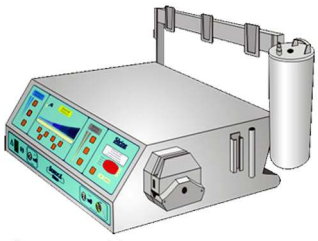
Service manual

Ultrasound Dissector
Sonoca 1xx/300/400/Lipo



Sonoca Lipo

Sonoca 400

Sonoca 300

Sonoca 1xx

Söring
INNOVATIVE SURGERY

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CE 0123

Read the instructions prior to performing any task!

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1 General information

1.1 Information about this service manual

This service manual provides important information on how to diagnose and correct the errors that may occur on the device. Compliance with all safety information and instructions provided in this manual is essential for safe operation.

In addition to the information provided in this manual, all local accident prevention regulations applicable to servicing the device as well as all general safety regulations must be observed.

The device must not be released for operation after repairs until all tests relevant to the safe operation of the device have been passed successfully.

Read the service manual carefully before commencing any work! It must be kept available to the service personnel at all times.

The service manual is not approved for use by the owner or his or her personnel. The application of the contents contained herein requires the qualification specified in the Personnel section.

The illustrations used throughout this manual are intended to illustrate the subject matter and may not be to scale and deviate from the actual model of the device.

Applicable in addition to this service manual are the instruction manuals for the discussed devices. Strictly adhere to the instructions contained therein - in particular, all safety instructions!

1.2 Explanation of symbols

Safety instructions

Safety instructions are marked with symbols in these instructions. The safety instructions are always introduced by signal words which express the extent of the danger.

DANGER!
This combination of symbol and signal word indicates an immediately-dangerous situation which could cause death or severe injuries if not avoided.

WARNING!
This combination of symbol and signal word indicates a possibly-dangerous situation which could cause death or severe injuries if it is not avoided.

CAUTION!
This combination of symbol and signal word indicates a possibly-dangerous situation which could cause slight injuries if it is not avoided.

NOTICE!
This combination of symbol and signal word indicates a possibly-dangerous situation which could cause property and environmental damage if it is not avoided.

Tips and recommendations

This symbol highlights useful tips and recommendations as well as information designed to ensure efficient and smooth operation.

Special safety instructions

The following symbols are used in the safety instructions to draw attention to specific dangers:

DANGER!
This combination of symbol and signal word indicates an immediately-dangerous situation due to electric shock. If an instruction so marked is not heeded, severe or even fatal injuries can be the consequence.

Additional markings

To emphasise instructions, results, lists, references and other elements, the following markings are used in these instructions:

Marking	Explanation
→	Step-by-step instructions
⇨	Results of action steps
↯	References to sections of these instructions and to other relevant documents
■	Listing without fixed sequence
[Buttons]	Operating elements (e.g. buttons, switches), display elements (e.g. signal lamps)
„Display“	Screen elements (e.g. buttons, programming of function keys)

1.3 Limitation of liability

All details and instructions in these instructions were compiled taking into account the applicable standards and regulations, the state of technology, as well as our many years of knowledge and experience.

In the following cases, the manufacturer assumes no liability for damage:

- Failure to follow these instructions
- Use deviating from the proper use
- Use of untrained personnel
- Unauthorised changes
- Technical alterations
- Use of non-approved spare parts

For special models, with the usage of additional order options or due to the latest technical changes, the actual scope of delivery can deviate from the explanations and depictions provided here.

Applicable are the obligations agreed upon in the delivery contract, the general terms and conditions, as well as the delivery conditions of the manufacturer and the legal regulations valid at the time the contract was concluded.

1.4 Copyright

This manual is protected by copyright and intended for in-house purposes only.

Except for in-house purposes, submitting this manual to third parties, duplications in any shape or form - even in excerpts - and using and/or disclosing the content of this manual are prohibited without the written consent of the manufacturer.

Non-compliance is subject to compensation for damages. Further claims remain reserved.

SONOCA® is a registered trademark of Söring GmbH.

1.5 Accessories

WARNING!

Risk of injury due to the use of improper accessories!

Improper or faulty accessories may lead to faulty operation or total loss and cause injuries to the user or the patient.

– Use only accessories that have been approved by the manufacturer.

Approved accessories can be ordered directly from the device manufacturer. For more information about these accessories, please log on to www.soering.com.

1.6 Warranty terms

The warranty terms are included in the manufacturer's Terms and Conditions.

1.7 Customer service

Our customer service division is available to provide technical information. See page 2 for contact details.

In addition, our employees are always interested in acquiring new information and experience gained from practical application; such information and experience may help improve our products.

2 Safety

This section provides an overview of all safety aspects that are essential to the best possible protection of the personnel and the safe and trouble-free operation of the unit.

Failure to follow the instructions and safety information provided in this manual may result in significant danger.

2.1 Responsibilities of the service partner

The service partner is the person or institution who operates the service point servicing the device. The service partner is obligated to observe all applicable regulations on occupational safety.

Apart from the occupational safety information provided in this manual, all regulations on safety, accident prevention and environmental protection applicable to the work area of the personnel must be observed. In particular, the service partner is responsible for:

- becoming familiar with the applicable occupational safety regulations and conducting a risk assessment to determine any additional risks in connection with the specific working conditions present at the work area of the personnel. The results of this risk assessment must be implemented into instructions on how to operate and service the device in a safe manner.
- verifying at regular intervals that the composed operating and safety instructions comply with the latest revision of the applicable regulations and revising them if necessary.
- clearly defining and assigning the responsibilities for all necessary work activities.
- ensuring that all employees handling the discussed devices have read and understood the instruction manual as well as the service manual. The service partner is also responsible for providing regular training and information on possible risks to his or her personnel.
- Furthermore, it is the service partner's responsibility to keep the work area and all necessary technical equipment in proper technical condition.

Responsibility towards the operator of the device

- Before releasing the device for operation, the service partner must ensure that the tests and safety inspections described in this service manual have been completed.
- The service partner must ensure that only spare parts approved by the manufacturer and components considered as compatible are used during service work on the device.

2.2 Personnel requirements

2.2.1 Requirements

WARNING!

Risk of injury due to insufficient qualification!

Improperly performed service activities may lead to significant property damage and severe personal injury including death to the personnel, the patients treated by the operator of the device or the service personnel.

Therefore:

- The device may only be serviced by personnel that possesses the minimum qualifications listed herein.
- Service activities not described in this manual may only be performed after consulting with the manufacturer.

All activities specified in this service manual require the following qualification:

Service personnel

Service personnel is capable of performing the troubleshooting and repair tasks assigned to them in a safe manner thanks to their professional training, their expertise and experience, and the instructions and authorization they received from the manufacturer.

Service personnel is capable of independently detecting, assessing, and averting possible risks to the user and his or her patients.

Service personnel is familiar with the contents of all applicable regulations, guidelines and standards required by law for the safe use of the device and is capable of implementing the requirements specified therein.

Service personnel possesses the technical knowledge required for the device's area of application and ensures that all safety and hygienic regulations applicable to medical equipment are observed by the operator of the device after the device has been released for operation.

Service personnel is authorized to perform the annual safety inspections required by law. Service personnel is deemed the authorized competent person as required by the instruction manuals for the devices.

Service personnel fulfills the requirements to be met by a skilled electrician and is, therefore, authorized to perform work on electrical installations.

In Germany, a qualified electrician must comply with the provisions of accident prevention regulation BGV A3 (e. g. Master Electrician). Similar regulations apply in other countries.

Authorized personnel may only include persons that can be expected to perform their work in a reliable fashion. Persons whose ability to respond is impaired, for example by drugs, alcohol or medication, are not permitted.

When selecting staff, observe all age and occupation-specific regulations applicable at the place of installation.

2.2.2 Unauthorised persons

WARNING!

Risk to life for unauthorised persons due to hazards in the danger and working zone!

Unauthorised persons who do not meet the requirements described here will not be familiar with the dangers in the working zone. Therefore, unauthorised persons face the risk of serious injury or death.

- Unauthorised persons must be kept away from the danger and working zone.
- If in doubt, address the persons in question and ask them to leave the danger and working zone.
- Cease work while unauthorised persons are in the danger and working zone.

2.3 Intended use/purpose

The ultrasound dissectors have been designed and constructed exclusively for the intended purpose described in their respective instruction manuals.

Any assessment of the device relevant to safety was made based on the technical specifications provided by the manufacturer.

Intended use also comprises the compliance with all specifications contained in this manual.

Any other use exceeding or deviating from the scope of intended use is considered to be inappropriate.

WARNING!

Danger from improper service and technical modifications!

Improper service and unauthorized technical modifications may impair the device's ability to operate as intended and lead to dangerous situations.

Therefore:

- Service the device only in accordance with the technical specifications provided by the manufacturer.
- Use only spare parts approved by the manufacturer and components considered compatible during service work on the device.
- Strictly adhere to all instructions provided in this service manual.

Claims of any kind for damages caused by unauthorized technical modifications are excluded.

Any damages caused by unauthorized technical modifications of the equipment are the sole responsibility of the service provider.

2.4 General safety information

Damaged lines

DANGER!

Danger to life from damaged lines!

Damage to the insulation of live lines may cause life-threatening injuries.

Damage to the wires may cause the device to malfunction and endanger the patient.

Therefore:

- Use only tested and undamaged lines.
- Cut off the power supply immediately and initiate repairs in case of damage to the insulation.
- Have work on the electrical connection performed by qualified electricians only.
- Cut off the electrical connection and check if it is de-energized prior to performing any work.
- Cut off the power supply and secure it from being switched back on prior to any maintenance, cleaning, and repairs.
- Keep moisture away from all live components, as moisture may lead to short circuits.

Electrical components

CAUTION!

Electrostatically sensitive components!

The components of the unit may be damaged or destroyed by electrostatic voltage.

Therefore:

- Before performing maintenance, always disconnect the unit from the power supply.
- When working on electrostatically sensitive components, always wear a grounded antistatic wrist strap.
- Always hold the components by their corners without touching the conductor paths, ICs, etc.
- Always place the components on antistatic surfaces.

Careless handling of tools and components

CAUTION!

Risk of injury from the careless handling of tools and device components!

Unless caution is exercised, tools and device components lying about may cause falls and injuries.

Therefore:

- Store tools and device components in such a way that they do not pose any danger.
- Move carefully when inside the work area.

Spare parts

WARNING!

Risk of injury from unsuitable spare parts!

Unsuitable spare parts may lead to faulty operation or total loss and cause injuries to the user or the patient.

Therefore:

- Use only spare parts that have been approved by the manufacturer.

Damaged components

WARNING!

Risk of injury from damaged components!

Damaged components can no longer be used safely on the patient. Any resulting device malfunctions may cause serious injury to the patient.

Therefore:

- Replace all damaged components completely with new original spare parts.
- Mark damaged components as such and dispose of them in the proper manner.

2.5 Environmental protection

Disposal

CAUTION!

Environmental hazard due to improper disposal!

Disposing of the device in an improper way represents an impermissible hazard to the environment.

Therefore:

– When the device has reached the end of its useful life, submit it to an authorized specialist in disposing of electronics or Söring GmbH.

