Uninterruptible Current Supply USV 011

+24 V / 1.2 Ah

The USV 011 Uninterruptible current supply is used to buffer the +24 V supply of an Industry PC (C-IPC, SIPC). The +24 V supply is normally connected to the +24 V output and is use to load the internal battery. In the event of a power loss, the internal battery absorbs the current from the +24 V supply. An adjustable USV time provides a flexible buffer time that serves to execute a controlled shutdown of the Industry PC.

Technical Data

Performance data

Internal energy storage (Battery)	2 x +12 V / 1,2 Ah maintenance-free lead batteries
USV-time	Configurable through the software and DIP switches from 4 to 692 Seconds
Load circuit	Constant current / constant voltage current: 270 mA to 350 mA voltage: Temperature controlled
Interfacing	1 x RS232 (2 x connections) 2 x +24 V (input & output)
Status LEDs	3 x battery status 3 x USV Status

Electrical requirements

Supply voltage (+24 V-input)	Typically +24 V DC +18 V t0 +30 V DC
Current consumption (+24 V-Input)	Depends on the load connected to the +24 V-output Internal current consumption: Maximum 500 mA
Supply voltage (+24 V-output)	Typically +24 V DC +18 V to +30 V DC
Current load (+24 V-output)	Maximum 3,0 A

Miscellaneous

Article number	01-470-011 (Sigmatek foil) 01-470-011-O (without foil)
Hardware version	1.x
Weight	Typically 2,2 kg (with 2 batteries)

Environmental conditions

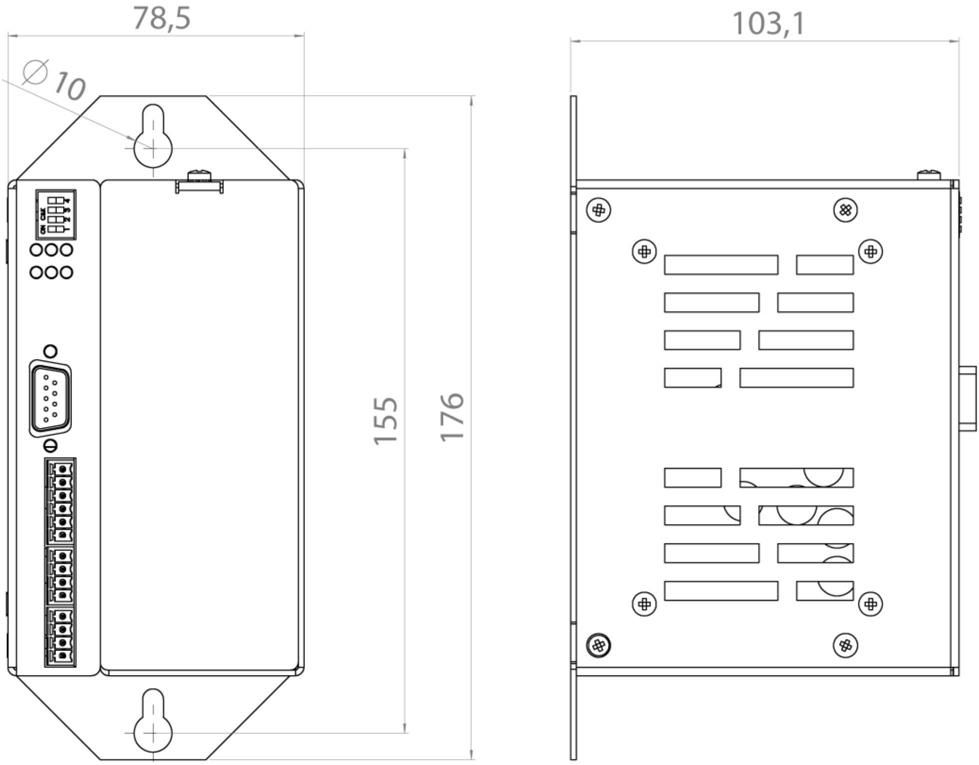
Storage temperature	-20 – +60 °C	
Operating temperature	0 – +40 °C [1)]	
Humidity	0 – 95 %, uncondensed	
EMV stability	According to EN 61000-6-2:2001 (Industry area)	
Shock resistance	EN 60068-2-27	150 m/s²
Protection	EN 60529	IP 20

1) At lower temperatures, the available battery capacity sinks and the charge time is significantly longer. At higher temperatures, the self-discharge rate rises and the battery can be damaged through loss of fluids.

