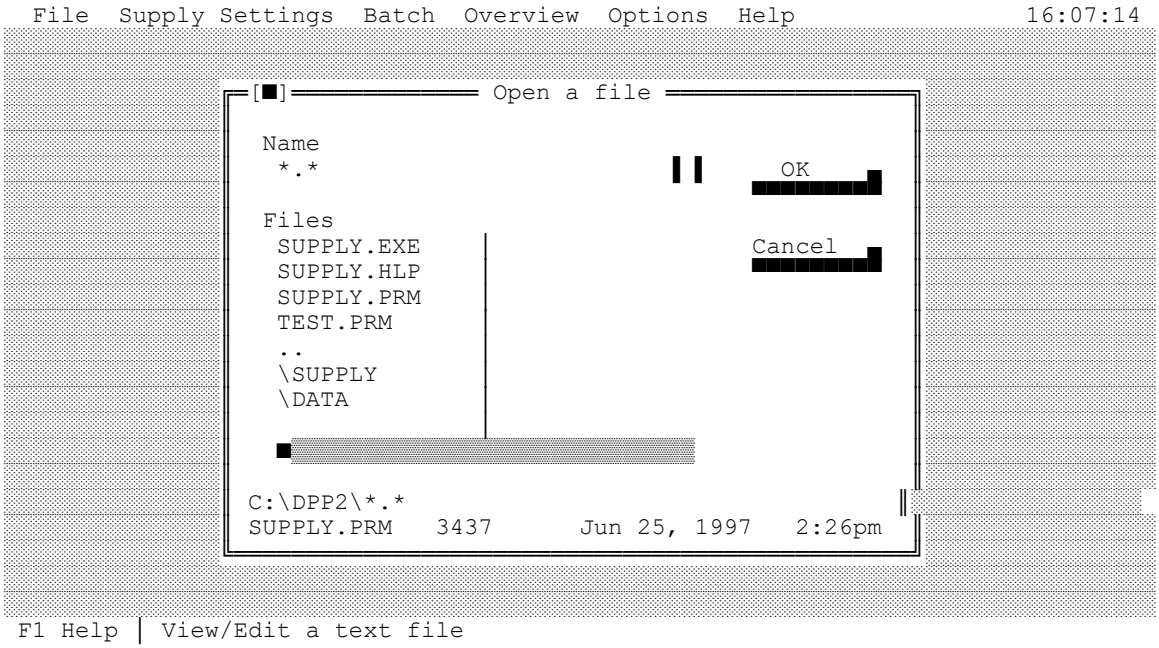
4.7. Editing files

The supply software offers the option to view/edit small text files. This options is mainly used to view/edit your parameter files and your log files. The editor functions are situated in the File menu at the menubar:



Opening a text file

The open command displays the Open a File window. In this window, you can select the file you want to view. You can also open a text file by pressing the F3 key.



The "Name" input box is where you enter the name of the file to open, or the filename mask to use as a filter for the "Files" list box (for example, *.LOG).

The "Files" list box lists the names of files in the current directory that match the filename mask in the "Name" input box, plus the parent directory and all subdirectories.
The "File information" panel shows the path name, file name, date, time, and size of the selected file.

Saving a text file

The "Save" command saves the text file that's in the active window to disk. The program opens the "save file" window, so you can rename the file and save it in a different directory or on a different drive. The "save file" window has the same style as the "open file" window.

Closing a text file

The "Close" command closes the currently opened text file. You can also click the close box in the upper left corner or press Alt+F3 to close a window.

4.8. Loading/Saving parameters from/to disk

The program includes functions to load or save all parameters of the supply. This means that you can save your supply settings to disk, and later on, can reload them into the supply.

Load parameters from disk

This command loads a parameter file from disk and sends the parameters to the supply. The parameter file is an ASCII text file, which you can view/edit with the open a file command. (See the *Editing files* paragraph).
After you choose the load parameters command, a "open a file" window appears. (See the *Editing files* paragraph on how to use this "open a file" window.)

After you've selected the parameter file, the program loads the file into memory and sends all parameters to the supply.

Saving parameters to disk.

This command saves all parameters of the supply to disk. After you choose this command, a "save file to" window appears. (See the *Editing files* paragraph on how to use this window).

After you've entered the file name, the program receives all parameters from the supply and saves them into the entered file name.

4.9. Logging data to disk

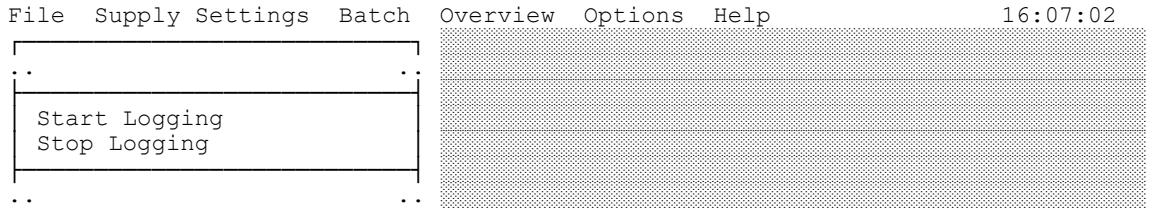
The program offers the option to save measured data from the supply to disk at a given timebase. So if you set the timebase to 10 minutes, the program adds a new line of measured data to the logfile every 10 minutes. This timebase can be set in the Options menu with the Program settings command.
The log file is an ASCII text file. This file has the following lay-out:

```
DPP2 Supply Log File

Created on Monday 16-Nov-1998

Time        IFwd1 IRev1 VFwd1 VRev1 IFwd2 IRev2 VFwd2 VRev2 FwdTime RevTime ON/OFF  Status
=============================================================================================
11:01:42       20    60  2.20  2.80    20    60  2.22  2.86   10.00    1.00   ON    Supply OK
11:01:52       19    62  2.20  2.75    20    59  2.25  2.86   10.00    1.00   ON    Supply OK
11:01:02       20    59  2.22  2.80    21    60  2.22  2.87   10.00    1.00   ON    Supply OK
11:01:12       20    60  2.19  2.79    20    60  2.22  2.85   10.00    1.00   ON    Supply OK
11:01:22       21    60  2.20  2.80    20    62  2.24  2.86   10.00    1.00   ON    Supply OK
```

There are two commands for data logging, and they are situated in the File menu:



Start logging

The start logging commands start the logging of measured data. Remember that before you start the logging, you can set the log time base in the program settings window!

When you activate the data logging, the program puts a window on screen, so you can see that the logging is active.

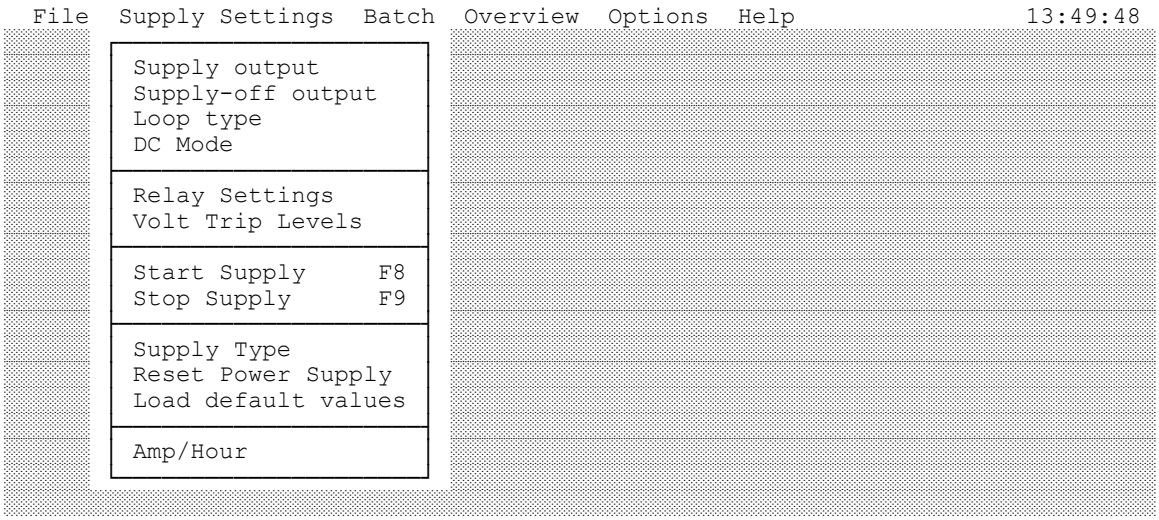
Stop logging

The stop logging commands stops the logging of measured data. After you stop the logging, the program will ask you to give a file name to store the logged data in. For information on how to use this window, see the *Editing files* paragraph.

After the data is saved, this file will automatically be opened into a text file, so you can view the logged data. You can close this file with the Close command in the File menu, by pressing the close box at the left upper corner, or by pressing Alt+F3.