3 Fundamentals of ultrasound surgery

3.1 Fundamental physical-technical principles

- The piezoelectric ultrasound converter built into the ultrasound instrument is excited to vibrate mechanically by the electrical excitation current generated by the signal generator (inside the Sonoca).
- These vibrations are transferred by the sonotrode, causing the tip of the sonotrode to vibrate mechanically (ultrasound).
- When the tip of the sonotrode comes into contact with the tissue, the ultrasound energy will separate the cells from the tissue complex (fragmentation) due to massive acceleration forces and the cavitation effect created.
- A tube connection is used to feed irrigation fluid (saline solution) to the ultrasound instrument. This fluid is fed through a thin Teflon tube either from the outside or the inside (through the hole in the sonotrode) depending on the type of the ultrasound instrument used. The fluid amount is controlled by a peristaltic pump.
- The irrigation fluid improves the injection of ultrasound, cools the tissue surface and, thereby, prevents the tissue from sustaining any thermal damage.
- The fragmented tissue is extracted through the hole in the sonotrode as a pulpy substance and enters the secretion bottle after passing through another hose line. The extraction is performed by a vacuum pump built into the Sonoca.
- Ultrasound cleans and kills bacteria on wound surfaces. This effect is utilized for wound treatment purposes.
- "Knives" excited by ultrasound can be used for making cuts.

3.2 Tissue interdependencies

Selectivity

- Ultrasound selectively affects the different types of tissue found in the human body.
- Intense fragmentation effect on epithelial, muscle, and parenchymal tissue.
- Vascular, nervous and connective tissue structures cannot be destroyed by the effects created by ultrasound.

Active principle

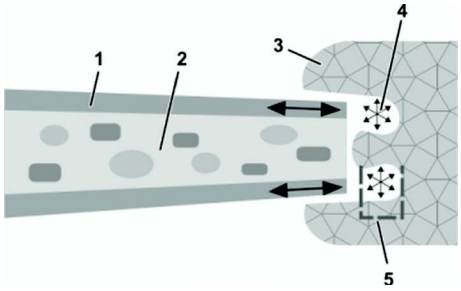

Fig. 1: Tissue interdependencies

1 Sonotrode tip
2 Disintegrated tissue, liquor, and blood
3 Parenchymal tissue
4 Cavitation forces
5 Zone of irreversible cell damage

- The effects created by ultrasound are, for the most part, based on the utilization of cavitation as well as thermal processes.
- Cavitation is defined as the formation and dissolution of cavities (µm-size bubbles) in liquids caused by pressure variations. Negative pressure results in the formation of bubbles which will collapse when the pressure increases and, thereby, generate impulse waves and so-called jets of liquid. Impulse waves can trigger pressure variations amounting to several 1,000 bar. This will cause cells to be detached from their united cell structure.
- Cavitation is linked to a high content of fluid in the biological tissue and depends both on the consistency as well as the temperature of the medium and the frequency and intensity of the ultrasound.
- This is why ultrasound is most effectively applied on cells with a high content of intracellular fluid. Neither blood vessels nor nerves will be affected.

Limitation of effectiveness

- Sound dispersion on cavity bubbles, sound absorption inside the tissue and spherical sound distribution result in a significant decrease in sound intensity the deeper the ultrasound waves penetrate the tissue. This limits the effect of the ultrasound applied to the surface of the tissue and prevents the deeper tissue structure from being affected.
- Tissue with smaller intracellular gaps contains less fluid and is most often interlaced with intracellular fibers (bone and cartilage tissue). This significantly obstructs cavitation from having an effect on the tissue.

- The separating forces generated during ultrasound cutting are significantly lower when compared to conventional microsurgical cutting instruments. This results in a lower amount of traumatization and mechanical aging of the tissue.
- The sonotrode transfers a small amount of electrical energy onto the tissue, and its effect is based on the acoustic or vibrational energy generated by high-power ultrasound. Coagulation instruments utilize the heat generated during the transfer of the ultrasound energy to create coagulation.

3.3 Handpieces and sonotrodes

General information

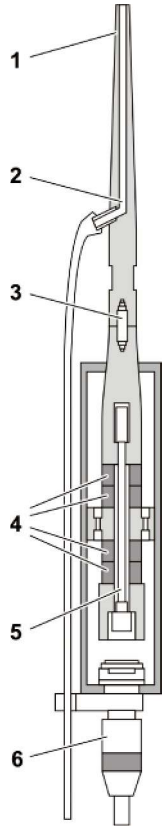

Fig. 2: Handpiece with sonotrode

1 Application tip (sonotrode)
2 Irrigation channel
3 Thread with aspiration channel
4 Piezo disks
5 Internal screw
6 Connector socket

- Ultrasound instruments operate in accordance with the electrostrictive principle. A transducer is made up of several small piezo-ceramic rings. The transducer converts the electrical vibration generated in the resonance frequency range of 25 kHz, 35 kHz or 55 kHz into mechanic vibration and excites the application tip (sonotrode) to vibrate.
- This principle of conversion allows for operation at low power dissipation. The principle also makes the installation of any additional cooling systems on the handpiece unnecessary.
- The operating frequency preferably used in combination with ultrasound dissection instruments is 25 kHz and generates sound intensities of up to 6 W/mm at a vibration amplitude of approx. 150 µm and a probe tip with a size of 15 mm^2.
- Dissection instruments intended for the fragmentation of tissue structures operate at a frequency of 25 kHz or 35 kHz.
- Macro-handpieces operate at 25 kHz.
- Micro-handpieces operate at 35 kHz.
- Cutting instruments utilizing the thermal effect created by the ultrasound vibration operate at a frequency of 55 kHz.

Notes

WARNING!

Risk of injury from damaged handpieces!

If damaged, a handpiece cannot be safely used on the patient. A broken handpiece may cause severe injuries. Breakage during use may result in foreign objects remaining in the tissue.

Therefore:

- Do not bring the handpiece into contact with any metal objects during operation as this may damage the tip.
- Do not cause too much mechanical stress on the handpiece during use (e. g. by exerting too much pressure or bending it).
- Keep the handpieces sterile and protected from impact, shock and vibration.
- Do not continue using handpieces that have become damaged.
- Have handpieces serviced and repaired only by the expert who has been authorized by the manufacturer.
- Properly dispose of handpieces that are no longer fit for use.

Some handpieces used for microsurgical procedures, e. g. neurosurgical treatments, operate without an aspiration system.

Sonoca handpieces can be cleaned manually. However, we recommend automatic reconditioning (cleaning and disinfecting at 93 °C in an automatic cleaning and disinfecting machine). Sterilization must take place at 134 °C. Observe the cleaning instructions specific to the respective instrument.

- For more information on safety, the area of application, and specific technical specifications, see the documentation for the respective handpiece.

4 System design

4.1 Description of assemblies

The ultrasound dissectors are composed of the following components:

- Power supply including power supply board (UNT) and power transformer
- Power supply unit (UPWNT) including voltage regulators for the ultrasound generator and other electronic components and for controlling the negative pressure controller
- Ultrasound generator (USG) for controlling the ultrasonic converter built into the ultrasound instrument
- CPU board (CPU)
- Display board (front panel)
- Vacuum system: Vacuum pump, negative pressure controller (except SONOCA 190 and SONOCA 180)
- Irrigation system: Peristaltic pump with drive motor (except SONOCA 190 and SONOCA 180)
- Housing

Not all models of the device contain a vacuum pump/irrigation pump.

Units without a vacuum/irrigation pump are housed in a smaller enclosure.

The Sonoca-Lipo model is equipped with a larger vacuum pump.

The design and function of the assemblies are described in the following sections.

Power supply components

The supply voltage is fed to the device switch via a line filter jack which also houses the device fuses. From there, the voltage is transferred to the power supply board.

Mounted on the power supply board are the voltage selector switch (115 V/230 V), the rectifier, filter capacitors, and a relay for activating the vacuum pump.

The power supply board is connected to the power transformer (primary and secondary side) as well as the vacuum pump and supplies the uncontrolled voltages (± 29 V= and approx. 160 V=) to the power supply unit.

The power supply unit houses the corresponding voltage regulators which are used to supply the remaining components.

Power supply unit

The power supply unit is composed of the following subcomponents:

- A low voltage regulator (+15 V, +5 V, and -15 V) to supply the remaining electronic components and the CPU board (+5 V).
- A variable voltage regulator for the ultrasound generator (0 V up to 100 V). This voltage sets the amplitude for the ultrasonic converter and varies with the output (amplitude) set on the device as well as the type of instrument used.
- The control of the motor used to drive the peristaltic pump as variable voltage regulator (0 to 15 V).
- The control of the proportional valve built into the vacuum control unit.
- The unit used to measure the vacuum.
- The interface with the CPU (I2C bus).

Ultrasound generator

The ultrasound generator contains all components necessary to control the ultrasonic converter built into the ultrasound instrument.

The generator is made up of an output stage, a frequency-variable oscillator, a measuring unit used to regulate the frequency to the resonance frequency of the ultrasonic converter, and an interface with the CPU (I2C bus).

The ultrasound generator output is connected to the socket used to connect the ultrasound instrument with the unit.

Instrument detection board

The instrument detection board is connected to the instrument socket.

For the purpose of identifying the components built into the instruments (diodes, Z-diodes, and jumpers) and to code the instruments, the connected device type is detected, and the ultrasound generator is set to the corresponding parameters (frequency and excitation current).

CPU board

The CPU board is used to control the general sequence of work steps taking place inside the device and contains the software (stored in the EPROM) and the configuration memory.

The board is connected to the power supply unit, the ultrasound generator, the instrument detection board, and the display board (I2C bus).

Vacuum pump

A relay connects the vacuum pump to the primary windings which are connected in series on the power supply board (activated). The pump is, therefore, always supplied with an operating voltage of 230 V irrespective of the set supply voltage (230 V / 115 V).

Fitted with 2 identically designed pump heads, the vacuum pump is constructed to function as a membrane pump. The aspiration connection on each pump head is connected to the vacuum control unit via a hose line.

The aspirated air is guided outside the pump through a sound absorber.

Vacuum control unit

The vacuum control unit contains the proportional valve and the pressure transducer used to measure the vacuum.

A hose line, a fine filter and a vacuum socket connect the vacuum control unit to the secretion bottle.

The interface used to measure the vacuum and control the proportional valve (pulse width modulation) is housed on the power supply unit.

Peristaltic pump

The peristaltic pump is mounted on the side of the device.

The drive motor (gear motor) is supplied by a variable voltage regulator (voltage 0 to 15 V) which is housed on the power supply unit.

The voltage specification is set by the CPU and transmitted via the I2C bus.

4.1.1 Arrangement of assemblies

Sonoca 300/400/Lipo

These devices are built into a larger housing. Their design is distinguished by their vacuum pump which is larger for the Sonoca Lipo and provides more aspiration power.