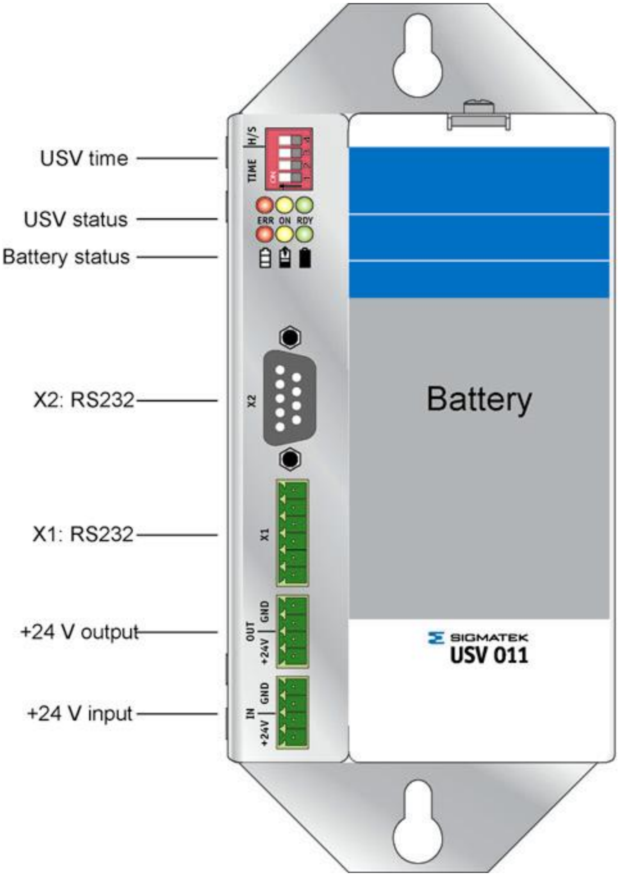
Self-discharge at 50 °C: 0,5 % (capacity per day)
Self-discharge at 60 °C: 1,0 % (capacity per day)

The capacity of the built-in lead batteries is not defined in factory condition.
The USV must charge for 5 hours before being connected to a load for the first time to ensure the function of the lead batteries!

Mechanical Dimensions

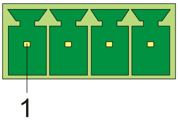


Connector Layout



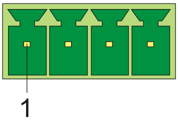
Connectors

+24 V supply input (4-pin Phoenix RM3,5)



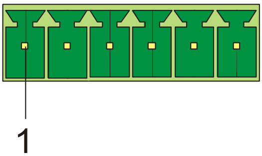
Pin	Function
1	+24 V
2	+24 V
3	GND
4	GND

+24 V supply output (4-pin Phoenix RM3,5)



Pin	Function
1	+24 V
2	+24 V
3	GND
4	GND

X1: RS232 connection to C-IPC (6-pin Phoenix RM3,5)



Pin	Function
1	RxD
2	TxD
3	RTS (USV Off)
4	CTS (+24 V OK)
5	DCD (battery weak)
6	GND

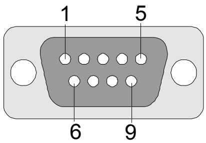
Status lines

Signal	Logic status	Signal status	Meaning
RTS	HI	<+3 V	Deactivate USV *)
CTS	HI	<+3 V	USV is active
DCD	HI	<+3 V	Battery is weak

To establish a connection to the C-IPC, a 1:1 connection must be used. The maximum length should not exceed 5 m. A shielded cable is recommended but not required the software interface over RxD / TxD is not used.

*) This is the default value and cannot be changed through the software!

X2: RS232 connection to the S-IPC (9-pin DSUB socket)



Pin	Function
1	DCD (battery weak)
2	RxD
3	TxD
4	Not used
5	GND
6	Not used
7	RTS (USV Off)
8	CTS (+24 V OK)
9	Not used

Status lines

Signal	Logic status	Signal status	Meaning
RTS	HI	<+3 V	Deactivate USV *)
CTS	HI	<+3 V	USV is active
DCD	HI	<+3 V	Battery is weak

To establish a connection to the S-IPC a 1:1 connection must be used (RS232 extension plug ←→ socket). The maximum length cannot exceed 5 m. A shielded cable is recommended but not required the software interface over RxD / TxD is not used.