4.10. Running the supply

All parameters needed to set the output currents, are found in the “Supply Settings menu”:



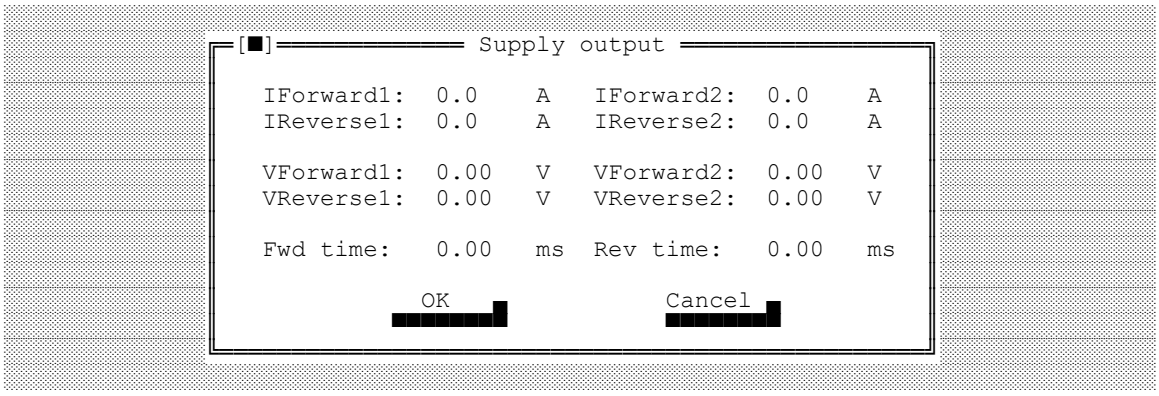
The supply contains a closed loop to control either the output current or the output voltage. To select which output is controlled, use the “Loop type” command. After you’ve selected the loop type, you must set the output currents or voltages and the FwdTime and RevTime. All these parameters can be found in the “Supply Settings menu” with the “Supply output” command.

When all these parameters are set, the supply can be turned on. You can also change the settings while the supply is turned on.

Warning: When you programmed a batch and want to run the batch, you shouldn't use this start command, but the start batch command! This will be explained more in the "Batch Operations" paragraph.

Setting the supply outputs

The output currents can be set with the “Output current” command. This command opens a window where you can enter the desired parameters:



You can set both the currents and voltages. By selecting the LoopType, you can select each setting.

For the small supplies (DPP2/150 and DPP2/300), the current resolution is in 0.1A. For all other supplies, the current resolution is 1A.

The forward time can be set from 2.00 to 500.00 msec, while the reverse time can be set from 0.10 to 6.50 msec. However, the maximum reverse time is limited by the following formula:

$$RevTime_{max} = \frac{(Irev_{max}/Irev)^2 * 20000\ \mu s}{2 * \text{output frequency}} \quad [\mu sec]$$

with a minimum of 0.10 msec and a maximum of 6.50 msec. Also, the maximum RevTime is limited to FwdTime/2.

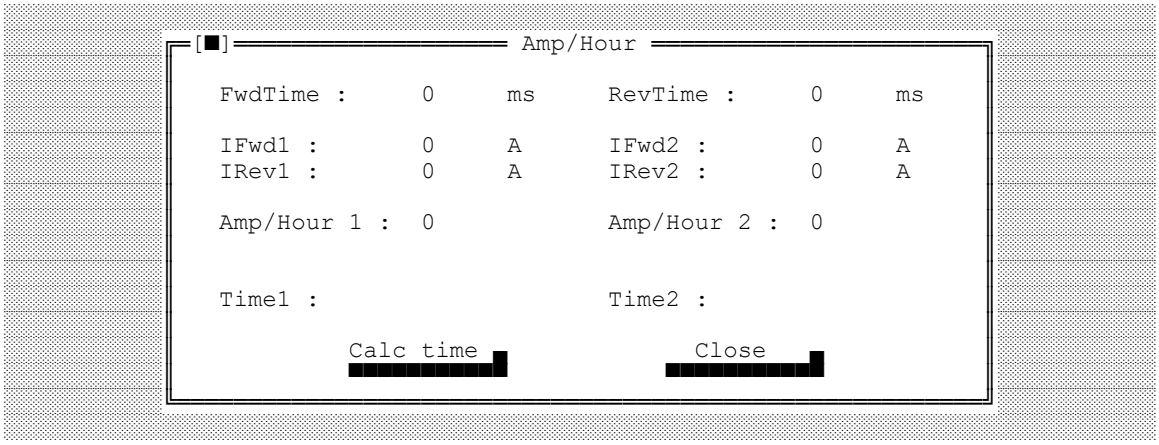
DC Mode

With the DC Mode command, The supply generates a DC current instead of a pulsed current. This means that no reverse current is made in DC mode.

4.10.1. AmpHour calculation

The "AmpHour" command calculates the time the supply must be running for a given AmpHour value.
First, the program will receive the settings (current, fwdtime and revtime) from the supply and put them in the window. You can change this settings if you like, to experiment with the AmpHour value and time. (These new settings WON'T be written to the supply!).

You can enter the desired Amp/Hour values and press the "Calc times" button to calculate the time that the supply should be turned on for the entered current values.

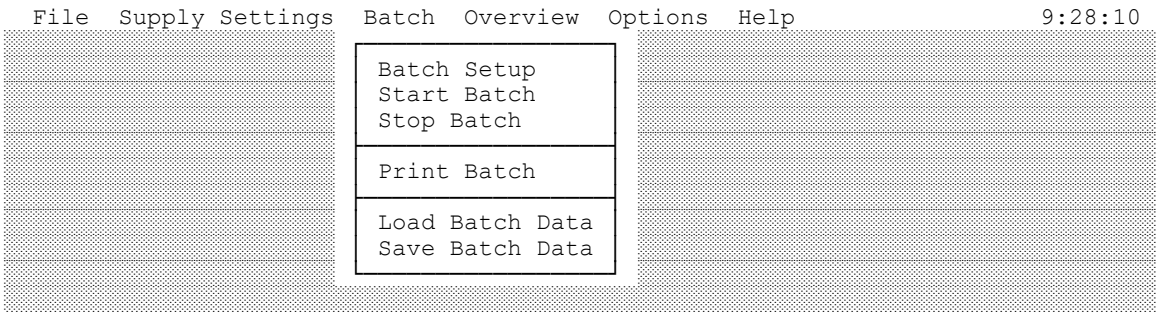


As you can see, the Amp/Hour and time can be calculated for both outputs.

4.11. Batch operations

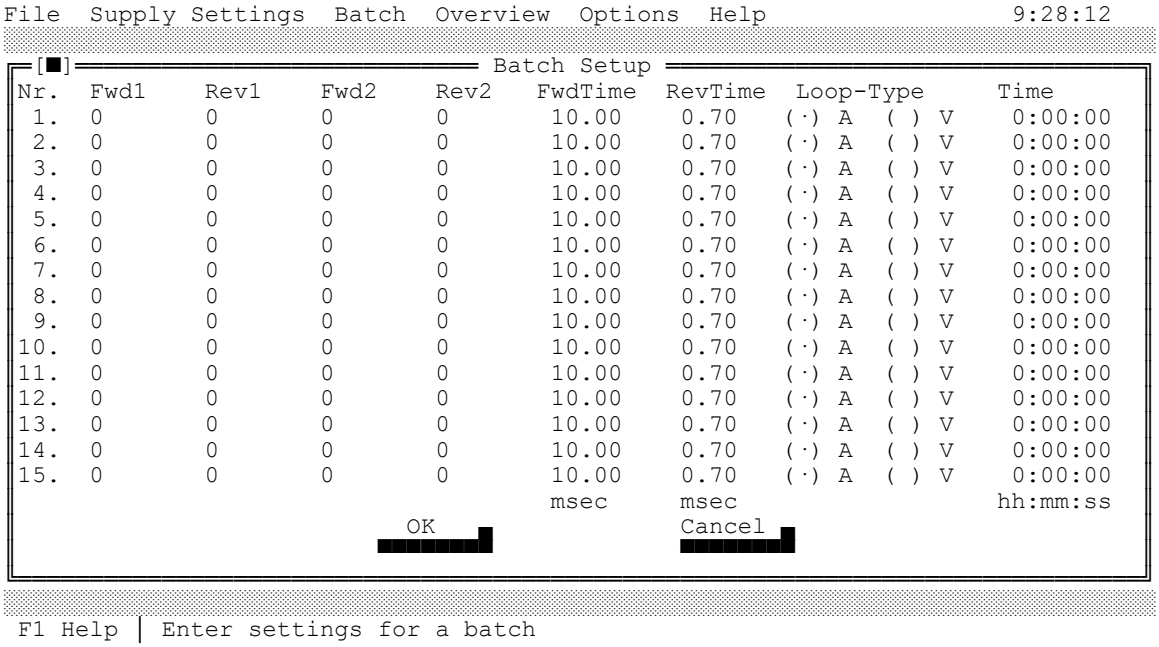
The batch option makes it possible to enter maximal 15 sets of supply settings. Each set contains the following supply settings: Fwd1, Rev1, Fwd2, Rev2, FwdTime, RevTime, loop-type and time. So you can enter 15 sets of settings, and give each set a time. When you start the batch, the settings of the first batch set will be send to the supply. After the time for set 1 has expired, the settings for set 2 are send etc. So this option makes it possible to send 15 different sets for 15 different times to the supply to generate 15 different output currents.