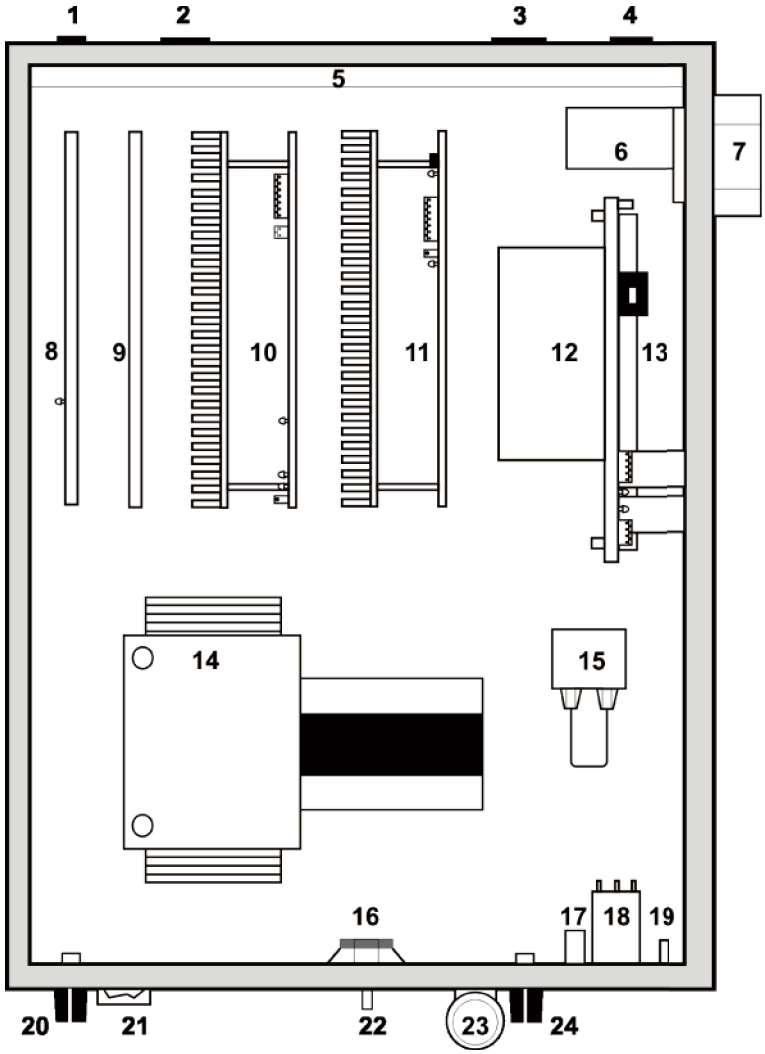

Fig. 3: Arrangement of the assemblies built into the Sonoca 300/400/Lipo

1 Power switch
2 Foot switch socket
3 Foot switch socket
4 Ultrasound connector socket
5 Front panel
6 Gear motor irrigation
7 Pump head
8 Handpiece detection unit
9 CPU
10 Ultrasound generator
11 Power supply unit
12 Power transformer
13 Power supply board
14 Vacuum pump
15 Vacuum control unit
16 Speaker

17 Fuse holder
18 Line filter
19 Ground bolt
20 Emergency vacuum connection (400/Lipo)
21 Emergency pump switch (400/Lipo)
22 Speaker potentiometer
23 Filter element
24 Vacuum connection

The tube connections for the vacuum system are not marked in the drawing.

Sonoca 180/185/190

These device do not include a vacuum pump.

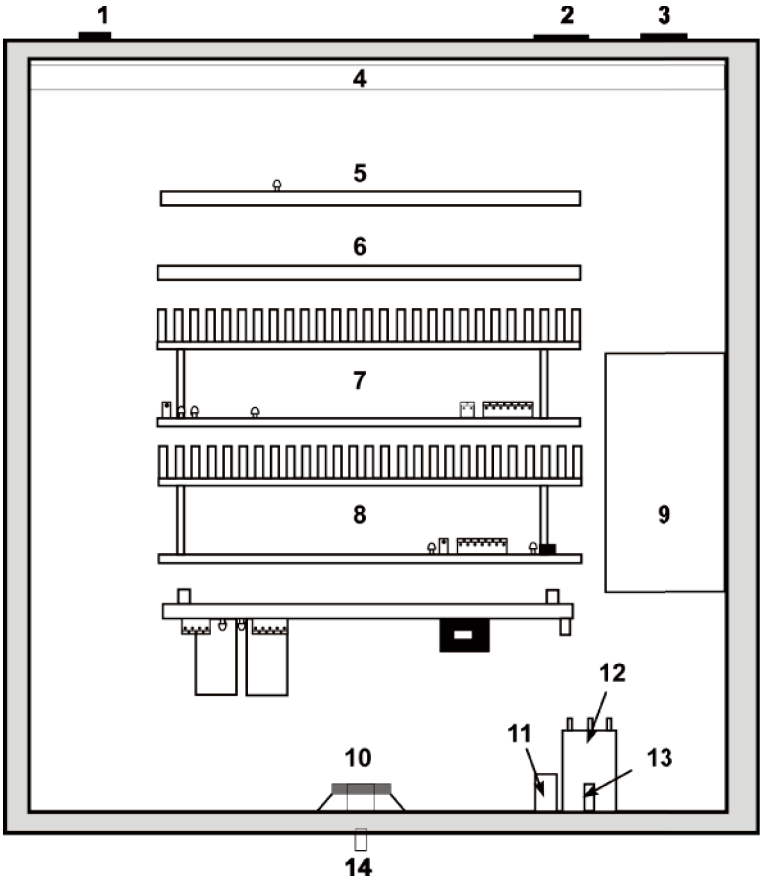

Fig. 4: Arrangement of the assemblies built into Sonoca 180/185/190 units

1 Power switch
2 Foot switch socket
3 Ultrasound connector socket
4 Front panel
5 Handpiece detection unit
6 CPU
7 Ultrasound generator
8 Power supply unit
9 Power transformer
10 Speaker
11 Fuse holder
12 Line filter
13 Ground bolt
14 Speaker potentiometer

4.1.2 Wiring of the assemblies

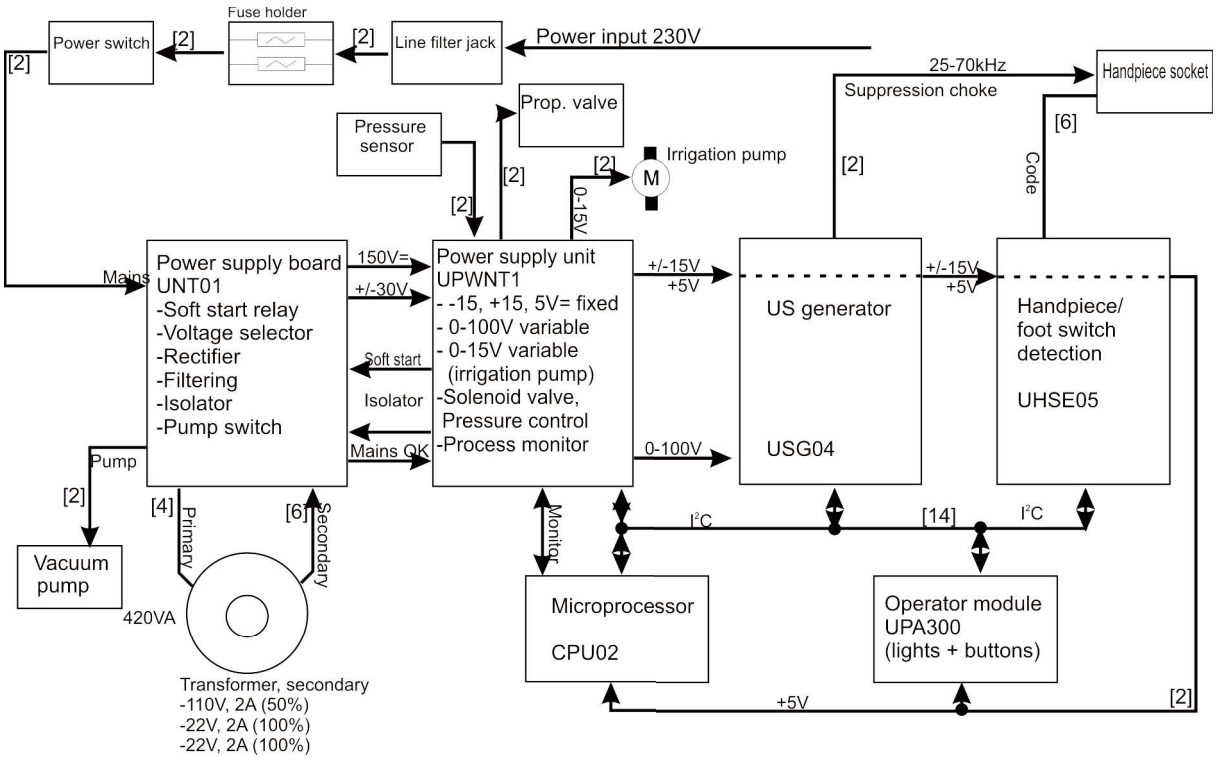

Fig. 5: Electrical wiring

4.2 Primary power supply

The following block diagrams of the power supply boards show the components of the primary power supply. They include all components connected to the power supply (live parts):

- Mains connection socket including fuse holder and filter
- Power switch
- Voltage selector (power supply board)
- Switching relay for vacuum pump (power supply board)
- Power transformer with thermal fuse

The supply voltage is fed to the dual-action power switch on the power supply board through the mains connection socket. The power supply board houses a noise filter that is approved for medical applications and a double fuse holder (2 micro fuses) providing fuse protection. The supply voltage is fed to the primary trans-

former windings through a voltage selector integrated on the power supply card. To ensure that it will be supplied with 230 V~ even if the supply voltage is only 115 V, the vacuum pump is powered by the primary windings of the power transformer (autotransformer circuit) which are connected in series. The vacuum pump (not included with all Sonoca devices) is controlled by a relay and switched on/off by the microprocessor.

Sonoca 1xx/300

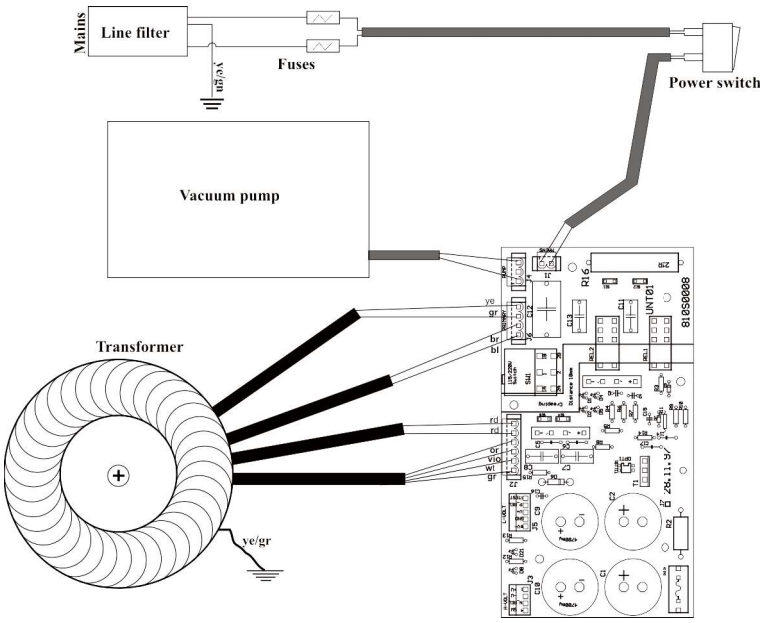

Fig. 6: Sonoca 1xx/300

1 Mains
2 Line filter
3 Fuses
4 Power switch
5 Vacuum (not included with Sonoca 1xx)
6 Transformer

The special models that include a large vacuum pump (Sonoca Lipo and Sonoca 400) are equipped with an additional emergency switch which can be used to switch on the vacuum pump if the unit cannot be started using the controls on the front due to a defect in the electronic system. The illustration shows the corresponding expansion of the primary power supply.

When switched over by the emergency switch, the supply voltage will be fed directly to the vacuum pump. The pump is protected by a separate fuse.

