Studer A Series

Active Monitor Speakers

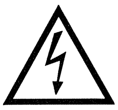
Operating and Service Instructions

Prepared and edited by
Studer Professional Audio GmbH
Technical Documentation
Althardstrasse 30
CH-8105 Regensdorf – Switzerland
http://www.studer.ch

Printed in Switzerland
Order no. 10.27.4540 (Ed. 0400)

Subject to change

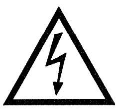
A Safety Information

CAUTION RISK OF ELECTRIC SHOCK DO NOT OPEN ATTENTION RISQUE DE CHOC ELECTRIQUE NE PAS OUVRIR ACHTUNG GEFAHR: ELEKTRISCHER SCHLAG NICHT ÖFFNEN	To reduce the risk of electric shock, do not remove covers (or back). No user-serviceable parts inside. Refer servicing to qualified service personnel.
	This symbol is intended to alert the user to presence of un-insulated *dangerous voltage* within the equipment that may be of sufficient magnitude to constitute a risk of electric shock to a person.
	This symbol is intended to alert the user to the presence of *important instructions* for operating and maintenance in the enclosed documentation.
CLASS I LED PRODUCT CLASS I LASER PRODUCT	Assemblies or sub-assemblies of this product can contain opto-electronic devices. As long as these devices comply with Class I of laser or LED products according to EN 60825-1:1994, they will not be expressly marked on the product. If a special design should be covered by a higher class of this standard, the device concerned will be marked directly on the assembly or sub-assembly in accordance with the above standard.

A1 First Aid

In Case of Electric Shock:

Separate the person as quickly as possible from the electric power source:
- By switching off the equipment,
- By unplugging or disconnecting the mains cable, or
- By pushing the person away from the power source, using dry insulating material (such as wood or plastic).
- After having sustained an electric shock, *always* consult a doctor.



Warning! ***Do not touch the person or his clothing before the power is turned off, otherwise you stand the risk of sustaining an electric shock as well!***

If the Person is Unconscious:

- Check the pulse,
- Reanimate the person if respiration is poor,
- Lay the body down, turn it to one side, call for a doctor immediately.

B General Installation Hints

Please consider besides these general hints also any product-specific hints in the "Installation" chapter of this manual.

B1 Unpacking

Check the equipment for any transport damage. A unit that is mechanically damaged or that has been penetrated by liquids or foreign objects must not be connected to the AC power outlet or must be immediately disconnected by unplugging the power cable. Repairs must only be performed by trained personnel in accordance with the applicable regulations.

B2 Installation Site

Install the unit in a place where the following conditions are met:

- The temperature and the relative humidity of the environment must be within the specified limits during operation of the unit. Relevant air values are the ones at the air inlets of the unit.
- Condensation must be avoided. If the unit is installed in a location with large variation of ambient temperature (e.g. in an OB-van), feasible measures must be taken before and after operation (for details on this subject, refer to Appendix 1).
- Unobstructed air flow is essential for proper operation. Air vents of the unit are a functional part of the design and must not be blocked in any way during operation (e.g. by objects placed upon them or placement of the unit on a soft support).
- The unit must not be heated up by external sources of heat radiation (sunlight, spot lights).

B3 Earthing and Power Supply

Earthing of units with mains supply (class I equipment) is performed via the protective earth (PE) conductor integrated in the mains cable. Units with battery operation (< 60 V, class III equipment) must be earthed separately.

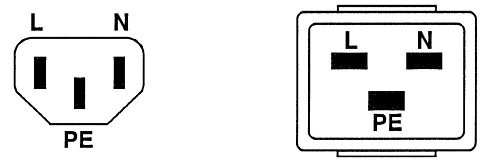
Earthing the unit is one of the measures for protection against electrical shock hazard (dangerous body currents). Hazardous voltage may not only be caused by a defective power supply insulation, but may also be introduced by the connected audio or control cables.

If the unit is installed with one or several external connections, its earthing must be provided during operation as well as while the unit is inoperative. If the earthing could be interrupted via the power supply (e.g. by pulling the mains plug), an additional, permanent earthing must be installed using the provided earth terminal.

Avoid ground loops (hum loops) by keeping the loop surface as small as possible (by consequently guiding the earth conductors in a narrow, parallel way), and reduce the noise current flowing through the loop by inserting an additional impedance (common-mode choke).

Class I Equipment (Mains Operation)

Should the equipment be delivered without a matching mains cable, the latter has to be prepared by a trained person using the attached female plug (IEC320/C13 or IEC320/C19) with respect to the applicable regulations in your country.
Before connecting the equipment to the AC power outlet, check that the local line voltage matches the equipment rating (voltage, frequency) within the admissible tolerance. The equipment fuses must be rated in accordance with the specifications on the equipment.
Equipment supplied with a 3-pole appliance inlet (protection conforming to class I equipment) *must* be connected to a 3-pole AC power outlet so that the equipment cabinet is connected to the protective earth.
For information on mains cable strain relief please refer to Appendix 2.