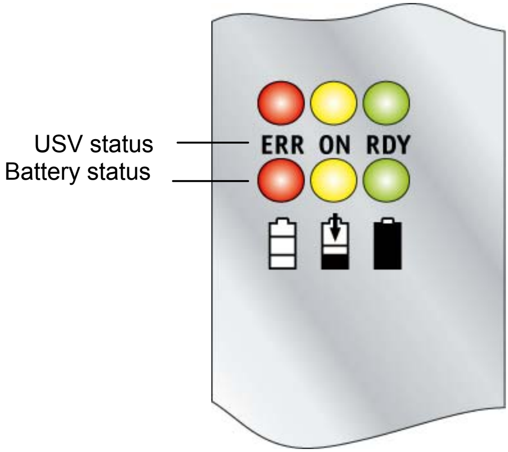
*) This is the default value and cannot be changed through the software!

Applicable connectors

X1: 6-pin Phoenix FK-MCP 1,5/6-ST-3,5
X2: 9- pin DSUB plug
Supply (2 x): 4-pin Phoenix FK-MCP 1,5/4-ST-3,5

The complete C-DIAS CKL 016 connector set with spring terminals is available at Sigmatek under the article number 12-600-016.

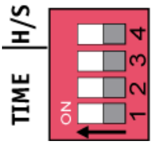
Status Display



USV Status	
Red	The USV is ready (Battery or charging circuit is defect, Analog measurement defect, over temperature)
Yellow	The USV is active, the battery is supplying current
Green	The USV is in Standby, the +24 V Input supply is available

Battery Status	
Red	Battery is empty (The low charge threshold was exceeded)
Yellow	Battery is charging (load circuit is active)
Green	Battery is fully loaded (The battery accepts no more current → it could also be that no battery is connected.

USV Time



S1	S2	S3	USV time	
			Minimum	Maximum
OFF	OFF	OFF	4 s	5 s
OFF	OFF	ON	9 s	11 s
OFF	ON	OFF	18 s	22 s
OFF	ON	ON	35 s	43 s
ON	OFF	OFF	71 s	87 s
ON	OFF	ON	142 s	173 s
ON	ON	OFF	283 s	346 s
ON	ON	ON	566 s	692 s

DIPswitches S1 – S3 define the maximum USV time (independent of the USV time setting in the software).
Therefore a longer USV time cannot be set using the software!
This function can be seen as a safety circuit.

DIPswitch S4 has the following function:

OFF ... The time set using the DIP switches serve as an emergency shut down. The USV must be activated through the software before the battery can absorb the load current. **Communication over the RS232** interface is imperative for this function or the USV. As long as no new USV time is sent, a default value of 3 minutes is set.

➔ Software mode

ON ... The USV time set with the DIPswitches is active independent of the software configuration. **No RS232 communication is required** (but still possible)!

➔ Hardware mode

USV Switch Points

1. Switching from the +24 V input to the battery: +18.5 V

With an input voltage of 18,5 V (±0,5 V), the +24 V OK status changes (CTS line from the RS232). If the switch threshold is exceeded, the +24 V input powers the +24 V output and the battery is charged. When the voltage falls below the threshold, the battery assumes the load current on the +24 V output.

2. Battery warning: +19.4 V

The low charge threshold is 19.4 V (±0.5 V). When the battery voltage falls below this value, the Battery OK signal changes (DCD line from the RS232). The USV 011 then signals the PC that the battery capacity is depleted and USV 011 the function is no longer available.

3. Battery protection: +17.6 V

As soon as the battery voltage falls below 17.6 V (±0.5 V), the USV 011 is deactivated (independent of the RTS signal from the RS232). This safety function should protect the battery from a low charge, thus extending the battery life.

4. Charging circuit

As long as the battery has not reached its nominal voltage, it will be charged with a constant current source, which supplies a current of 310 mA (±40 mA). As soon as the battery has reached its nominal voltage, the charging circuit changes to the temperature controlled voltage source mode. Because at low temperatures the chemical process is slower, the charging voltage must be raised.

Temperature	Charging voltage
0 °C	+28.9 V
10 °C	+28.7 V
20 °C	+28.4 V
30 °C	+28.0 V
40 °C	+27.6 V
50 °C	+27.2 V [1)]
60 °C	+26.8 V [1)]

[1)] Charging process can already lead to a loss of fluid!