Sonoca 400/Lipo

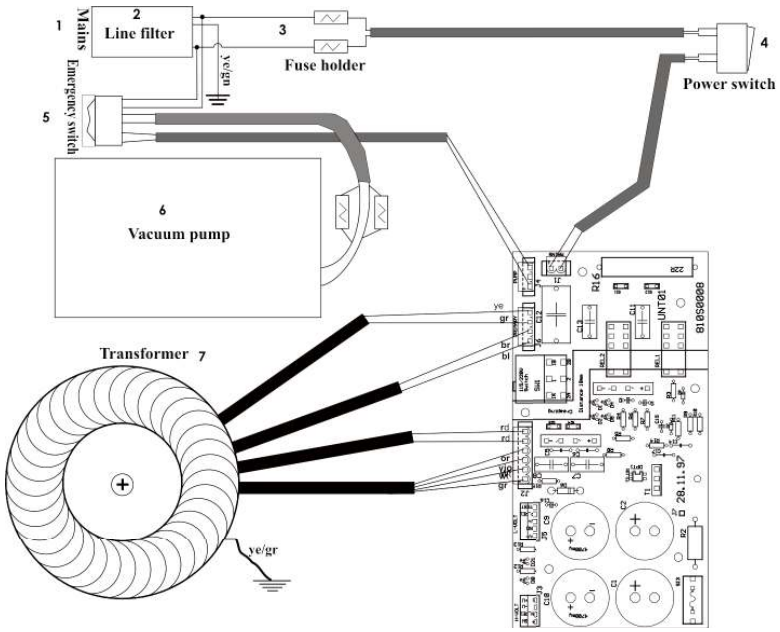

Fig. 7: Sonoca 400/Lipo

1 Mains
2 Line filter
3 Fuses
4 Power switch
5 Emergency switch
6 Vacuum (not included with Sonoca 1xx)
7 Transformer

4.3 Circuit boards and modules

4.3.1 Description of the power supply board

Overview

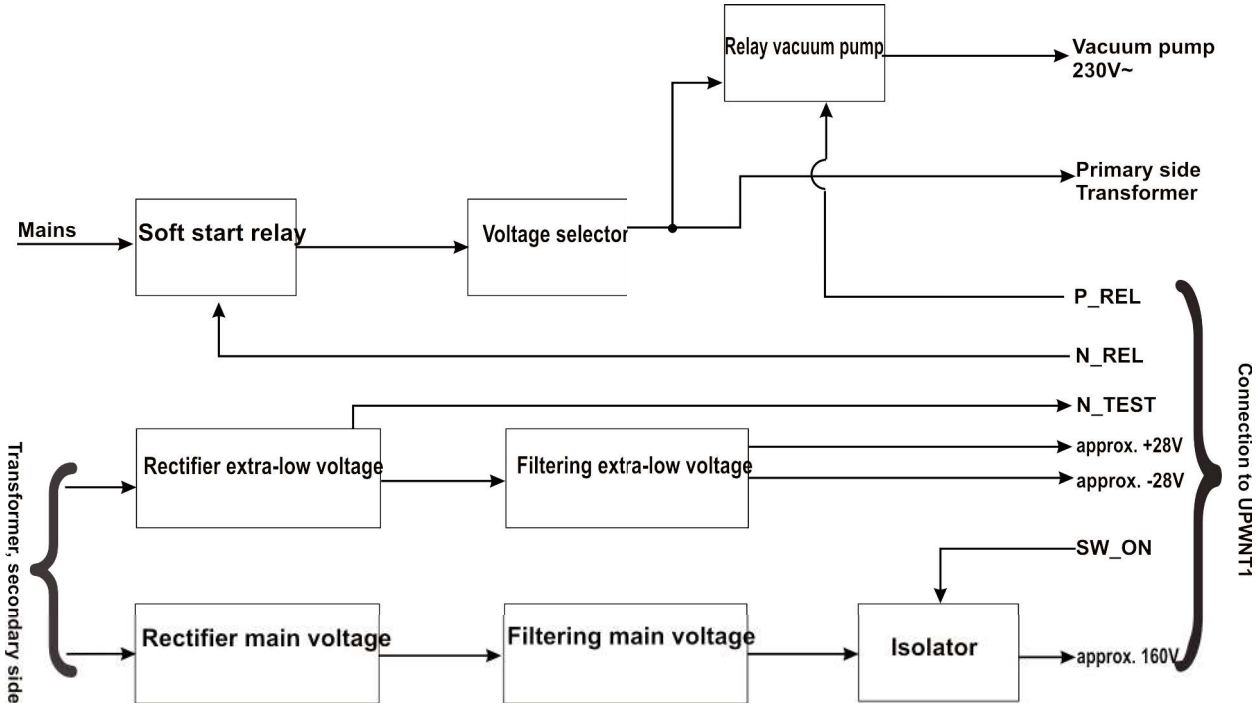

Fig. 8: Block diagram - power supply board

Design and function

The power supply board houses all components necessary to feed electrical power to the device. The board is connected to the mains on the primary side. From there, the supply to the power transformer on the primary side is fed through a switch-on current limiter and a voltage selector. A relay is used to switch a vacuum pump on and off.

The secondary side of the power transformer is also connected to the board. This section of the board provides for the rectification and filtering of the secondary voltages in the power transformer: 115 V and 21 V. These filtered voltages are fed to the power supply unit. The filtered 115 V voltage (approx. 160 V=) is fed through an isolator (MOS transistor) which is controlled by the power supply unit.

4.3.2 Power supply unit

Overview

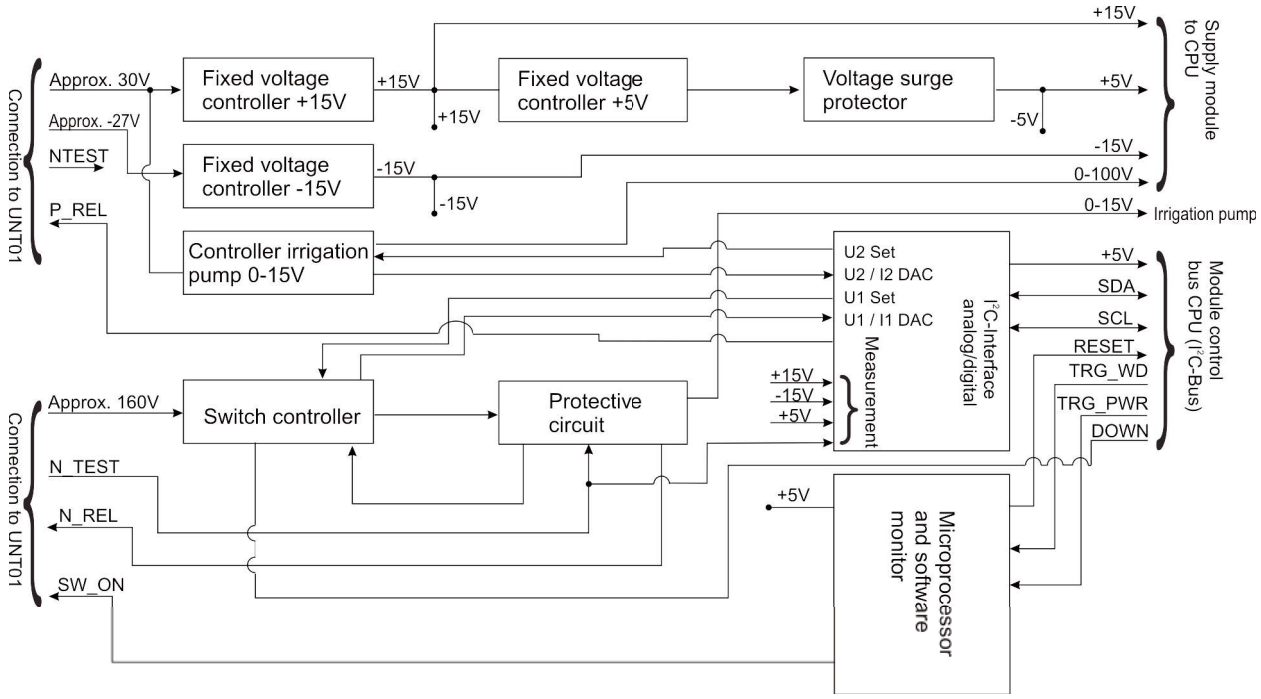

Fig. 9: Block diagram - power supply unit

Design and function

The power supply unit is the central voltage supply unit for the entire unit. It is fed with uncontrolled voltages of approx. -28 V, +28 V, and +160 V by the power supply board.

The power supply unit supplies the controlled and stabilized voltages necessary for the CPU, the instrument detection unit and the power module.

The following voltages are supplied:

- Fixed voltages +15 V, -15 V, and +5 V
- 0 V to 15 V for the irrigation pump (set by CPU via I2C bus)
- 0 V to 100 V for the power section of the ultrasound module
- Pulsed voltage (30 Vs^2) with a duty cycle of approx. 30 % to 80 %, pulse frequency approx. 1 kHz to control the proportional valve built into the vacuum control unit

The following currents, voltages and values are transferred to the CPU board via an I2C interface:

- Current and voltage of the U1 voltage regulator (0 to 100 V)
- Current and voltage of the U2 regulator (for the irrigation pump)
- Current fixed voltages (±15 V, +5 V)
- Pressure transducer value (vacuum)

The power supply unit supplies the control signals for the pump relay and the current limiter relay (housed on the power supply board).

This module also houses a protective circuit including excess current cut-off for the power output (0 V to 100 V) as well as a voltage surge protector circuit for the CPU (5 V voltage supply) which will shut down the 5 V output by means of a thyristor.

Another protective circuit is used to monitor the microprocessor software (watchdog) and submits a RESET signal when the watchdog trigger signal is missing or incorrect.

When the watchdog signal is triggered, the protective circuit will generate a RESET signal for the CPU and lock the power supply to the power output (0 V to 100 V).

An additional watchdog circuit ensures that the power output cannot supply any voltage unless a monoflop has been triggered with a sufficiently high frequency. If the signal is not triggered, the isolator on the power supply board will be locked. The signals necessary for this purpose as well as the I2C bus are fed to the CPU through a ribbon cable.

The block diagram shows the basic design of the power supply unit.

LEDs and potentiometer

ID	Function	Comment
D1	+5 V available	Must be on
D2	+15 V available	Must be on
D3	-15 V available	Must be on
D4	Voltage irrigation pump	Brightness varies with motor voltage
D5	Relay current limiter	Comes on after approx. 1/2 s
D6	Relay irrigation pump	Normally off

ID	Function	Comment
D32	Reset	On during reset/switch-on, otherwise off
P1	Setting +5 V	Fine-tune voltage +5 V
P2	Frequency valve	Setting to approx. 1 kHz

4.3.3 Ultrasound generator

Overview

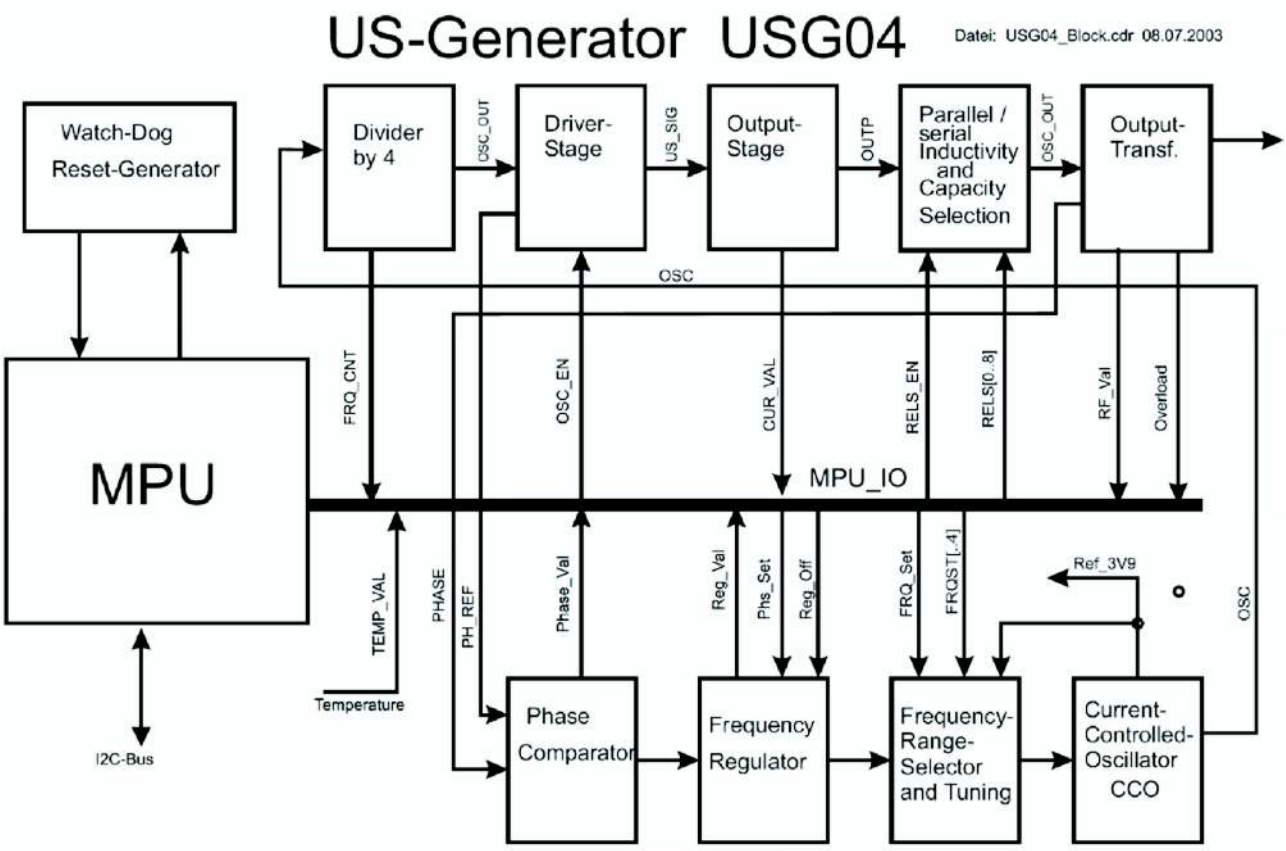

Fig. 10: Block diagram - ultrasound generator

Design and function

The ultrasound generator consists of:

- Frequency-adjustable oscillator
- Driving and output stage (designed as a half bridge)
- A series inductivity (8 inductivity levels adjustable by relay)
- Correction capacitors (setting the resonance frequency of the resonance circuit)

- Output transformer (potential separation and impedance adjustment)
- Measuring circuits for determining the phasing of current and voltage (for regulating the system to the resonance frequency)
- Microcontroller with its own firmware for sequence control. The firmware contains all control and regulating algorithms necessary to control the ultrasound system.

The ultrasound generator provides the signal necessary to excite the ultrasound converter built into the instrument. The excitation current generated by the ultrasound generator excites the piezo disks of the ultrasonic converter to generate thickness vibrations. These vibrations are transferred by the sonotrode.

The ultrasonic converter forms a vibrating system in conjunction with the sonotrode. This system must be excited by the excitation pressure to vibrate exactly at the resonance frequency. The extremely low bandwidth of the vibrating system requires that the frequency control work accurately.

The correct excitation frequency of the oscillator is calculated based on the phasing of the current and voltage of the output signal and adjusted precisely even if the resonance frequency changes.

The instruments are distinguished by their resonance frequency and the required excitation current. The parameters set for the ultrasound generator vary with the type of the instrument used.

To reduce the CPU load, the ultrasound generator is equipped with its own microcontroller.

Signal paths

A frequency-variable oscillator supplies its square wave signal to the output stage (half bridge) by means of a divider and driver circuit. The output stage receives its operating voltage (0 to 100 V) from the power supply unit.

The square wave signal generated in the output stage is transmitted to the output transformer via a series oscillator circuit. By selecting the correct amount of inductivity and capacity (gradual selection by relay), the resonance frequency is adjusted approximately to the instrument's resonance frequency. This forces a current through the ultrasonic converter which is almost independent of the ultrasonic converter's load resistance and, thereby, ensures a constant ultrasound amplitude.

The phasing of current and voltage is measured and evaluated to set the oscillator frequency to the resonance frequency of the ultrasound instrument and adjust the oscillator frequency throughout operation.

Errors caused by overload and/or the loss of the resonance frequency will be detected and reported to the CPU via the I2C bus. The necessary start parameters (varying with the type of the instrument) are transmitted via the same bus.

4.3.4 Instrument detection card

The instrument detection unit is galvanically isolated from and designed to detect the different instruments connected to the device and the pressing of the button (finger switch, foot switch). Once the instrument is detected, the corresponding signals are submitted to the CPU.

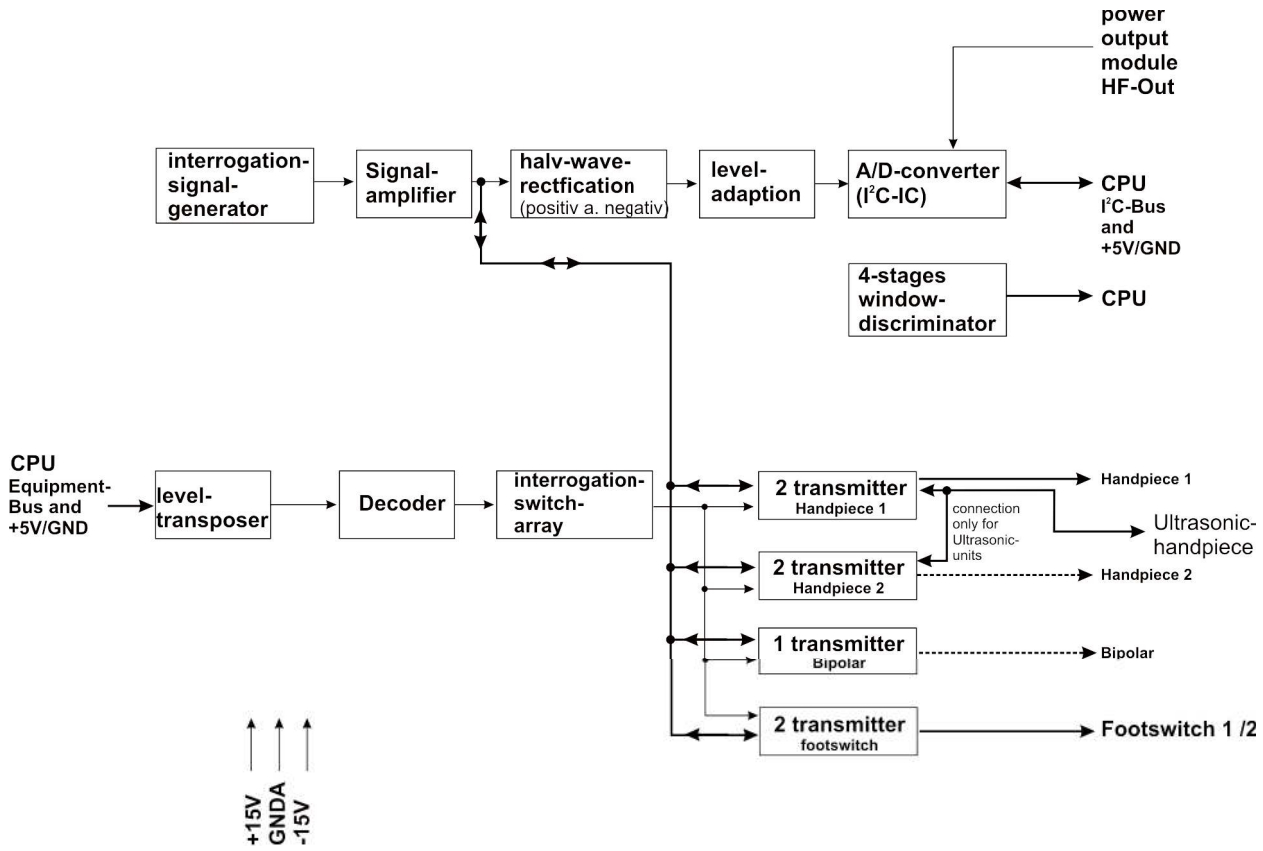

Fig. 11: Block diagram - instrument detection unit

Function

An oscillator generates alternating short pulses at a frequency of approx. 22 kHz and approx. 16 V_{SS}, which are then in succession transmitted to transformers. The primary signal is affected in different ways by diodes, Z-diodes or jumpers (short circuits) that are connected to the secondary side. The signal is evaluated by corresponding comparators and transmitted to the CPU.

The CPU software uses the signal sequences to detect the connected type of instrument. The use of 3 different transformers makes it possible to distinguish between various combinations of diodes, Z-diodes and jumpers and, thus, types of instruments.

The actuations of the foot switch are detected based on the same procedure.

The LED (red) flashes periodically when the software is running.

4.3.5 Microcontroller assembly/CPU board

The CPU is the central control system of the Sonoca. It receives its information from other assemblies via parallel data lines or the I2C bus. The data output is issued via the addressable system bus, a pulse-width-modulated signal or the same parallel data lines/I2C bus used for the data inputs.

Overview

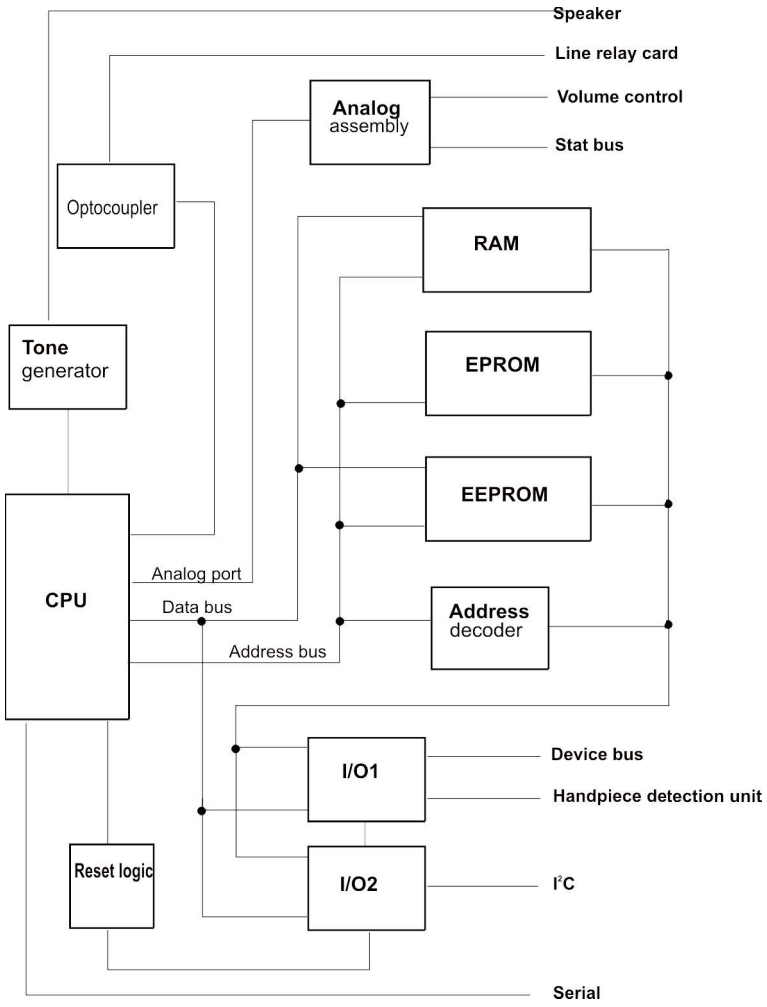

Fig. 12: Block diagram - microcontroller

Connection to the front panel (display)

The front panel is connected to the CPU via the I2C bus. The button input is received by reading the different I2C input modules.

The data output for the LEDs and the bar graph displays is provided by the specification of the respective I2C output modules. The CPU also supplies power to the panel.

Connection to the instrument detection assembly

Data between the CPU and the instrument detection assembly is exchanged by parallel data lines.

The instrument detection assembly cannot detect an instrument without the assistance of the CPU. When trying to detect an instrument, the instrument detection assembly checks the connected device for the different possible wiring options and reports the results of this check to the CPU. The CPU can use the results of this check to identify the correct instrument.