The “batch” menu contains the following commands :



Batch Setup

The “Batch Setup” command is where you enter the values for each set. When you select this command, the following window appears:



For each batch nr, you can set the Fwd1, Rev1, Fwd2 and Rev2 setting. By setting the loop-type, you can select if your settings are currents or voltages. The other two parameters you can set are FwdTime and RevTime.

The time setting determines the time a batch number is active. This time must be entered in the following format : **hh:mm:ss** or **mm:ss**.

If you do not wish to use all 15 sets, you can make the time for those sets 00:00:00 and the program will skip these sets. (The default time for each set is 00:00:00).

After you've set these batch settings, you can start the batch.

Start batch

Choose this command to start the batch. The settings of the first batch number are send to the supply and the supply is turned on. On screen, a window will appear which tells which batch nr is currently active and the time remaining for that batch. When the last entered batch time is finished, the supply will be turned off automatically.

Warning: Be sure to use the "Start Batch" command instead of the "Start Supply" command in the "Supply Settings" menu. If you choose "Start Supply", the batch won't be started!

Stop batch

This command stops the batch. The supply will be turned off. Be sure that you use the "Stop Batch" command instead of the "Stop Supply" command!

Print Batch

This command sends all batch data to the printer. After you choose this command, the program asks you to confirm the print. You can press Yes to confirm.
You can select the desired printer port in the "Program Settings" menu.

Load batch Data

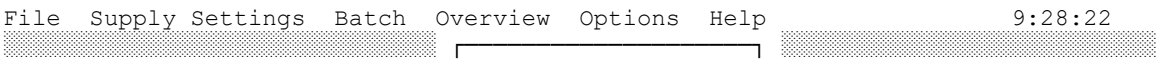
With the "Load Batch Data" command, you can retrieve a batch you saved to disk. After you choose the load batch command, a "Open" window appears. (For more information about this window, see the *Editing Files* paragraph). After you've selected a filename, the batch data of this file are loaded into memory.

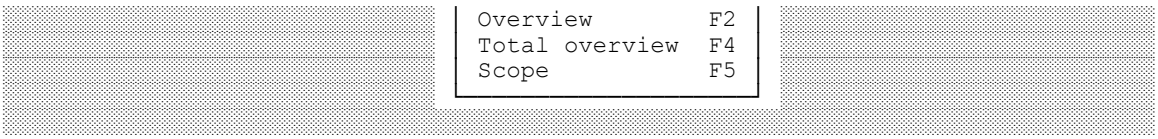
Save batch Data

The "Save Batch Data" command saves the batch data in memory to disk. After you choose this command, a "Save" window appears. (For more information about this window, see the *Editing Files* paragraph). After you've entered a filename, the batch data is saved from memory to disk.

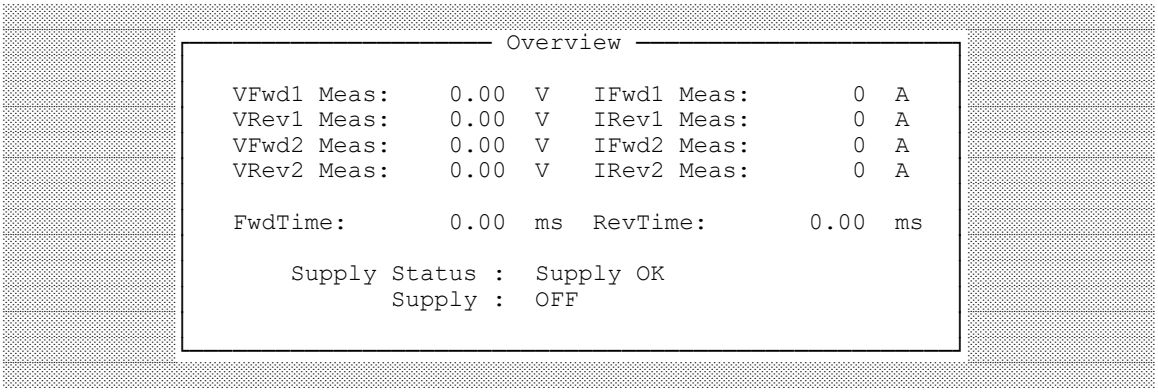
4.12. Overview

An overview window gives a continuous overview of the measured values and the status of the supply. The program can activate two independent overview windows.





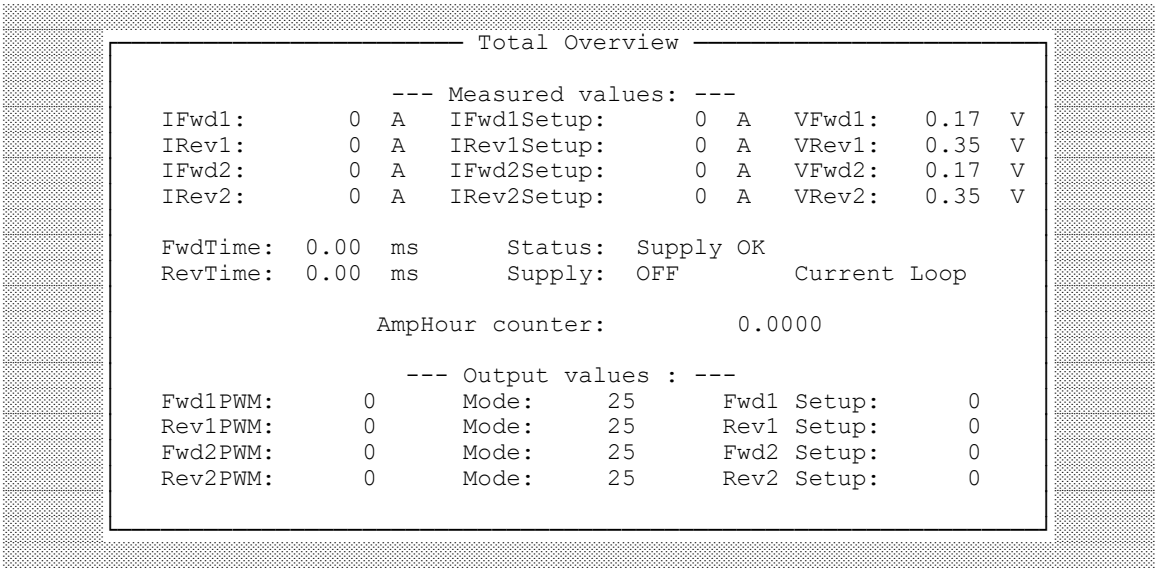
The simplest overview screen can be activated by the "Overview" command or by pressing the F2 key. This command toggles the overview window on/off. So if you want to close the overview window, just press F2 again.
The overview window contains the basic measured values, like currents and voltages:



While the overview window is opened, all other menu functions are accessible. So during overview, you can view/set all supply settings. (The overview window keeps on refreshing its values).

The second overview window ("Total Overview") is a more detailed one, and is mostly used for test-reasons or service.

This window can be activated by the F4 key and looks like this:



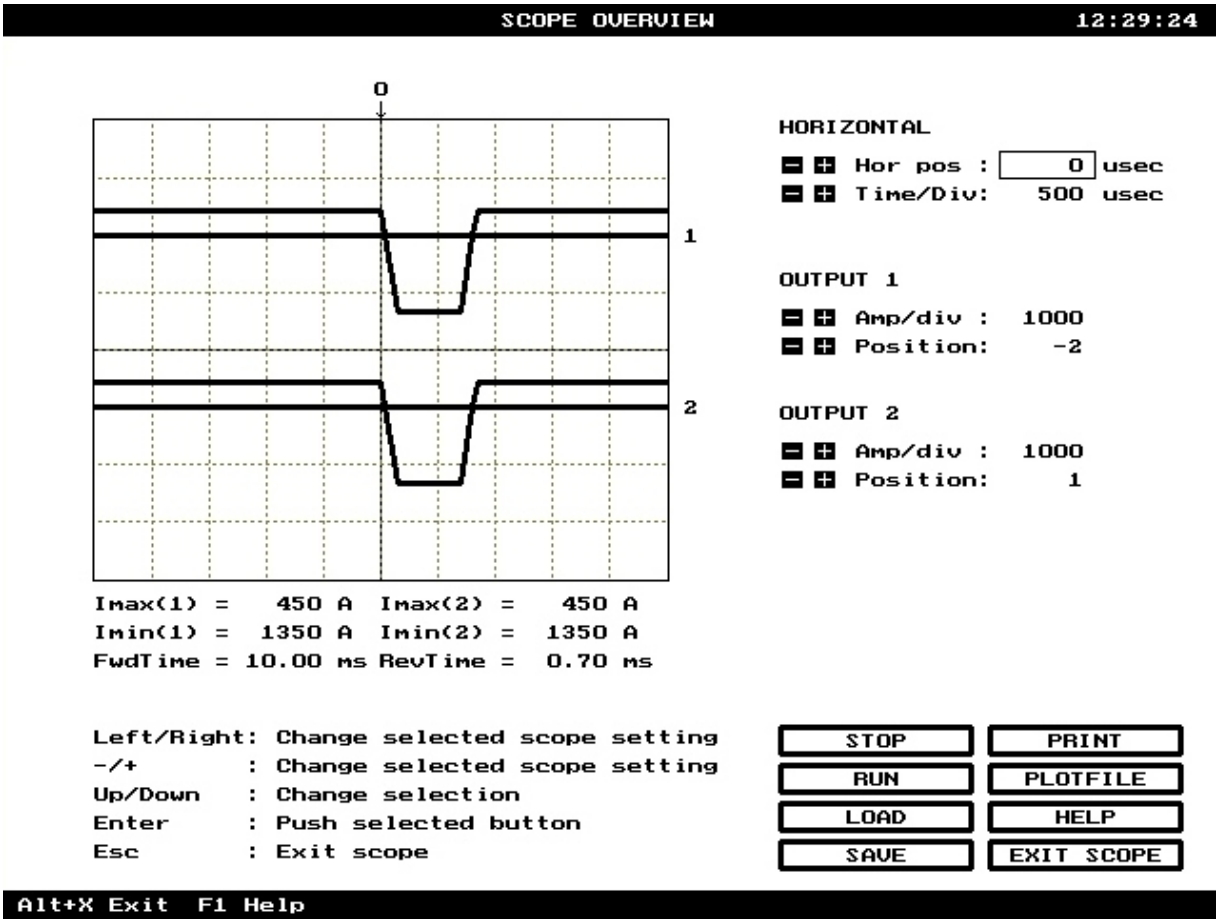
As you can see, this window not only contains measured values, but also some output values which tells us more about the currents and the amphour counter.

4.13. Scope function

A different way of displaying the measured values is the scope function. This function displays the two output currents in a graphical way. This command simulates an oscilloscope in which you can see the output currents.
While you are in the scope function, the data logging and batch functions are still active.

Warning: The waveforms displayed in the scope are not real output currents! The displayed waveforms are calculated from the measured currents, setup currents and setup times. Therefore the scope won't display noise, or any faults in the output currents that may be visible on a normal scope!

When you start the scope function, the following screen appears:



The scope can be operated with the following keys:

- LEFT/RIGHT : Change selected scope setting
- UP/DOWN or -/+ or TAB : Change selected value
- ENTER : Push selected button
- F1 : Help screen for scope
- ESC or ALT+X : Exit scope function

Any pushbutton can also be pressed by pressing its highlighted letter. (For example: The 'L' from LOAD is highlighted, so by pressing the 'L', the LOAD button is pushed).

The second way to operate the scope is by using the mouse. You can click on a desired button or click on a setting to change its value.

The scope has the following settings:

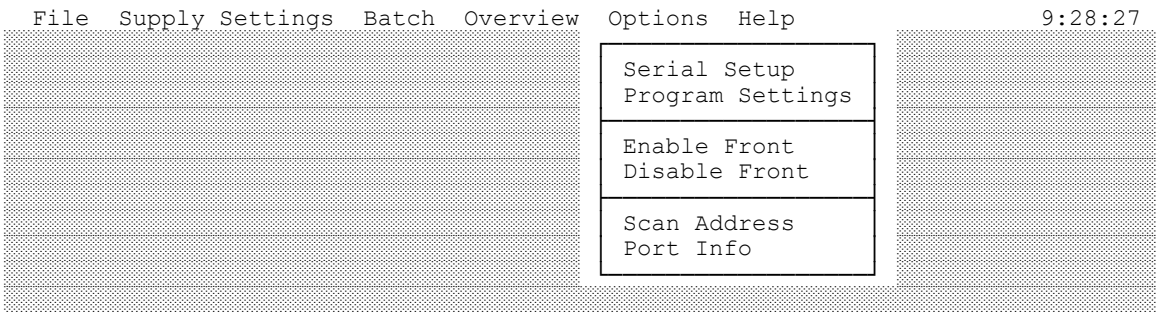
HORPOS	:	Horizontal position of pictures in µsec. By changing this value, you can move the picture to the left or right.
TIME/DIV	:	Time in µsec for each division. If you change this setting, you can take a more detailed look at the pulse or view several pulses in one screen.
OUTPUT1		
AMP/DIV	:	Amps for each division. By changing this value, you can amplify the waveform.
POSITION	:	Vertical position of ouput1 current. This setting can be used to move the waveform up or down (including the zero-line). This can be useful to place the waveforms on top of each other for comparison.
OUTPUT2		
AMP/DIV	:	Amps for each division.
POSITION	:	Vertical position of output2 current.

The scope has the following commands:

STOP	:	Stops and holds the scope picture. When the scope is in 'stop' mode, the picture won't be refreshed until you give a 'run' command.
RUN	:	Restarts the scope.
LOAD	:	Load a saved picture from disk. After the picture is loaded, the scope is in the 'stop' mode.
SAVE	:	Save waveform picture to disk.
PRINT	:	Send waveform picture and measured values to printer. You can select the printerport in the program settings menu.
PLOTFILE	:	Generate a HPGL plotfile from waveforms. You can use this option if you want to send the waveform to a plotter, or to import it into an graphical application like CorelDraw.
EXIT	:	Exit scope function and return to main program.

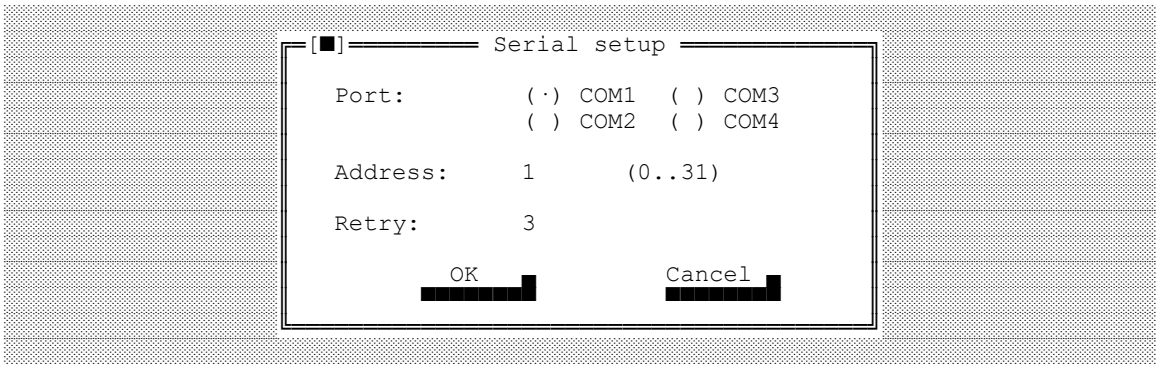
4.14. Options menu

The options menu contains commands to change the settings of this program. The options functions are situated in the Options menu at the menubar:



4.14.1. Serial Setup

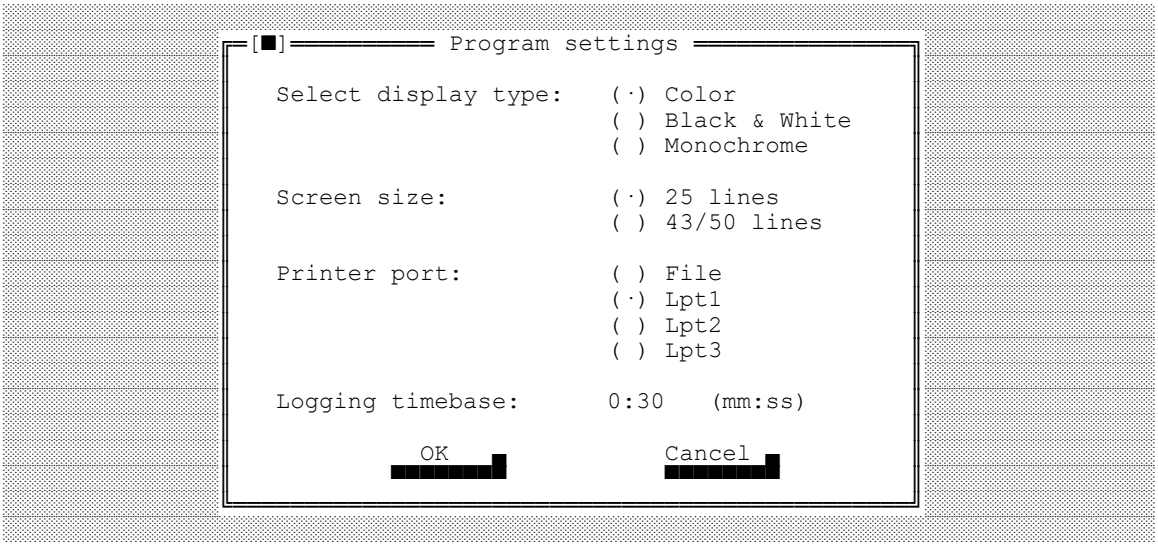
You can set up the serial communication and set the address of the supply to use with the "Serial Setup" command.
The serial setup window contains four parameters:



Port:	Here you can select the desired COM port to use.
Address	This is the current address this program uses. The entered address must be in the range of 0..31
Retry	Select the number of retries before a communication error is shown.