RS232 Communications Protocol

1. Status bits

The USV 011 sends a status to the PC as required. This is defined as follows:

HI-Byte								LO-Byte							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
USV Error				USV Status				Battery error				Battery status			

LO-Byte: Battery status and error
D0: 1 = Battery is fully charged
D1: 1 = Battery is charged with continuous current
D2: 1 = Battery is charged with a temperature controlled constant voltage source
D3: 1 = Warning: The battery capacity is low

D4: 1 = Error: batteries are charged asymmetrically
D5: 1 = Error: battery current is too high (hardware error)
D6: 1 = Error: the discharge current is too high
D7: 1 = Error: The battery temperature is too high

HI-Byte: USV status and error
D0: 1 = USV is on standby, battery OK
D1: 1 = USV is active, the USV time is running
D2: 1 = USV is deactivated (RTS line from the RS232 or software instruction)
D3: 1 = Warning: the battery is almost empty (low charge threshold has been reached)

D4: 1 = Error: charging circuit, analog value measurement defect (Hardware error)
D5: 1 = Error: the batteries are charged asymmetrically or empty
D6: 1 = Error: The discharge current is too high
D7: 1 = Error: The ambient temperature is too high

Caution: an overload of the battery caused by too high a discharge current or environmental temperature can damage the battery!

2. Communication parameters

Baud rate	9600 Baud
Data bits	8
Stop bits	1
Parity	None

3. USV 011 communication protocol

Basically, 3 bytes are sent to the USV. The USV returns a 4-byte answer. Each data transfer starts with STX ($02) and ends with ETX ($03)

3.1 Set USV time:

(The maximum USV time set with the DIP switch are measured in seconds)

Start	1. Byte	2. Byte	3. Byte	End
STX	$00	USV time (Lo-Byte)	USV time (HI-Byte)	ETX

As long as no USV time is sent, the default value of 189 seconds (3 minutes) is set.

Answer:

Start	1. Byte	2. Byte	3. Byte	4. Byte	End
STX	Battery status	USV status	USV time (Lo-Byte)	USV time (HI-Byte)	ETX

3.2 Deactivate USV:

Start	1. Byte	2. Byte	3. Byte	End
STX	$01	$00	$00	ETX

Answer:

Start	1. Byte	2. Byte	3. Byte	4. Byte	End
STX	Battery status	USV status	$00	$00	ETX

3.3 Read analog values:

Start	1. Byte	2. Byte	3. Byte	End
STX	$02	$00	*Info*	ETX

Info:
$00: USV time
$01: Voltage of battery 1
$02: Voltage of battery 2
$03: Voltage of both batteries (batt 1 + batt 2)
$04: Voltage of both batteries with a 1 A electronic load
$05: Battery current (battery is charging)
$06: Current from the battery (load current with active USV)
$07: Internal resistance of the battery

Answer:

Start	1. Byte	2. Byte	3. Byte	4. Byte	End
STX	Battery status	USV-Status	Analog value (LO)	Analog value (HI)	ETX

The analog input values are standardized by the USV 011:

Analog value	Range	Digital value	Resolution	Precision
Batt 1	0,0 V .. +15.0 V	0 .. 150	10 d / V	±0.1 V
Batt 2	0,0 V .. +15.0 V	0 .. 150	10 d / V	±0.1 V
Batt 1 + Batt 2	0,0 V .. +30.0 V	0 .. 300	10 d / V	±0.1 V
Batt 1 + Batt 2 (with 1 A load)	0,0 V .. +30.0 V	0 .. 300	10 d / V	±0.1 V
Load current	0,00 .. +0.80 A	0 .. 80	10 d / mA	±10 mA
Discharge current	0,00 .. + 5.50 A	0 .. 550	10 d / mA	±10 mA
Internal resistance	0,0 Ω .. 30.0 Ω	0 .. 300	10 d / Ω	±0.1 Ω

I.e.:

- A voltage of 123 d corresponds to 12.3 V
- A current of 45 d corresponds to 450 mA (0.45 A)
- A resistance of 67 d corresponds to 6.7 Ω

3.4 Read EEProm

Start	1. Byte	2. Byte	3. Byte	End
STX	$03	$00	*EE-Info*	ETX

EE-Info:
$00: Module header + calibration data
$01: Header + charge history
$02: Header + discharge history

Answer:

Start	1. Byte	2. Byte	Data	End
STX	Battery status	USV status	*Data*	ETX

Data:
$00: Module header + calibration data – Data: 256 Bytes
$01: Header + charge history – Data: 8 + 1440 Bytes
$02: Header + discharge history – Data: 8 + 240 Bytes

3.5 Set RTS Polarity

Start	1. Byte	2. Byte	3. Byte	End
STX	$04	$00	*RTS-Polarity*	ETX

RTS-Polarity:
$00: RTS logic HI = deactivate USV (Default)
$FF: RTS logic LO = deactivate USV

Answer:

Start	1. Byte	2. Byte	Data	End
STX	Battery status	USV status	*RTS-Polarity*	ETX

3.6 Service mode (read raw values):

Start	1. Byte	2. Byte	3. Byte	End
STX	$FF	$00	*Info*	ETX

Info:
$00: Read Digital Inputs from the controllers
$01: Raw voltage value batt 1 + batt 2
$02: Raw voltage value batt 2
$03: Raw current value