Another function of the instrument detection assembly is to transmit the foot switch status via a data line.

Connection to the power supply

The supply voltage for the CPU is provided by the power supply. The CPU can then receive the current voltage and electrical power values from the I2C bus.

The I2C bus is also used to transmit the heat sink temperature as well as the overcurrent conditions. This allows the CPU to detect faults in the power supply or the connected assemblies and prevent the operation of the device in the event of an error.

Connection to the ultrasound module

The operation of the ultrasound module requires the help of the CPU. The ultrasound module is controlled via the I2C bus, which is also used to submit feedback. This feedback is required to allow the ultrasound module to reliably tune to the frequency of the connected instrument.

4.3.6 Front panel/display board

Overview

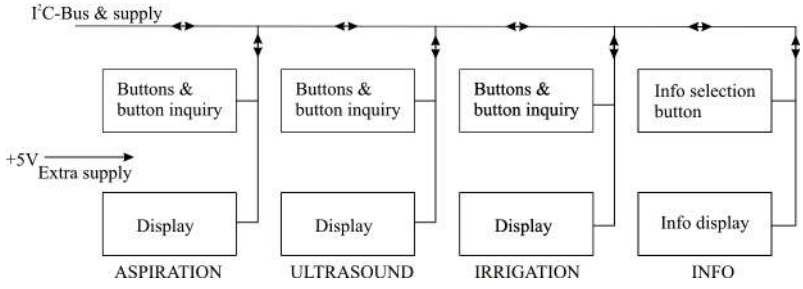

Fig. 13

Design and function

The front panel houses operating buttons as well as displays for parameters and device information. It is divided into four functional groups.

Data between front panel and CPU is transferred via the I2C bus. The front panel is supplied with +5 V/Gnd.

The front panel can be coded by plugging the coding pins on the soldering side into the respective positions.

Function groups front panel

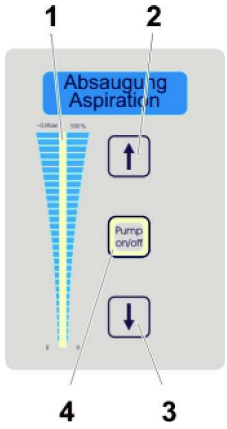

Fig. 14: Control panel aspiration (example Sonoca 400)

Aspiration system

Function	Device	Item
Intensity bar graph display	300/400/Lipo	1
Intensity setting	300/400/Lipo	2/3
Pump On/Off	300/400/Lipo	4

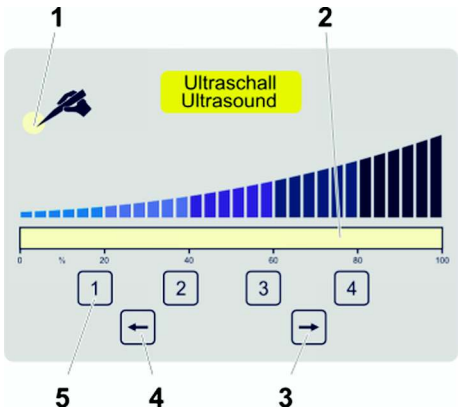

Fig. 15: Control panel ultrasound (example Sonoca 400)

Ultrasound

Function	Device	Item
Active display ultrasound	300/400/Lipo/1xx	1
Intensity bar graph display	300/400/Lipo/1xx	2
Output setting	300/400/Lipo/1xx	3/4
Output level hotkeys	300/400/Lipo/1xx	5

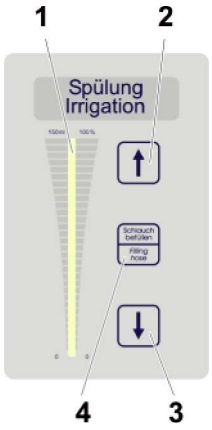

Fig. 16: Control panel irrigation (example Sonoca 400)

Irrigation system

Function	Device	Item
Irrigation intensity bar graph display	300/400/Lipo	1
Intensity setting	300/400/Lipo	2/3
Fill tube button	300/400/Lipo	4

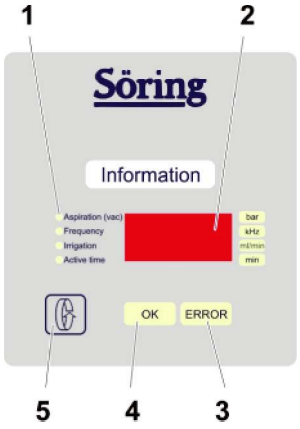

Fig. 17: Info panel (example Sonoca 400)

Info panel

Function	Device	Item
Parameter display	300/400	1
Error code display	300/400/Lipo/1xx	2/3
Error display	300/400/Lipo/1xx	3
3-digit 7-segment display	300/400/Lipo/1xx	2
Functionality display	300/400	4
Info selector key	300/400	5

4.3.7 Aspiration system

The aspiration system is integrated into the Sonoca and consists of the following components:

- Membrane vacuum pump
- Vacuum control unit to control the rate of aspiration
- Vacuum/bacteria filter (type ZFB 300-08, by SMC)
- Mini coupling, self-closing (type 0171031, by UNIMATIC)
- Vacuum tube with plug-in sleeve and plastic nipple for connecting the vacuum nozzle to the secretion bottle
- Secretion bottle
- Aspiration tube (single-use item) with Luer lock connection for the ultrasound instrument

Design and function

The two aspiration nozzles of the dual-head membrane vacuum pump are connected to the vacuum control unit by 2 silicone tubes.

The vacuum control unit contains a proportional valve that is used to control the air volume that needs to be aspirated (air flow). Located on the "other side" of the proportional valve is a pressure sensor that is used to measure the negative pressure.

Additional silicone tubes are used to connect the vacuum control unit to a bacteria filter and the vacuum nozzle of the Sonoca unit. There, the secretion bottle is connected via a plug-in vacuum connection and the aspiration tube.

The negative pressure in the secretion bottle is regulated to the desired nominal value ("aspiration rate" value set on the control panel) by measuring the negative pressure and varying the opening position of the proportional valve. The negative pressure is controlled by means of a control algorithm programmed into the software. To allow this algorithm to function properly, the program must know at which set digital value the proportional valve will start opening and at which the valve is fully open.

The software also requires sensor data to determine the air pressure (no vacuum) and the value of the maximum vacuum. This data can be re-entered in the corresponding service modes (nos. 6-9) if, for example, the vacuum control unit or the power supply unit (which processes the sensor data) has been replaced.

As the vacuum pump will not start running with the negative pressure at its maximum, a ventilation valve (steel pipe with a small drill hole) has been integrated in one of the two aspiration tubes.

The exhaust air is transported through 2 silicone tubes which are routed, first, from the pressure side of the pump heads to the interior of the unit and, then, into the open through the openings in the housing.

The secretions from the instrument are aspirated through a hose line (single-use item) which connects the instrument to the designated nozzles (embedded in the secretion bottle cap). A protection valve also integrated into the cap of the section bottle prevents fluid from entering the device when the secretion bottle is full.

Summary

- The vacuum pump, drive motor (230 V~) is switched on and off by a relay housed on the power supply board.
- The vacuum control unit contains a proportional valve which is controlled by the power supply unit by means of a square wave signal (approx. 1 kHz) of variable pulse width. The signal (current) of the pressure sensor is processed on the power supply unit and then supplied to the CPU via an AD converter.
- A bacteria filter is wired between the negative pressure controller and the aspiration nozzle to ensure that no germs can be aspirated and blown into the environment by the vacuum pump. The filter insert (white when new) must be replaced as soon as it shows visible discoloration.

4.3.8 Irrigation system

The irrigation system is integrated into the Sonoca and consists of the following components:

- Direct current motor 12 V, 0.5 A, max. 3,000 revolutions/min, reducible to 100 rpm by reduction gear unit (by Crouzet)
- Peristaltic pump (type PPS 7518-50, by Novodirect)
- Silicone tube for fluid dispension
- Irrigation tube (single-use item) with Luer lock connection for the ultrasound instrument

Design and function

The gear motor built into the unit is used to power a peristaltic pump located on the side of the housing. The peristaltic pump can be opened in a single step to insert the irrigation tube. When the pump is closed, the locking clips on the side prevent the tube from slipping through the pump.

The pump motor is controlled by the CPU which uses the voltage (0-15 V) supplied by the power supply unit to set the desired speed needed for the required amount of liquid (ml/min).

The Fill tube function is triggered with the push of a button and causes the pump to run at its maximum speed. The info display indicates the set amount of fluid.

Irrigation fluid

The irrigation fluid is led from the storage bottle hanging from the irrigation bottle hanger through the tubing system and the pump into the instrument where it will exit as a dosed jet from the tip of the instrument during internal irrigation or from the mouthpiece during external irrigation.

Infiltration solution

The infiltration solution is led from the storage bottle hanging from the irrigation bottle hanger through the tubing system and the pump into the infiltration instrument. Infiltration is triggered by the respective foot switch.

5 Inspections

5.1 Checking the accessories

Cables, tubes and handpieces

1. Before releasing the device and the accessories for operation, check all cables, tubes and handpieces for damage.
2. Replace cables, tubes and handpieces if they are damaged and dispose of them properly.

Sonotrodes

1. Check the sonotrodes for wear.
2. Have worn sonotrodes serviced professionally.

The scope of the safety-related checks (STK) is described in the instruction manual.

6 Service mode settings

General information

The following subchapters describe the standard settings for each individual type of device.

- Always follow these specifications when adjusting the settings.
- Settings before the device is released for operation.

Service mode

There are special service modes for calibrating and testing the Sonoca devices. These modes can be used to adjust the negative pressure controller, etc.:

The service modes are divided into main functions including their associated subfunctions. The number of possible subfunctions varies with the respective main function.

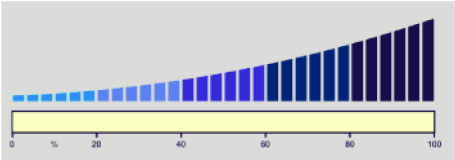

Fig. 18: Ultrasound output display

- Main and subfunctions are indicated as binary values by means of the display segments of the ultrasound output display.

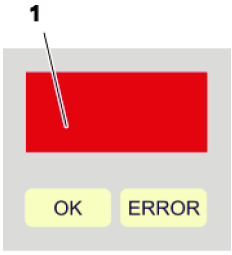

Fig. 19: Display

- Set values (parameters) are shown on the numeric display (1).

6.1 Activation and basic function of the service mode

Service mode cannot be activated unless the unit has been prepared (booted) accordingly.

Display

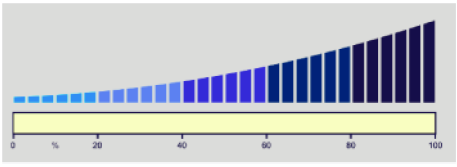

Fig. 20: Ultrasound output display

- The main function is displayed as binary values by means of the first 8 segments of the ultrasound output display (Fig. 20). The bit with the highest value (MSB) represents the first segment on the left.
- The subfunction is also indicated as binary values by means of the next 8 segments.

Only the first 16 segments shown on the display starting on the left are relevant.

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Significance main function								Significance subfunction							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1

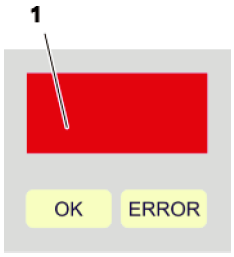

Fig. 21: Display

- Parameters are shown on the numeric display (1). The respective functions will then have no subfunctions.