4.14.2. Program Settings

The “Program settings” command allows you to change all kind of settings the program uses:



Display type	Select if you’re using a color, black & white or monochrome monitor.
Screen size	Select how many lines you want on your screen. This option can be useful if you use the overview window. It is possible to move the overview window, so that you can see all information on your screen.
Printer port:	Select the output port to where your printer data is send. You can also print to file. (SUPPLY.PRN)
Logging timebase	This is the timebase for the logfile. For more information about logging data to disk, see the “Logging data to disk” paragraph.

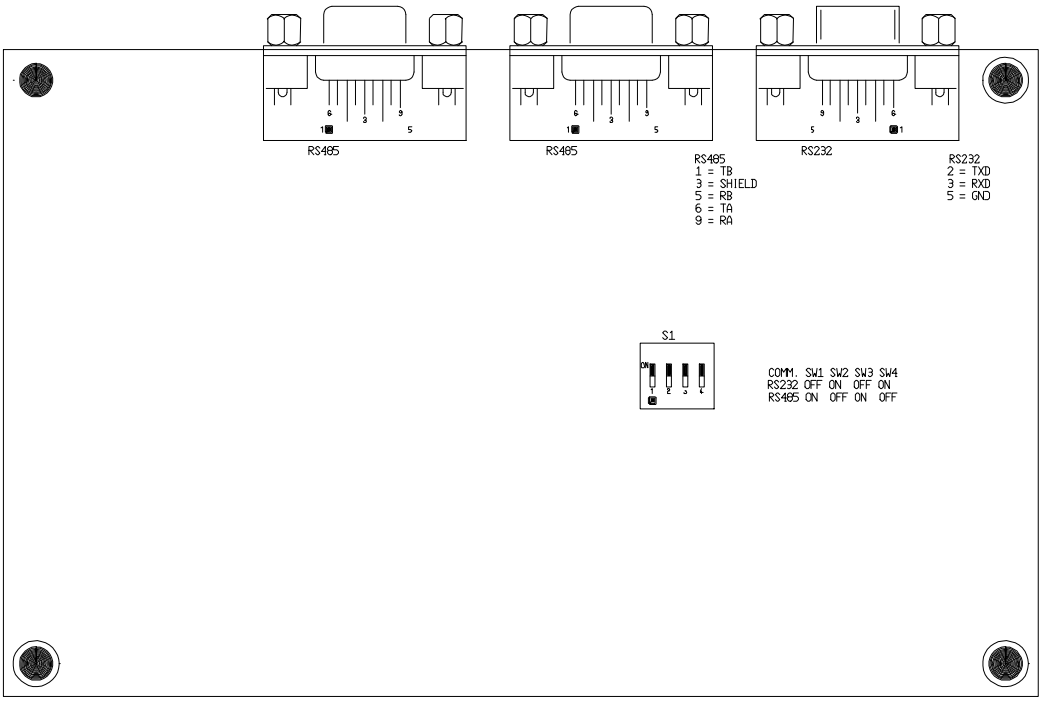
4.14.3. Scan Address

The “Scan address” command scans all addresses (0..31) to see if a supply is attached to that address. Each scan may take a few seconds, so this may take a while. You can stop the scanning by pressing a key.
The program shows all addresses on screen, and shows if the address is found or not. If it is found, the supply type will appear next to the address (like DPP2/1800). If the address is not found, a “-” appears.

5. Serial communication

The supply can be controlled by either a RS-232 connection or a RS-485 connection. The RS-232 connection can be used to control only one supply at a time and therefore will probably be used for testing the supply. The more practical way of communicating with the supply is the RS-485 connection, which makes it possible to communicate with a maximum of 32 supplies at the same time.

To select which communication you desire, a dip-switch is situated inside the control unit of the supply. Inside this control unit, a communication board is situated at the rear side of the unit:



With the dip-switch S1, you can select which communication to use:

Connection	1	2	3	4
RS-232	OFF	ON	OFF	ON
RS-485	ON	OFF	ON	OFF

5.1. RS-232 connection

The supply contains one sub-D connector (male) on the back plane for the RS-232 communication with the following connections:

PIN	SIGNAL
2	TxD
3	RxD
5	GND

All other pins are not connected.

The cable should be a one to one connection, so pin 2 should be connected to pin 2 etc.

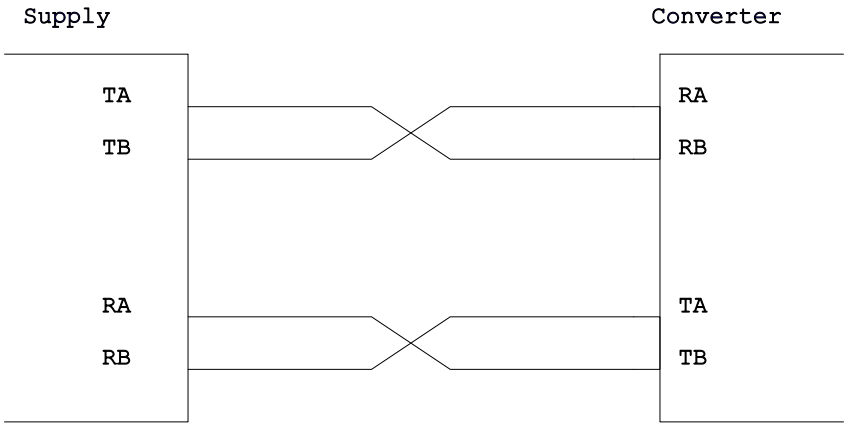
5.2. RS-485 connection

The supply contains two identical sub-D connectors (female) on the back plane with the following connections:

PIN	SIGNAL
1	TB
3	SHIELD
5	RB
6	TA
9	RA

All other pins are not connected.

To use the RS-485 communication with a PC, you need a RS-232 to RS-485 converter. The following figure shows how you should connect the supply to a converter.



5.3. The Modbus protocol

The language used by all supplies is the MODBUS protocol. This protocol provides a standard that the supply uses for parsing messages. During communication, the protocol determines how each supply will know its device address, recognize a message addressed to it, determine the kind of action to be taken, and extract any data or other information contained in the message. The supply will construct the reply message and send it using the Modbus protocol.
The protocol used, complies to standard Modbus specification for slave nodes, using either the binairy format RTU (Remote Terminal Unit) or ASCII. Both will be recognized automatically.

RTU	ASCII
8 bit-wide characters	7 bit-wide characters
No parity	No parity
1 stop bit	2 stop bits.
Selectable baudrate	Selectable baudrate.

The program uses two functions of the MODBUS protocol :

- Read parameter (function 3)
- Write parameter (function 16)

5.3.1. Read single parameter

The next message is send by the computer to read a parameter:

Address	Function number	Parameter number		Number of parameters to read		CRC word	
	3	H byte	L byte	0	1	L byte	H byte

The first byte contains the address of the supply. This is necessary, because it is possible to connect more supplies to one serial port.
The second byte send is the function number. This number is always 3 when you read a parameter.
The third and fourth byte contain the number of the parameter to read. The third byte contains the high byte, the fourth byte contains the low byte.
Byte 5 and 6 indicate how many parameters must be read. In our case, this is always 1.
The last two bytes contain the CRC word. This word is added for error checking.

When the address, function number, parameter number and CRC word are valid/correct, the supply will react by sending the next message: (If one or more of the values are not correct, the supply will send nothing back.)

Address	Function number	Number of bytes	Parameter value		CRC word	
	3	2	H byte	L byte	L byte	H byte

5.3.2. Write single parameter

To change a parameter, the next message will be send by the computer:

Address	function number	Parameter number		Number of parameters to write		Number of bytes	Parameter value		CRC word	
	16	H byte	L byte	0	1	2	H byte	L byte	L byte	H byte

After the message is checked, the supply will confirm the writing of the parameter with the following message:

Address	Function number	Parameter number		Number of written parameters		CRC word	
	16	H byte	L byte	0	1	L byte	H byte

5.3.3. Read multiple parameters

To read out more parameters with only one message, you can use the multiple parameter read command. This can be very time saving, when you must read all measured parameters. To read all measured data, send the following message:

Byte-nr.			
1		Address	n
2		Function Number	3
3..4	(Hi/Lo)	Parameter number	100
5..6	(Hi/Lo)	Number of parameters to read	9
7..8	(Lo/Hi)	CRC16	

The supply will react with the following message:

Byte-nr.			
1		Address	n
2		Function Number	3
3		Number of bytes	18
4..5	(Hi/Lo)	Ifwd1 meas. [A]	
6..7	(Hi/Lo)	Irev1 meas. [A]	
8..9	(Hi/Lo)	Ifwd2 meas. [A]	
10..11	(Hi/Lo)	Irev2 meas. [A]	
12..13	(Hi/Lo)	Vfwd1 meas. [V]	
14..15	(Hi/Lo)	Vrev1 meas. [V]	
16..17	(Hi/Lo)	Vfwd2 meas. [V]	
18..19	(Hi/Lo)	Vrev2 meas. [V]	
20		Supply status (0=Off / 1=On)	
21		Fault register	
22..23	(Lo/Hi)	CRC16	

5.3.4. Write multiple parameters

To write more parameters with only one message, you can use the multiple parameter write command. The multiple write command sends the following supply settings : Ifwd1, Irev1, Ifwd2, Irev2, FwdTime and RevTime.