Answer:

Start	1. Byte	2. Byte	3. Byte	4. Byte	End
STX	Battery status	USV status	Raw value (LO)	Raw value (HI)	ETX

Digital Inputs:
D0: 0 = +24 V Input voltage available
D1: 0 = Battery voltage OK (above the low charge threshold)
D2: 0 = Battery is full
D3: 0 = USV deactivated
D4: 1 = Deactivate USV (RTS Signal from RS232)

3.7 Service mode (write digital output):

Start	1. Byte	2. Byte	3. Byte	Ended
STX	$FF	$01	*Digital outputs*	ETX

Digital outputs:
D0: 1 = Deactivate charging circuits
D1: 1 = Activate USV (release battery)
D2: 1 = Activate electronic load (1 x with short 1 A load)
D3: 1 = disable symmetry (= deactivate analog measurement)
D4: 1 = disable USV status led (red)

Answer:

Start	1. Byte	2. Byte	3. Byte	4. Byte	End
STX	Batt status	USV status	$01	Digital outputs	ETX

3.8 Service mode (write to EEProm):

Start	1. Byte	2. Byte	Data	End
STX	$FF	$AD	*Calibration data*	ETX

Calibration data:
Module header + Calibration data – Data: 256 Byte

Answer:

Start	1. Byte	2. Byte	3. Byte	4. Byte	End
STX	Batt Status	USV Status	$AD	$00	ETX

Each service mode ends the automatic function of the USV 011!
The service mode cannot be used for the normal function of the USV 011!
It serves only for precise error analysis and testing by Sigmatek.

4. EEProm Data

4.1 Module header (organized by Byte)

Address	Data	Description
$00	$xx	Checksum
$01	123	Identification
$02	221	Module group 221 = USV
$03	1	Variant 1 = USV 011
$04	3	Number of channels
$05	$1x	Hardware version $10 = HW-V1.0, $11 = HW-V1.1, …

4.2 Calibration data

(Address = Byte, Data is organized by Word, Little Endian / Intel Format)

Address	Data	Description
$40	$xxxx	Checksum
$42	12345	Identification
$44	10	Length of the following data block in WORD
$46	$0003	Number of channels (2x voltage, 1x current)
$48	I.e. 0000	Voltage offset for batt 2
$4A	I.e. 0150	Gain multiplicand for the voltage of batt 2
$4C	I.e. 1024	Gain divisor for the voltage of batt 2
$4E - $52	-	Calibration values for the voltage of both batteries (batt 1 + batt 2)
$54 - $58	-	Calibration values for the current measurement

Calculation of the analog input values

I.e.:	Offset	0000
	Gain multiplicand	0250
	Gain divisor	0256

Conversion formula for analog inputs

$$\text{Value} = \frac{(Rawvalue + Offset) \bullet Multiplicand}{Divisor}$$

This calculation of the analog value is done by the USV 011!

4.3 Header

(Address = Byte, Data is organized by Word, Little Endian / Intel Format)

Address	Data	Description
$00	$xxxx	Pointer to the current start address (first valid entry)
$02	$xxxx	Pointer to the current end address (last valid entry)
$04	$xxxx	Pointer to the last start address (Backup)
$06	$xxxx	Pointer to the last end address (Backup)

The data is stored in a ring buffer; the last value is overwritten with the updated value. The valid data is located between start address and the end address. A backup of the pointer makes it possible to reconstruct the last charge/discharge process after a new charge/discharge process has been started.

4.4 Charge history

(Address = Byte, Data is organized by Word, Little Endian / Intel Format)

Address	Data	Description
$00	$xxxx	Voltage of battery 1
$02	$xxxx	Voltage of battery 2
$04	$xxxx	Charging current
$06	$xxxx	Internal resistance

The data is stored successively (address $08 contains the voltage from battery 1). Updated values are written to the EEProm each minute. This results in a history of 720 words/4 = 180 minutes

4.5 Discharge history

(Address = Byte, Data is organized by Word, Little Endian / Intel Format)

Address	Data	Description
$00	$xxxx	Voltage batt 1 + batt 2
$02	$xxxx	Discharge current

The data is stored successively (address $04 contains the voltage from battery 1 + battery 2). Updated values are written to the EEProm each second. This results in a history of 120 words/2 = 60 seconds

Batteries

The batteries can be changed by removing the battery covers; the batteries can than be removed individually. Thereafter, the new batteries are inserted and the battery cable re-connected. An empty battery requires approximately 10 hours until it's fully recharged.