Preparation

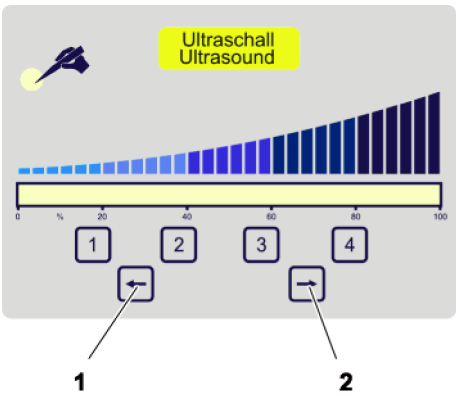

Fig. 22: Arrow keys

1. Press and hold the right (2) arrow key.
2. Switch the device on and wait until the display comes on while pressing the right (2) arrow key.
   - Since the device will skip the self-test, the Sonoca can still be activated if the self-test (for troubleshooting purposes) fails.

Enabling service mode

→ The general service function is activated by pressing the arrow keys (Fig. 22/1 and 2) at the same time.

- The numeric display shows the software version.
- The 16th segment of the ultrasound output display lights up.

Setting the service function

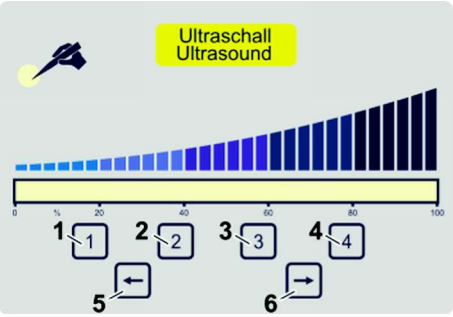

Fig. 23: Numeric and arrow keys

- Use buttons (2) and (3) to decrease and increase the main function, respectively.
- Press the left (5) and right (6) arrow keys to decrease and increase the subfunction, respectively.
- Use the arrow keys to adjust the value (parameter) for functions which allow for such an adjustment to be made. There will be no subfunctions in this case.
- Save the parameter (value set on the display) by pressing button (4).

6.2 List of service functions

Main function	Subfunction	Description
0	1–7	Display firmware (CPU, USG4), error count, error status
1	0–11	Indicates analog values
2	none	Indicates ultrasound instrument code on the numeric display
3	none	Indicates the inductivity level of the ultrasound module on the numeric display
4	none	Indicates the capacity level (0 to 31) on the numeric display
5	none	Indicates the ultrasound instrument frequency in 100 Hz increments with the ultrasound instrument activated
6	none	Indicates/stores the value measured by the pressure sensor, air pressure
7	none	Indicates/stores the maximum vacuum
8	none	Sets the opening onset for the proportional valve

Main function	Subfunction	Description
9	none	Sets the maximum opening position of the proportional valve
10	0–17	Measured values of the last self-test
11	0–93	Error count (selection as subfunction for each error)
12		Error sequence, the last 255 errors (including code) in sequence, left arrow key jumps back by one error
13	1–3	Operating hours ultrasound m x 1,000 hrs, n x 1 hrs, p x min
14	1–3	Operating hours aspiration m x 1,000 hrs, n x 1 hrs, p x min
15	1–3	Operating hours ultrasound m x 1,000 hrs, n x 1 hrs, p x min
16–22		internal use only (device production and repairs)
23	1–2	Operating hours device n x 1 hrs, p x min

6.3 Display of device data – service mode 0

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 0								Subfunctions 1 to 7 (example 7)							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
													■	■	■

Subfunctions and parameters

No.	Parameter (numeric display)	Explanations
1	Software CPU	Display 4.xx
2	Error number (device)	0 indicates no error, list
3	Firmware version USG module	Display 1.xx
4	Error number USG module	60 indicates no error
5	Error status	0 = OK, 1 = warning, 2 = error, 3 = fatal error

No.	Parameter (numeric display)	Explanations
6	Measured value triggering an error	High byte
7	Measured value triggering an error	Low byte

6.4 Display of analog values – service mode 1

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 1								Subfunctions 0 to 11 (example 11)							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
							■					■		■	■

Subfunctions and parameters

No.	Parameter (numeric display)	Explanations
0	Voltage U1 (output stage USG)	varies with ultrasound instrument and output
1	Current (U1), current USG	varies with the load of the ultrasound instrument
2	Voltage U2 (pump motor)	varies with the pump setting
3	Current (U2)	varies with the motor load
4	Same as subfunction 0	
5	Fixed voltage +5 V	
6	Signal temperature sensor	
7	Negative pressure	Negative pressure in secretion bottle
8	Fixed voltage +5 V	
9	Fixed voltage +15 V	
10	Charging voltage Siebelko	
11	Fixed voltage -15 V	

6.5 Display of service mode 2

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 2								no subfunction							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
						■									

Assignment code and instrument

The instrument code is indicated on the numeric display. The list is not subject to revision service.

CODE	Type number					
0	no ultrasound instrument					
1	not assigned					
2	97-101/ -301	97-102/-302/ -322	97-103/-303/ -323	97-104/-304/ -324	97-105	97-112
3	94-001	94-004/-005	94-054	94-101/-105/ -106		
4	94-003					
5	92-040	92-112/-020/ -021				
6	not assigned					
7	not assigned					
8	94-112					
9	not assigned					
10	94-016					
11	94-009	94-017				

CODE	Type number					
12	96-K01	96-K02/-K10/-K11	96-K20/-K21/-K22	96-K23/-K30/-K31		
13	91-020	91-021/-024				
14	94-001-HF	94-101-HF/-106-HF				
15	92-030					
16	97-60x					
17	not assigned					
18	98-K300					

6.6 Display of inductivity level – service mode 3

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 3								no subfunction							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
						■	■								

Explanation

The display shows the inductivity level of the connected dissection instrument.

6.7 Display of capacity level – service mode 4

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 4								no subfunction							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
					■										

Explanation

The display shows the capacity level of the connected dissection instrument.

6.8 Display of instrument frequency – service mode 5

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 5								no subfunction							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
					■		■								

Explanation

The display shows the measured instrument frequency for a connected and activated dissection instrument.

- Display in kHz with one decimal place.

6.9 Pressure sensor value atmospheric pressure – service mode 6

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 6								no subfunction							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
					■	■									

Explanation

This service mode is used to determine the pressure sensor value at atmospheric pressure.

The pressure sensor value at atmospheric pressure is needed as an offset value for regulating the negative pressure and must be established and saved in case of a malfunction of the vacuum system.

Calibration

1. Make sure the vacuum pump is switched off.
2. Make sure the tube connection to the Sonoca is disconnected from the secretion bottle.
   - This is necessary for the outside air pressure to affect the pressure sensor.
3. Select service mode 6.
   - The current atmospheric pressure is measured and indicated on the numeric display.
4. Save the measured value by pressing the numeric key (4) on the ultrasound control panel.

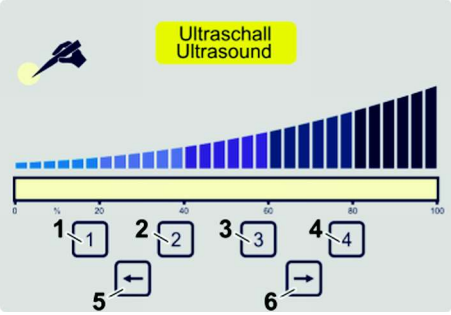

Fig. 24: Ultrasound control panel

The value to be saved must fall between 130 and 137.

6.10 Pressure sensor value vacuum – service mode 7

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 7								no subfunction							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
					■	■	■								

Explanation

This service mode is used to establish the pressure sensor value at the maximum negative pressure generated by the vacuum pump.

Just as the sensor value at atmospheric pressure, this value is used for vacuum control and must be established and saved in case of malfunctions on the vacuum system.

Calibration

1. Detach the vacuum tube which connects the device to the secretion bottle from the secretion bottle.
2. Seal the end of the tube (e. g. by bending). Make sure the seal is 100% tight.

3. Select service mode 7.
   - The pump starts automatically.
4. Make sure the end of the tube is tight and the vacuum nozzle is properly inserted on the device.
   - The measurement is taken and shown as a digital value on the numeric display.
5. As soon as the value is stable (not dropping any further), save the value by pressing the numeric key (4) on the ultrasound control panel.

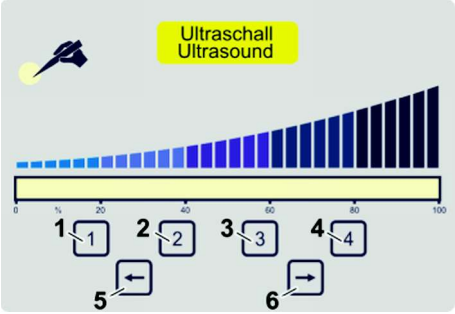

Fig. 25: Ultrasound control panel

The value to be saved must fall between 50 and 56. Values that are too high are an indication of leaks or an insufficient final vacuum of the pump.

6.11 Opening onset proportional valve – service mode 8

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 8								no subfunction							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
				■											

Explanation

The opening onset of the proportional valve is the value at which the valve begins to open, i. e. aspirate.

The opening onset is used to control the negative pressure.

Calibration

1. Connect the aspiration tube with the aspiration nozzle on the Sonoca.
2. Set service function 8.
   - The pump will be activated automatically.

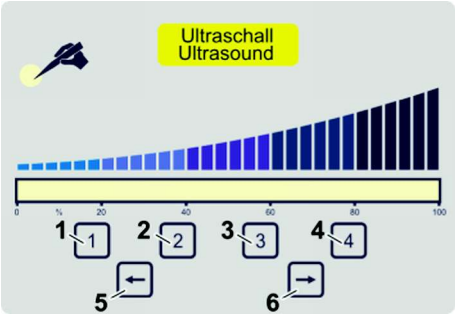

Fig. 26: Ultrasound control panel

3. Use the arrow keys (5 and 6) on the ultrasound control panel to adjust the value until a barely noticeable aspiration of air through the aspiration tube occurs.

   Check the current effect by closing and opening the aspiration tube using your finger.

4. As soon as the desired value is stable, save the value by pressing the numeric key (4) on the ultrasound control panel.

6.12 Maximum opening proportional valve – service mode 9

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 9								no subfunction							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
				■			■								

Explanation

To provide for the optimum time response of the vacuum control, the software requires the digital value at which the proportional value is fully open.

This value can be calculated by checking the negative pressure between the vacuum connection (aspiration tube) and a flow control valve.

The wider the proportional valve opens, the greater the air volume flowing through the flow control valve and, in turn, the greater the negative pressure between flow control valve and the aspiration nozzle of the Sonoca device.

Required equipment

- Measuring fixture: Pressure gauge measuring negative pressure including flow control valve

Calibration

1. Connect the measuring fixture to the aspiration tube.
2. Connect the aspiration tube to the vacuum nozzle of the Sonoca.

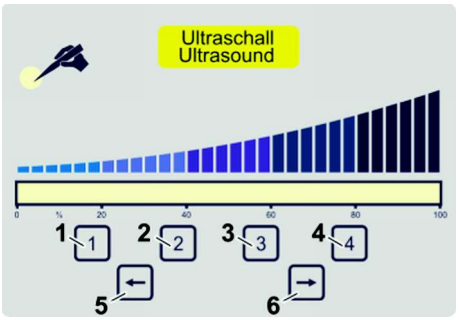

Fig. 27: Ultrasound control panel

3. Select service function 9.
   - The vacuum pump will be activated automatically.
   - The current value will be displayed on the numeric display.
4. Use the arrow keys (5/6) on the ultrasound control panel to adjust the value until the negative pressure is reduced slightly.
   - The valve is now not completely open.
5. Adjust the value in the opposite direction until the negative pressure barely reaches the limit without increasing any further.
   - This is the value at which the proportional valve barely reaches its fully open position.
6. As soon as the value is set, save the value by pressing button (4) on the ultrasound control panel.