To write all settings, send the following message:

Byte-nr.			
1		Address	n
2		Function Number	16
3..4	(Hi/Lo)	Parameter number	0
5..6	(Hi/Lo)	Number of parameters to write	6
7		Number of bytes	12
8..9	(Hi/Lo)	fwd1 Set [A]	
10..11	(Hi/Lo)	Irev1 Set [A]	
12..13	(Hi/Lo)	Ifwd2 Set [A]	
14..15	(Hi/Lo)	Irev2 Set [A]	
16..17	(Hi/Lo)	FwdTime [*10µsec]	
18..19	(Hi/Lo)	RevTime [*10µsec]	
20..21	(Lo/Hi)	CRC16	

5.3.5. CRC Checking

The CRC field is two bytes, containing a 16-bit binary value. The CRC value is calculated by the transmitting device, which appends the CRC to the message. The receiving device recalculates a CRC during receipt of the message, and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal, an error results.

The CRC is started by first pre-loading a 16-bit register to all 1's. Then a process begins of applying successive eight-bit bytes of the message to the current contents of the register. Only the eight bits of data in each character are used for generating the CRC. Start and stop bits do not apply to the CRC.

During generation of the CRC, each eight-bit character is exclusive Ored with the register contents. Then the result is shifted in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. The LSB is extracted and examined. If the LSB was a 1, the register is then exclusive Ored with a preset, fixed value (= hex A001). If the LSB was a 0, no exclusive OR takes place.

This process is repeated until eight shifts have been performed. After the last (eighth) shift, the next eight-bit byte is exclusive Ored with the register's current value, and the process repeats for eight more shifts as described above. The final contents of the register, after all the bytes of the message have been applied, is the CRC value.

When the CRC is appended to the message, the low-order byte is appended first, followed by the high-order byte.

Example:

To read the supply type (parameter 10) of the supply with address 1, the following message is send (CRC included, all numbers are 8-bit) :

Message send : 1 3 0 10 0 1 164 8
Message received : 1 3 2 7 8 187 178 (Result = 7*256+8 = 1800)

To set the FwdTime (parameter 6) of the supply with address 1 to 1000 (10.00 msec) :

Message send : 1 16 0 6 0 1 2 3 232 166 136 (3*256+232=1000)
Message received : 1 16 0 6 0 1 225 200

Example with multiple parameters:

Read multiple parameters from address 1
(all measured values are 0, supply is on, status is ok):
Message send: 1 3 0 100 0 9 196 19
Message received: 1 3 18 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 243 18

Write multiple parameters to address 1
(Ifwd1 = 100, Irev1 = 300, Ifwd2 = 200, Irev2 = 600, fwdtime = 1000, revtime = 70):
Message send: 1 16 0 0 0 6 12 0 100 1 44 0 200 2 88 3 232 0 70 20 131
Message received: 1 16 0 0 0 6 64 11 0 0

6. List of parameters and fault codes

Nr	Parameter		Range	Default	Description
1	Loaddefaults		-	-	Load default values into memory
2	CurrentLoop		0 – 2	0	Select CURRENT (0), VOLTAGE (1) or AUTOMATIC (2) loop
3	SupplyOn		0 – 1	0	Supply in RUN/STOP mode
4	Fault / Reset			0	Fault register / reset command
5	RevTime		10 – 700	70	RevTime * 10 µsec
6	FwdTime		200-50000	1000	FwdTime * 10 µsec
7	RevDeadTime		0 – 166	0	Rev dead time * 10 µsec
8	FwdDeadTime		0 – 166	0	Fwd dead time * 10 µsec
9	Address		0 – 31	1	Communication address
10	SupplyType	R	P	P	Supply type
11	VFwd1Set		0 – 1000	0	Forward1 voltage setting * 0.01V
12	VRev1Set		0 – 1000	0	Reverse1 voltage setting * 0.01V
13	VFwd2Set		0 – 1000	0	Forward2 voltage setting * 0.01V
14	VRev2Set		0 – 1000	0	Reverse2 voltage setting * 0.01V
15	IFwd1Set		0 – IF	IF/2	Forward1 current setting in A
16	IRev1Set		0 – IR	IR/2	Reverse1 current setting in A
17	IFwd2Set		0 – IF	IF/2	Forward2 current setting in A
18	IRev2Set		0 – IR	IR/2	Reverse2 current setting in A
19	VFwd1Level		0 – 1000	0	VFwd1 threshold level
20	VRev1Level		0 – 1000	0	VRev1 threshold level
21	VFwd2Level		0 – 1000	0	VFwd2 threshold level
22	VRev2Level		0 – 1000	0	VRev2 threshold level
23	IFwd1Level		0 – IF	0	IFwd1 threshold level
24	IRev1Level		0 – IR	0	IRev1 threshold level
25	IFwd2Level		0 – IF	0	IFwd2 threshold level
26	IRev2Level		0 – IR	0	IRev2 threshold level
27	FaultRelay		0 – 3	3	Fault relay 0/1/normally open(2)/closed(3)
28	RunRelay		0 – 3	3	Run relay 0/1/normally open(2)/closed(3)
29	StopRelay		0 – 3	3	Stop relay 0/1/normally open(2)/closed(3)
30	VtripEnable		0 – 1	0	Enable voltage trip levels
31	VFwd1Trip		0 – 1000	650	VFwd1 trip level * 0.01V
32	VFwd2Trip		0 – 1000	650	VFwd2 trip level * 0.01V
34	EnableFront		0 – 1	1	Front controls are enabled
35	ProcVersion	R	-	-	Version of main processor software x.xx
36	Frontversion	R	-	-	Version of front processor software x.xx
37	DCMode		0 – 1	0	Set supply in DC mode (1=DC, 0=Pulse)
41	Acc		10 – 100	30	Acceleration time from zero to max current/voltage (in seconds)

6.1. Overview parameters

These overview parameters are READ-ONLY!

Nr	Parameter	Range	Description
101	IFwd1Meas	0 – IF	Measured forward1 current
102	IRev1Meas	0 – IR	Measured reverse1 current
103	IFwd2Meas	0 – IF	Measured forward2 current
104	IRev2Meas	0 – IR	Measured reverse2 current
105	VFwd1Meas	0 – 1000	Measured forward1 voltage * 0.01V
106	VRev1Meas	0 – 1000	Measured reverse1 voltage * 0.01V
107	VFwd2Meas	0 – 1000	Measured forward2 voltage * 0.01V
108	VRev2Meas	0 – 1000	Measured reverse2 voltage * 0.01V
109	SetupF1Meas	0 – IF	Measured forward1 setup current
110	SetupR1Meas	0 – IR	Measured reverse1 setup current
111	SetupF2Meas	0 – IF	Measured forward2 setup current
112	SetupR2Meas	0 – IR	Measured reverse2 setup current
113	Fwd1PWM	0 – 300	Fwd1 pwm to altera
114	Rev1PWM	0 – 300	Rev1 pwm to altera
115	Fwd2PWM	0 – 300	Fwd2 pwm to altera
116	Rev2PWM	0 – 300	Rev2 pwm to altera
117	Fwd1Mode	25,50,100	Fwd1pwm is 25, 50 or 100%
118	Rev1Mode	25,50,100	Rev1pwm is 25, 50 or 100%
119	Fwd2Mode	25,50,100	Fwd2pwm is 25, 50 or 100%
120	Rev2Mode	25,50,100	Rev2pwm is 25, 50 or 100%
121	Fwd1Setup	0 – 2047	Fwd1 setup to altera
122	Rev1Setup	0 – 2047	Rev1 setup to altera
123	Fwd2Setup	0 – 2047	Fwd2 setup to altera
124	Rev2Setup	0 – 2047	Rev2 setup to altera
125	LoopTypeOut	0 – 1	Shows if the supply is in current or voltage mode. This parameter tells you if you are controlling currents or voltages in the automatic mode
126	AmpHour.L	-	Low 4 chars of AmpHour value (in BCD)
127	AmpHour.H	-	High 4 chars of AmpHour value (in BCD)
128	SwitchMod	0-255	Switch modulation value (0 = no modulation, 255 = full modulation
129	SwitchNr	0-2	Number of switch which is modulating

P = Supply type = 600
IF = Maximum forward current in A
IR = Maximum reverse current in A
R = Read only