The batteries should not be changed when voltage is present!

	FIRM	TYPE	DATA
Lead battery	EXIDE / SONNEN-SCHEIN	A512 / 1.2 S	12 V / 1.2 Ah

Calculation for the battery lifespan:

- Battery capacity: 1,2 Ah
- Cycles: 300
- Life span cycles: 300 x 1,2 Ah = 360 Ah

Theoretical USV charge/discharge cycles:

$$\frac{Lifespancycles \bullet 3600}{USV - Zeit \bullet Loadcurrent}$$

Lifespan cycles = 360 Ah
USV time = USV time in Seconds
Current load = load on the +24 V output in ampere

Caution: This calculation does not include temperature-dependant deterioration.

I.e.:

Lifespan cycles = 360 Ah
USV time = 10 Seconds
Current load = 3 ampere

Theoretical USV charge/discharge cycles:

$$\frac{Lifespancycles \bullet 3600}{USVtime \bullet Currentload} = \frac{360 Ah \bullet 3600}{10 s \bullet 3 A} = 43200$$

As a rule, the batteries must be changed yearly under normal conditions.

Battery Rating

1. Battery voltage

The following voltages can be measured over the hardware:

- Voltage from batt 1 + batt 2 (total voltage)
- Voltage from batt 2

With these two measurements, the voltage from each battery can be determined. Unfortunately, establishing a direct correlation between the battery voltage and the capacity is not possible.

The following error conditions can be detected with the voltage measurement:

- Asymmetric Battery charge: If the battery voltage shows a difference of more than 3.0 V, it is a good indication that the USV 011 function is strongly impaired since the batteries show a difference in capacity. A symmetrization integrated in the USV 011 ensures that the battery voltages (capacity) are equalized. This process, however, can require several hours.
- Empty batteries: A voltage smaller than +5 V indicates a battery with a low charge. If the battery is stored over a longer period with such a low voltage, a defect is highly probable. Sulfate crystals form outward from both lead plates that, in the worst case, can form a bridge in the middle causing a short circuit. In addition, the internal resistance increases massively because the sulfate crystals reduce the electron-transporting surface of the lead plates.

2. Battery current

Both the charging and discharging current can be measured.

An error has occurred when:

- If the charging current is over 500 mA, the charging circuit or analog measurement is defect. To avoid further damage, the charging circuit should be deactivated and the USV 011 should be exchanged.
- The discharge current exceeds 5.0 A. Such high discharge current places extreme stress on the battery and the total capacity cannot be utilized.

3. Internal resistance

The USV 011 has an integrated measurement for internal resistance. The battery is loaded for a short time with 1 A and the charging circuit is deactivated simultaneously.

The internal resistance is dynamic and is calculated using the formula:

$$Ri = \frac{dU}{dI} = \frac{dU}{1A} = dU$$

Because the current load is 1 A, the voltage difference between loaded and load-free batteries is equals the internal resistance.

The internal resistance determines the following:

- High impedance battery: if the internal resistance is continuously over 2,0 Ω, the battery is either empty or defect. A battery that has exhausted its lifespan cycles but reaches its nominal voltage relatively fast indicates high internal impedance. The same effect can occur in a battery with a low charge (<5.0 V).
- Empty battery: an Initially high internal resistance that decreases with the charging time is normal and means that the battery capacity is slowly increasing.
- Cable break: an internal resistance larger than 10 Ω means that there is no battery connected or the connector cable is defect.

4. History

The battery history provides a good basis for estimating whether the USV 011 can bridge a new USV time. From the charge history, how the battery voltage, current and internal resistance behaved during the charging process.

Observing the charge history:

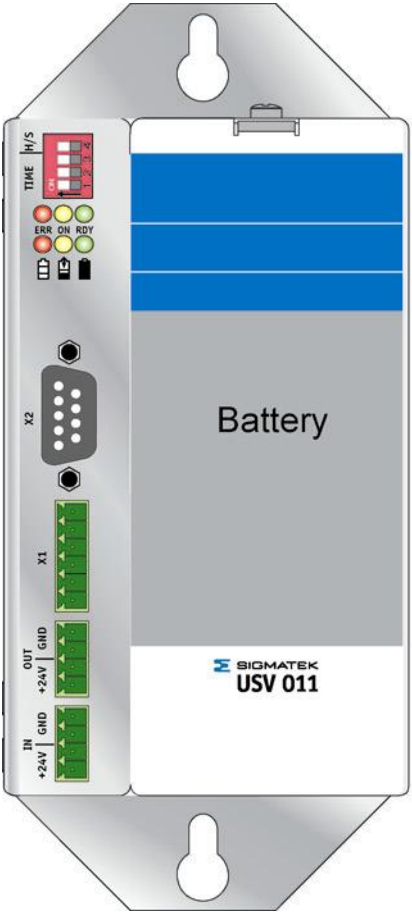
- A battery that does not absorb current after discharging and reaches its nominal voltage quickly is and indication of low capacity and high internal resistance.
- A battery that does not reach its nominal voltage has one or more short-circuited cells internally.