6.13 Measured values of the last self-test – service mode 10

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 10								Subfunctions 0 to 17 (example 17)							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
				■		■					■				■

Explanation

Various error codes and the analog values measured during the self-test can be displayed by selecting subfunctions 0 to 17.

Subfunctions	Designation	Nominal	Limits	Self-test step
0	Error code	0	-	1.1
1	Error code	0	-	1.2
2	Error code	0	-	1.3
3	Error code	0	-	1.4

Subfunc-tions	Designation	Nominal	Limits	Self-test step
4	Error code		?	1.5
5	Measured value +5 V	159	151, 167	2.1
6	Measured value +5 V	159	151, 167	2.2
7	Measured value +15 V	172	163, 181	2.3
8	Measured value charging voltage	151	106, 196	2.4
9	Measured value -15 V	147	139, 154	2.5
10	U1 = 0 V	0	0, 2	3.1
11	U1 = 10 V	15	13, 17	3.2
12	U1 = 80 V	119	113, 126	3.3
13	I (U1 = 80 V)	0	0, 1	3.4
14	Isolator test	0	0, 10	3.5
15	not used	-		3.6
16	Instrument detection unit	10	10, 10	4.1
17	Instrument detection unit	10	10, 10	4.2

6.14 Error rate – service mode 11

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 11								Subfunctions 0 to 93 (example 67)							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
				■		■	■		■					■	■

Explanation

Subfunctions 0 to 93 correspond to error codes 0 (no error) to 93.

Upon selection of the corresponding subfunction/error number, the display will indicate how often the respective error has occurred.

6.15 Error history – service mode 12

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 12								no subfunction							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
				■	■										

Explanation

Selecting service mode 12 will show the error code of the error that occurred last.

The error codes are stored in a ring buffer which can hold 255 entries.

Error code 0 (no error) will not be stored.

Switching between entries

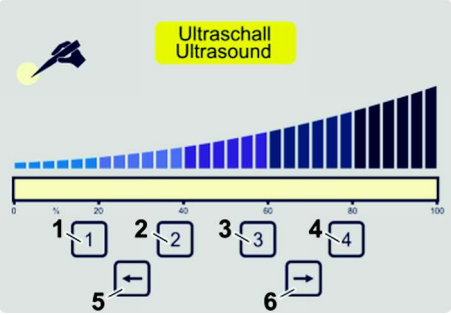

Fig. 28: Ultrasound control panel

- Use the left arrow key (5) on the control panel to display each previous error.

The occurrence of the same error code with every push of the left arrow key is an indication of a general problem (e. g. a measured value possibly reaching the tolerance limit during the self-test).

6.16 Operating time ultrasound – service mode 13

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 13								Subfunctions 1 to 3 (example 3)							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
				■	■		■							■	■

Explanation

The operating time of the ultrasound output can be read on the numeric display.

The sum of the 3 subcomponents is the overall operating time of the ultrasound output.

Subfunctions and parameters

Subfunction	Time factor	Calculation
1	Display x 1,000 hrs	Value x 1,000 hrs
2	Display hrs	Value x 1 hrs
3	Display min	Value x 1 min

6.17 Operating time aspiration – service mode 14

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 14								Subfunctions 1 to 3 (example 3)							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
				■	■	■								■	■

Explanation

The operating time of the aspiration system can be read on the numeric display.

The sum of the 3 subcomponents is the overall operating time of the aspiration system.

Subfunctions and parameters

Subfunction	Time factor	Calculation
1	Display x 1,000 hrs	Value x 1,000 hrs
2	Display hrs	Value x 1 hrs
3	Display min	Value x 1 min

6.18 Operating time irrigation – service mode 15

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 15								Subfunctions 1 to 3 (example 3)							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
				■	■	■	■							■	■

Explanation

The operating time of the irrigation system can be read on the numeric display.

The sum of the 3 subcomponents is the overall operating time of the aspiration system.

Subfunctions and parameters

Subfunction	Time factor	Calculation
1	Display x 1,000 hrs	Value x 1,000 hrs
2	Display hrs	Value x 1 hrs
3	Display min	Value x 1 min

6.19 Overrun aspiration – service mode 16

Indication on the ultrasound output display

Segment position (from the left)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main function 16								no subfunctions							
128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
			■												

Explanation

The aspiration system will keep running for a certain period after the ultrasound has been switched off. This period can be adjusted.

Setting

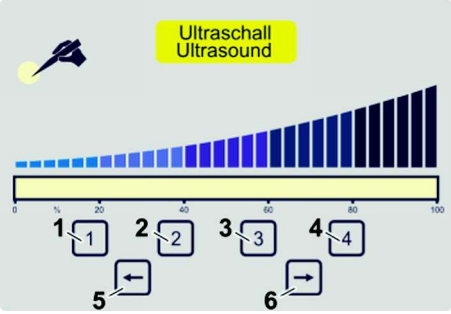

Fig. 29: Ultrasound control panel

1. Set service function 8.
   - The set overrun is displayed in minutes with one decimal place on the numeric display.
2. Use the arrow keys (5/6) on the ultrasound control panel to adjust the value.
3. As soon as the desired value is set, save the value by pressing button (4) on the ultrasound control panel.

Do not modify this value unless absolutely necessary.

7 Error diagnosis and troubleshooting

7.1 Self-test evaluation

The bulk of the errors that may occur will cause the self-test to fail.

The analysis of the possible causes is based on the information reported for the faulty self-test position (logged step-by-step).

Troubleshooting

Test steps 1.x:

- Check the CPU or the configuration memory for CRC errors.
- Check for I2C errors (I2C cable, plug-and-socket connections, etc.).

Test steps 2.x:

- Re-measure extra-low voltages.
- Check the ADCs on the power supply unit for defects.

Test steps 3.x:

- Check the U1 isolator on the power supply board for voltage errors.
- Check the control on the power supply unit for defects.

Test steps 4.x:

- Check the dissection instrument detection board for malfunctions.

Test steps 5.x:

- Check the US module for errors.

The measured values and error codes during a faulty self-test can be read using service mode 10.

This mode shows the possible causes of self-test errors which occur frequently, but not on a regular basis (e. g. measured value close to a limit).

No.	Test	Limits measured value	Comment / possible cause
1.1	Watchdog external	-	on power supply unit
1.2	Watchdog internal	-	CPU
1.3	CRC error	-	Configuration memory CPU

No.	Test	Limits measured value	Comment / possible cause
1.4	RAM test	-	RAM on CPU
1.5	Address error I2C bus	Error code	Check I2C bus connections
2.1	Measurement +5 V channel 1	151, 167	ADC on power supply unit
2.2	Measurement +5 V channel 2	151, 167	
2.3	Measurement +15 V	163, 181	ADC on power supply unit
2.4	Charging voltage Siebelko power supply	106, 196	incorrect supply voltage
2.5	Measurement -15 V	139, 154	ADC on power supply unit
3.1	Set value U1 = 0 V	0, 2	Power supply unit
3.2	Set value U1 = 10 V	13, 17	Power supply unit
3.3	Set value U1 = 80 V	113, 126	Power supply unit
3.4	I (U = 80 V): supposed to be zero	0, 1	no leakage current
3.5	U1 = 80 V, isolator off	0, 10	Isolator on UNT01
3.6	Self-test USG4		Result under test 5.1
4.1	Test 1 instrument detection unit	10, 10	Malfunction instrument detection unit/ foot switch pressed when the device was switched on
4.2	Test 2 instrument detection unit	10, 10	Malfunction instrument detection unit
5.1	Test result USG4	Error code	Self-test USG4 failed

7.2 Table of errors

Error description	Cause	Check / additional causes / remedy
no function, power switch not lit	No supply voltage Mains fuse defective Internal interruption	Check/replace Check internal wiring
No function after switch-on	Primary power supply Power supply unit	LEDs power supply board and power supply unit (+/-15 V, +5 V), relay must click audibly
Ultrasound not operational when triggered, error indicated	US generator/ dissection instrument US load to high	Check other dissection instrument, sonotrode clogged/defective
No function indicated (OK) when dissection instrument is connected	US generator/ dissection instrument US load to high Connection to US socket defective	Check other dissection instrument, sonotrode clogged/defective
No irrigation	Tube missing/inserted improperly or clogged Motor/pump head jams	Check tube, dissection instrument, mechanics (pump), and motor
No aspiration	Clogging	Check tubes, secretion bottle, and dissection instrument
	Pump motor, vacuum control unit, power supply unit	Check voltage on motor (230 V~), motor overload protection, power supply unit (valve control) using a voltmeter
	Test using service modes 6, 7, 8, and 9	Mode 6 (displayed value OK) Mode 7 (aspirates, value OK) Can modes 8, 9 be set?
Self-test fails	Error in various assemblies	Check pin-and-socket connectors and wiring.
Self-test 4.1 error	Foot switch/instrument	Foot switch was pressed when the device was switched on. Pull foot switch off and restart device. Device must be off for at least 10 s. Pull off instrument and restart device as before.

Error description	Cause	Check / additional causes / remedy
		Replace instrument if necessary.
Instrument ERROR	Instrument/cable	Check and, if necessary, replace instrument and connecting line

7.3 Replacement of assemblies

Electronic assemblies

Each electronic assembly is fixed in place with 2 M4 hexagon socket screws and can be easily replaced by undoing these screws.

Vacuum pump

- When replacing the vacuum pump, check if the hose lines are properly connected.
  This applies, in particular, to the vacuum control unit, the bacteria filter, and the plug-in vacuum connection.
- Always verify that these connections are tight. For this purpose, connect a pressure gauge (for vacuum) to the vacuum socket.
- During normal operation, the vacuum socket is connected to the secretion bottle.
- After a brief activation of the vacuum, the negative pressure must remain stable for at least a minute, i. e. no false air must be aspirated.

CPU

- When replacing the CPU, you must reuse the configuration memory.
  - The configuration memory contains all data necessary to adjust and configure the device.

Vacuum control unit/ power supply unit

- When replacing the vacuum control unit or the power supply unit, recalibrate the set values of the proportional valve and the pressure sensor (service modes 6-9).

8 Disassembly and disposal

Damaged components must be disassembled and disposed of in an environmentally safe manner.

8.1 Disassembly

Clean the component prior to scrapping and dispose of it following all applicable occupational safety and environmental protection regulations.

- Switch the device off and secure it from being switched back on.
- Remove the component and clearly mark it as damaged while stored for disposal.
- Verify that all residual energy has been released.
- Remove all operating supplies and remaining processing and packaging materials and dispose of them in an environmentally safe manner.

8.2 Disposal

- Dispose of the component or submit it to the manufacturer or a certified waste management specialist.
- Metal parts such as housing, trolley and filling tray can be scrapped.

WARNING!

Danger to life due to biological contamination!

Improper disposal involves the risk of biological contamination. The resulting risk of infection may lead to serious disease or death.

Therefore:

– Dispose of all single-use accessories and other contaminated products in accordance with all regulations applicable to biologically contaminated products.

CAUTION!

Environmental damage due to improper disposal!

Electric scrap and electronic components are subject to hazardous waste treatment and may only be disposed of by certified specialists!

9 Appendix

9.1 Approved spare parts

The spare parts listed below are approved for use on the SONOCA. Contact the manufacturer for information on additional approved spare parts.

When ordering spare parts, always provide the serial number as well as the software version of your device.

Circuit boards

Item number	Designation	Code designation
	Instrument detection board	UHSE
	CPU board/microcontroller	CPU
	Power supply board	UNT
	Display board/front panel	
	Ultrasound generator	USG

Components

Item number	Designation	Code designation
	Power supply unit	UPWNT
	Power transformer	
	Vacuum pump	
	Vacuum control unit	
	Line filter	
	Filter element	
	Gear motor irrigation	

10 Index