6.2. Fault codes

Fault message	Fault code	Description
	0	Supply is OK
Phaseloss	1	One input voltage line is low
Charging	2	Supply is charging DC link. As soon as the DC link has its correct voltage, charging disappears.
Overvoltage fwd1	3	Measured forward1 voltage is too high
Overvoltage rev1	4	Measured reverse1 voltage is too high
Overcurrent fwd1	5	Measured forward1 current is too high
Overcurrent rev1	6	Measured reverse1 current is too high
Overvoltage fwd2	7	Measured forward2 voltage is too high
Overvoltage rev2	8	Measured reverse2 voltage is too high
Overcurrent fwd2	9	Measured forward2 current is too high
Overcurrent rev2	10	Measured reverse2 current is too high
Charging error	11	Error charging the DC-link
No Charge Power	12	Not used. For compatibility with older supplies
Temperature error	13	Overtemperature
SupplyType error	14	Error with supply-type selection
Internal comm error	15	Communication with front board failed
Feedback error	16	Supply cannot receive any measured currents

6.3. Explanation AmpHour parameters

The AmpHour value is a 8 digit value, and therefore is split into 2 parameters. Each parameter contains 4 digits which are stored in the BCD format.
The following example calculates the BCD value of the BCD value 1001 0011 0110 0001:
The BCD format splits the parameter (16 bits) into 4 parts of 4 bits, and then each four bit number is decoded.

Bit number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Binary value	1	0	0	1	0	0	1	1	0	1	1	0	0	0	0	1
BCD value	9				3				6				1			

So the BCD code 1001 0011 0110 0001 represents the value 9361.

The following example shows how to combine the two parameters into an AmpHour value:
Lets say that the received values are as followed:

	Binary value	BCD value
AmpHour.L	1001 0011 0110 0001	9361
AmpHour.H	0111 0101 0000 0010	7502

The AmpHour.H value contains the 4 most significant digits and AmpHour.L contains the 4 least significant digits. So the AmpHour value in our example is 75029361

7. Line-inductance

7.1. Introduction

As you can see in chapter 1.1, the power supply produces a DC output current with an adjustable reverse current pulse.
Figure 7.1 shows the ideal current pattern of a Reverse Pulse Power Supply.

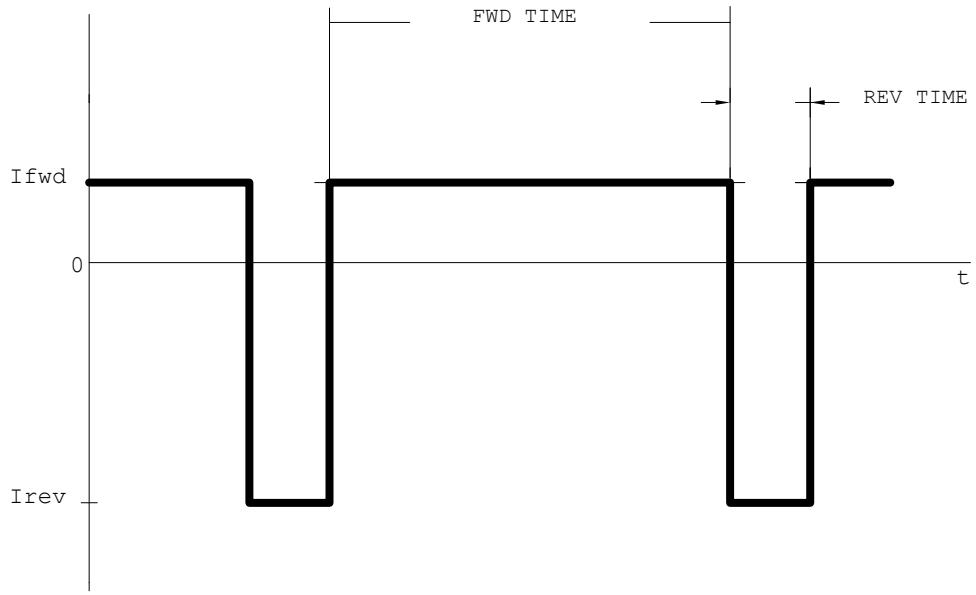


Figure 7.1: The ideal current pattern of a Reverse Pulse Power supply.

When we take a detailed look to the reverse pulse, we will see that during the pulse, the forward current must go down and the reverse pulse must be build to generate an effective pulse. The time necessary to build the reverse pulse depends on the following 3 items:

- The amplitude of the **current** to build
- The available **voltage** of the supply
- The **induction** of the circuit (the magnetic resistance)

The ratio of these 3 physical magnitudes is as follows:

$$U = L * di/dt$$

where:

U	= voltage	in V
L	= inductance	in Vsec/A (=H, Henry)
di	= element of current	in A
dt	= element of time	in sec

Therefore, a more practical waveform is shown in figure 7.2.

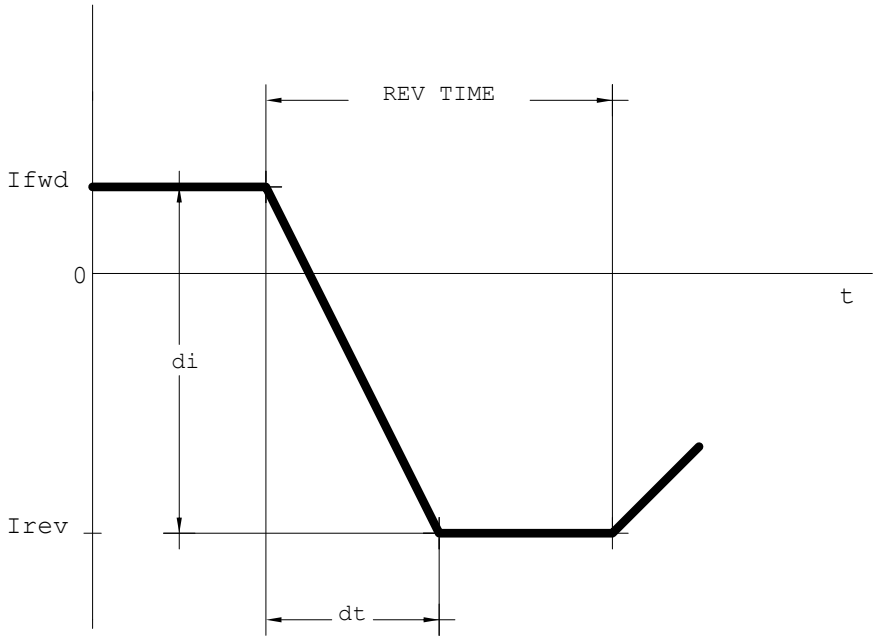


Figure 7.2: The Reverse Pulse.

The necessary time to build the reverse current is lost time. To reach the highest possible efficiency, this time has to be as short as possible. By reading the above explanation, we can conclude that we can do this by making the available voltage higher and by minimizing the induction of the circuit.

For the voltage, the limit factor is the safety of the operator, with a maximum safety factor of 42V. The maximum voltage of the reverse pulse power supply is 30V, which may be increased by 30%.

The induction of the total circuit can be divided into two parts : the internal induction of the power supply and the inductance of the connection to the copper bath. The internal induction of the power supply is already minimized. When we take a look at the external connection, it is important to choose a cable with a very low inductance.

7.2. The connection from supply to bath

The power supply has an anode and a cathode output which should be connected to the anode and cathode of the acid copper bath. In a double sided bath, there are two anodes and a common cathode.

The connection is build with two conductor lines. There are four shapes of conductors:
- flat
- ribbon conductor
- round
- round wire conductor

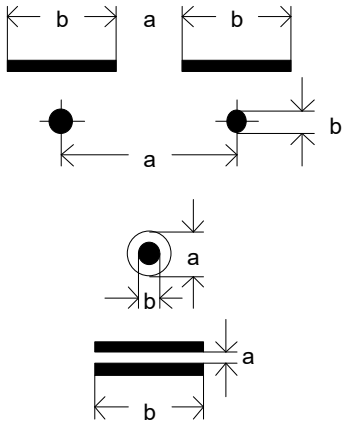
All these conductors can have different positions to each other, so we can make the following combinations:

(1) Ribbon twin-conductor line

(2) Round-wire twin-conductor line

(3) Coaxial cable

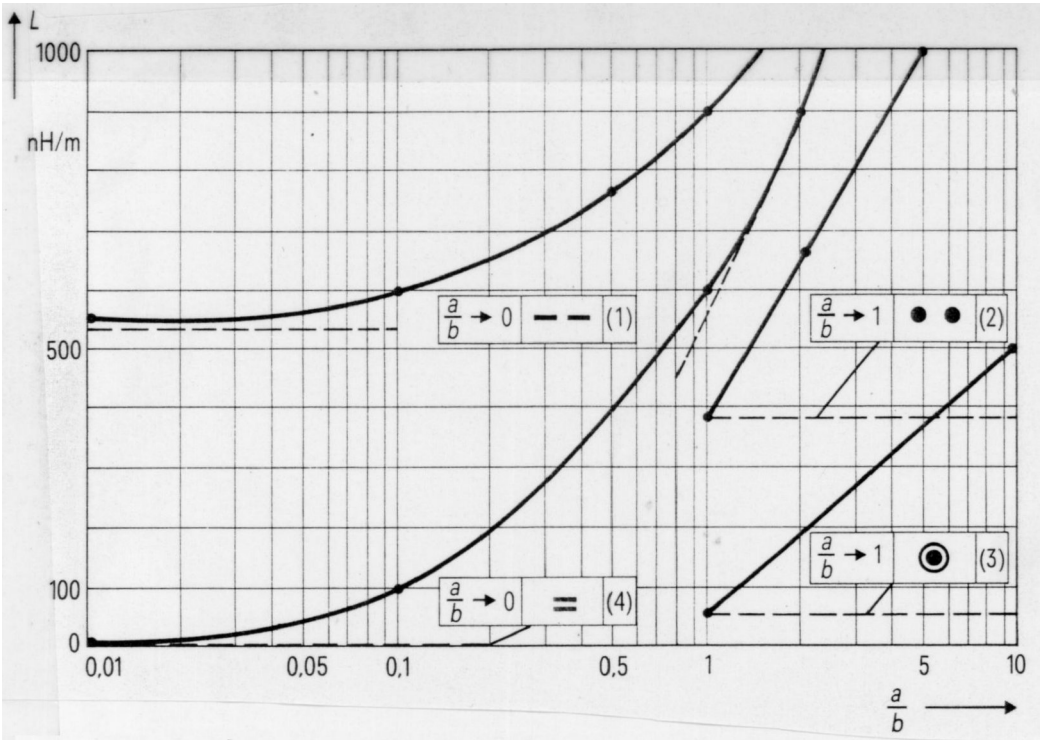
(4) Copper bus bars



The inductance of the different line types depends on the ratio of a to b (a/b). The table below shows the inductance per meter cable for the different line types for the limit of the ratio a/b.

Type	Line variant	limit value a/b	inductance L in nH/m
(1)	ribbon twin-conductor line	0	555
(2)	round-wire twin-conductor line	1	377
(3)	coaxial cable	1	50
(4)	copper bus bars	0	0

When we put the inductance in a graph, for the ratio of a/b from 0 to 10, we get the following results:

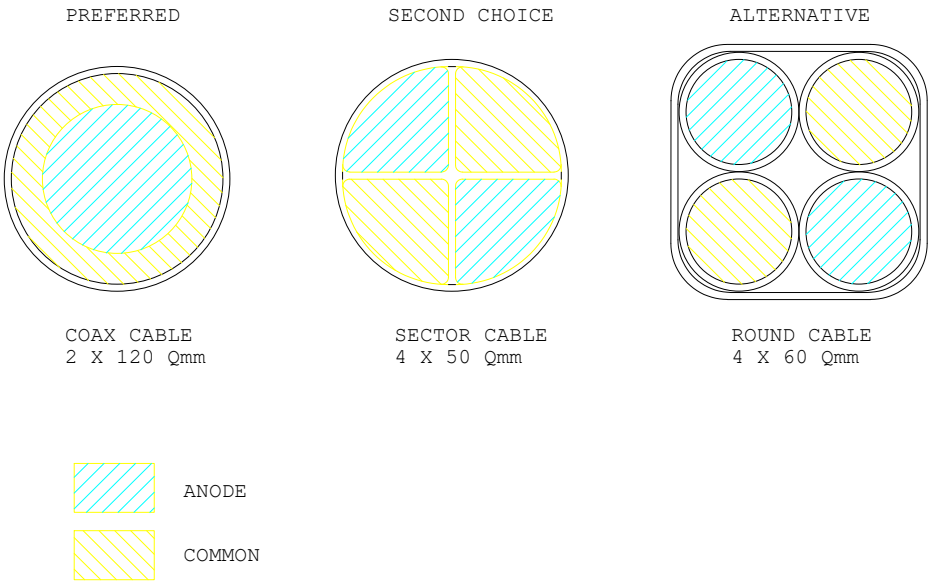


7.2. Conclusion

For the most ideal connection between a reverse pulse power supply and an acid copper bath, copper bus bars should be used with the conductors placed as close to each other as possible. That is why we have to look for such a conductor and the optimal connection method between the copper bus bars to the supply as well as to the bath.

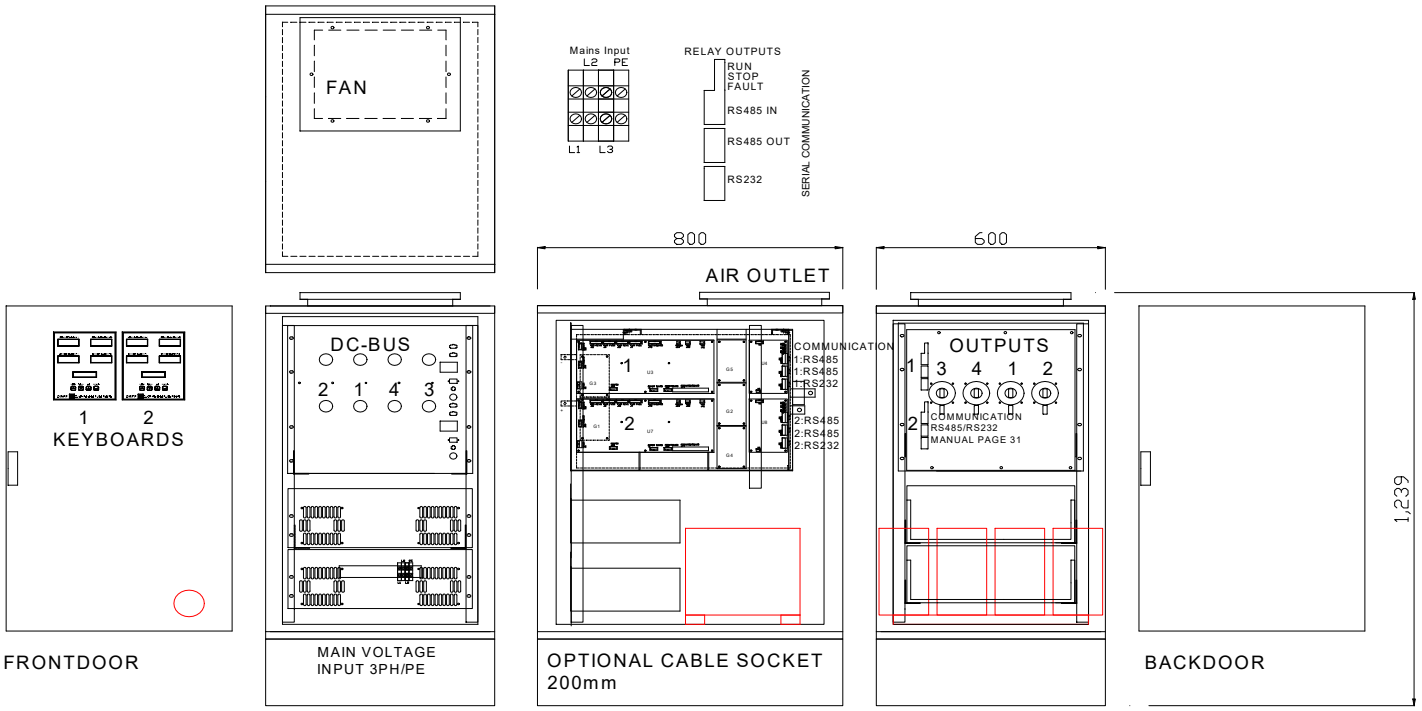
8. Connection to bath.

There are two types of cables you can use to connect the supply to the bath:



On the following two pages, you will find the connections from the supply to the bath for each type of cable.

8.1. Connections.



9. Specifications.

Technical specifications DRPP power supplies			
	Type	D4K-1000-12	
Parameter	Formula		
n,outputs	Number of outputs	4	
IF	Forward current per side	250	A
IR	Reverse current per side	750	A
Iout1,2,? RMS	SQRT(0,9IF? 0,1IR?	335	A/output
Icom	4*Iout, total cathode current	1340	A
UDC	DC-link voltage	30.0	VDC
UF	maximum Forwardvoltage	6	V
UR	maximum Reversevoltage	12	V
Pout	nIF*UF*0.9+nIR*UR*0.1	9000	W
Mains power	Total input power of the unit	12000	kVA
Imains 400V	Rated input current: L1/L2	19.3	A
	Rated input current: L3	19.3	A
	Recommended value Mains fuse	25.0	A
Imains 480V	Rated input current: L1/L2	16.1	A
	Rated input current: L3	16.1	A
	Recommended value Mains fuse	25.0	A
Imains 230V	Rated input current: L1/L2	35.0	A
	Rated input current: L3	35.0	A
	Recommended value Mains fuse	36.0	A
Parameter explanation:			
Iout1,2 RMS	Minimum current capability anode connection		
UDC	DC link voltage in the power supply		
Pout	Maximum total output power		

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