Observing the discharge history:

- The battery voltage at the end of the USV time can be used as a criterion for estimating the residual capacity. A linear correlation, however, is not given since the characteristic curve changes with temperature and age.
- The curve of the battery voltage during the USV time is an additional start point. A steep voltage drop is an indication of low capacity or a very large load.

Mounting Guide

1. Mounting position



The lead batteries used are basically acid dense, however each cell has a pressure vent to release steam in an emergency. This can happen when the battery is operated in high ambient temperatures. The vent is located on top; therefore the mounting position shown above is the only option possible.

2. Environmental temperature

High environmental temperatures lead to greater self-discharge:

Self discharge at 50 °C: 0,5 % (capacity per day)
Self discharge at 60 °C: 1,0 % (capacity per day)

It is strongly recommended that the battery be kept away from sources of heat. The life span of the can be reduced dramatically through high ambient temperatures. With the use of control cabinet fans, caution should be taken to ensure that the USV 011 is place in the path of the cool air. The function of the USV 011 is rated for a maximum temperature of +40 °C. The battery is also affected even when it’s just on standby.

Wiring Guide

Connection S-IPC

+24 V from power supply

- The +24 V from the power supply/transformer is connected to the +24 V input.
- The +24 V output of the USV 011 is connected to the S-IPC (C-IPC or any processor module).
- The RS232 communication is established by the S-IPC over X2 of the USV 011 to COM1 or COM2 of the S-IPC (A USB ←→ RS232 converter can also be used on the S-IPC in case COM1 and COM2 are already in use).

Connection to C-IPC

- Supply voltages: see above
- RS232 communication is established with the C-IPC over X1 of the USV 011 to X11 of the C-IPC

Configuration of the Windows USV Driver (Standard)

Advantages:

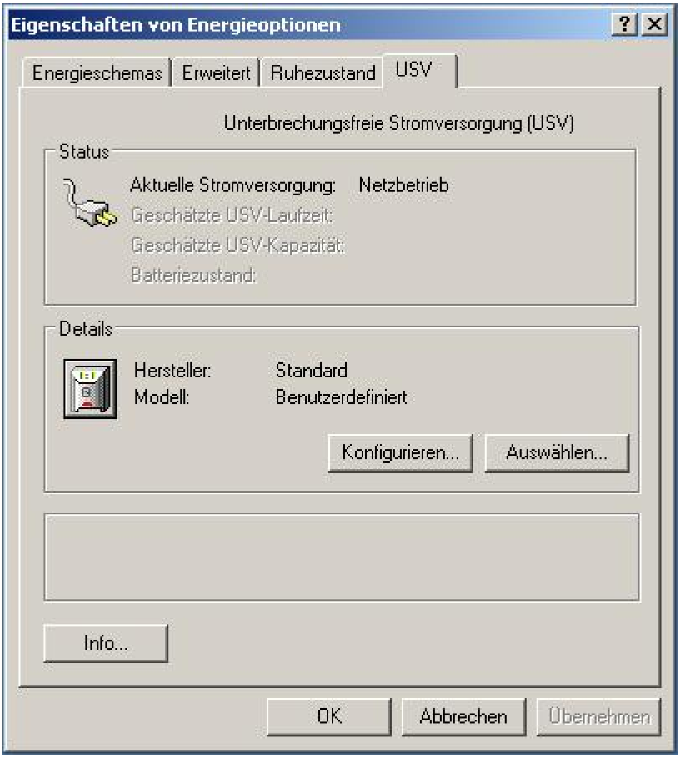
- No functions integrated in the application are necessary
- The USV works in **hardware mode**

Disadvantages:

- The USV time set with the DIPswitch must be somewhat longer as the USV time set in windows
- No battery monitor can be integrated in the application since the USV driver occupies the entire serial port.
- Defective or empty batteries are not detected by the application.
- When not connected, the USV 011 shuts down directly after start-up.

1. Open Energy Management

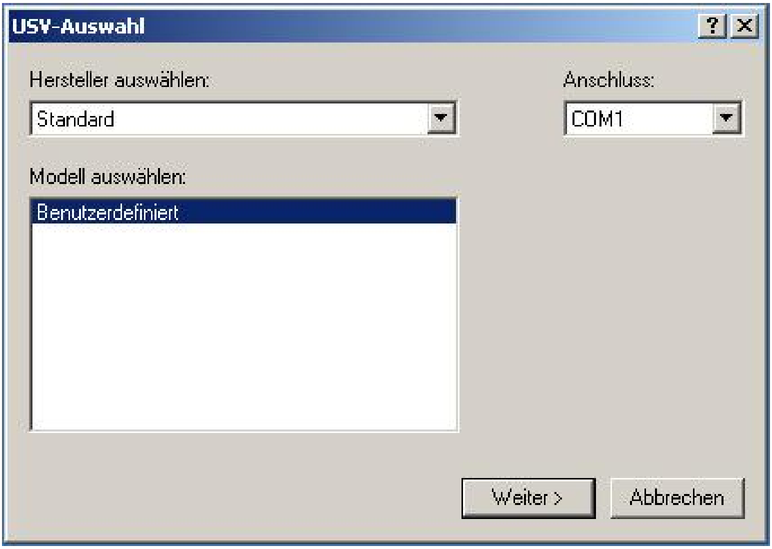
- Open „Start“ – „settings“ – „System“ – „Display“
- Then select the „Screen saver“ tab
- Open „Energy management“
- Select the „USV“ tab



- In Windows 2000, it is possible that under the “APM” tab, “Activate support for advanced power management” must be selected (√).

2. Select USV Driver

- Press „Select...“



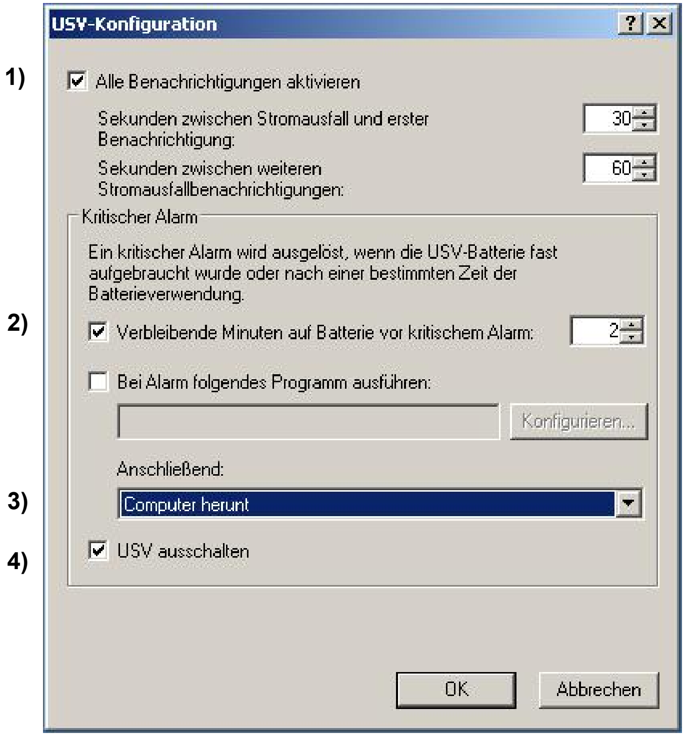
- Select manufacturer: „Standard“
- Select model: „User defined“
- Connection: select serial Interface for the USV 011
- Next press „continue >“

3. Set Signal Polarity

- Select polarity „negative“ as shown above.

Configure USV

- Press „Configure...“



- Windows detects the CTS signal from the RS232 as soon as the supply voltage falls out and the USV 011 changes to battery operation. From this point on, the USV time is running.
- **1)** Notifications can be used that require the user to save all important data.
- **2)** Under „ Remaining minutes on battery before critical alarm“, the bridging time (minimum 2 minutes) can be set. Please make sure that the USV time set with the DIPswitch is longer!
- **3)** After the time has elapsed, a critical alarm is triggered, which automatically closes all programs and shuts the PC down.
- If the battery discharges before the specified time has elapsed, Windows detects the DCD signal from the RS232. In this case a critical alarm is generated immediately and the PC is shut down.
- **4)** After a successful shutdown, the USV is deactivated over the RTS line of the RS232 (with a 10 second delay).

Revision History

USV 011

Date	Revision	Reason
14.03.2006	1.0	Charge / discharge histories are not implemented
31.03.2006	1.1	Charge / discharge histories are implemented
24.04.2006	1.1	RTS Polarity conversion expanded