IEC 320 / C13 IEC 320 / C19

Female plug (IEC320), front-side view:		National American Standard:
L (Live)	Brown	*Black*
N (Neutral)	Blue	*White*
PE (Protective Earth	Green/Yellow	*Green*

Class III Equipment (Battery Operation up to 60 V_{DC})

Equipment of this protection class must be earthed using the provided earth terminal, if one or more external signals are connected to the unit (see explanation at the beginning of this paragraph).

B4 Electromagnetic Compatibility (EMC)

The unit conforms to the protection requirements relevant to electromagnetic phenomena that are listed in the guidelines 89/336/EC and FCC, part 15.

- The electromagnetic interference generated by the unit is limited in such a way that other equipment and systems can be operated normally.
- The unit is adequately protected against electromagnetic interference so that it can operate properly.

The unit has been tested and conforms to the EMC standards of the specified electromagnetic environment, as listed in the following declaration. The limits of these standards ensure protection of the environment and corresponding noise immunity of the equipment with appropriate probability. However, a professional installation and integration within the system are imperative prerequisites for operation without EMC problems.
For this purpose, the following measures must be followed:

- Install the equipment in accordance with the operating instructions. Use the supplied accessories.
- In the system and in the vicinity where the equipment is installed, use only components (systems, equipment) that also fulfill the EMC standards for the given environment.
- Use a system grounding concept that satisfies the safety requirements (class I equipment must be connected with a protective ground conduc-

tor) and that also takes into consideration the EMC requirements. When deciding between radial, surface, or combined grounding, the advantages and disadvantages should be carefully evaluated in each case.

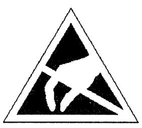
- Use shielded cables where shielding is specified. The connection of the shield to the corresponding connector terminal or housing should have a large surface and be corrosion-proof. Please note that a cable shield connected only single-ended can act as a transmitting or receiving antenna within the corresponding frequency range.
- Avoid ground loops or reduce their adverse effects by keeping the loop surface as small as possible, and reduce the noise current flowing through the loop by inserting an additional impedance (e.g. common-mode choke).
- Reduce electrostatic discharge (ESD) of persons by installing an appropriate floor covering (e.g. a carpet with permanent electrostatic filaments) and by keeping the relative humidity above 30%. Further measures (e.g. conducting floor) are usually unnecessary and only suitable if used together with corresponding personal equipment.
- When using equipment with touch-sensitive operator controls, please take care that the surrounding building structure allows for sufficient capacitive coupling of the operator. This coupling can be improved by an additional, conducting surface in the operator's area, connected to the equipment housing (e.g. metal foil underneath the floor covering, carpet with conductive backing).

C Maintenance

All air vents and openings for operating elements (faders, rotary knobs) must be checked on a regular basis, and cleaned in case of dust accumulation. For cleaning, a soft paint-brush or a vacuum cleaner is recommended.
Cleaning the surfaces of the unit is performed with a soft, dry cloth or a soft brush.
Persistent contamination can be treated with a cloth that is slightly humidified with a mild cleaning solution (soap-suds).
For cleaning display windows, commercially available computer/TV screen cleaners are suited. Use only a slightly damp (never wet) cloth.
Never use any solvents for cleaning the exterior of the unit! Liquids must never be sprayed or poured on directly!
For equipment-specific maintenance information please refer to the corresponding chapter in the Operating and Service Instructions manuals.

D Electrostatic Discharge during Maintenance and Repair

Caution:



Observe the precautions for handling devices sensitive to electrostatic discharge!
Many semiconductor components are sensitive to electrostatic discharge (ESD). The life-span of assemblies containing such components can be drastically reduced by improper handling during maintenance and repair work. Please observe the following rules when handling ESD sensitive components:

- ESD sensitive components should only be stored and transported in the packing material specifically provided for this purpose.
- *When performing a repair by replacing complete assemblies, the removed assembly must be sent back to the supplier in the same packing*

material in which the replacement assembly was shipped. If this should not be the case, any claim for a possible refund will be null and void.

- Unpacked ESD sensitive components should only be handled in ESD protected areas (EPA, e.g. area for field service, repair or service bench) and only be touched by persons who wear a wristlet that is connected to the ground potential of the repair or service bench by a series resistor. The equipment to be repaired or serviced as well as all tools and electrically semi-conducting work, storage, and floor mats should also be connected to this ground potential.
- The terminals of ESD sensitive components must not come in uncontrolled contact with electrostatically chargeable (voltage puncture) or metallic surfaces (discharge shock hazard).
- To prevent undefined transient stress of the components and possible damage due to inadmissible voltages or compensation currents, electrical connections should only be established or separated when the equipment is switched off and after any capacitor charges have decayed.

E Repair

Removal of housing parts, shields, etc. exposes energized parts. For this reason the following precautions must be observed:

- Maintenance may only be performed by trained personnel in accordance with the applicable regulations.
- The equipment must be switched off and disconnected from the AC power outlet before any housing parts are removed.
- Even if the equipment is disconnected from the power outlet, parts with hazardous charges (e.g. capacitors, picture tubes) must not be touched until they have been properly discharged. Do not touch hot components (power semiconductors, heat sinks, etc.) before they have cooled off.
- If maintenance is performed on a unit that is opened and switched on, no un-insulated circuit components and metallic semiconductor housings must be touched, neither with your bare hands nor with un-insulated tools.

Certain components pose additional hazards:

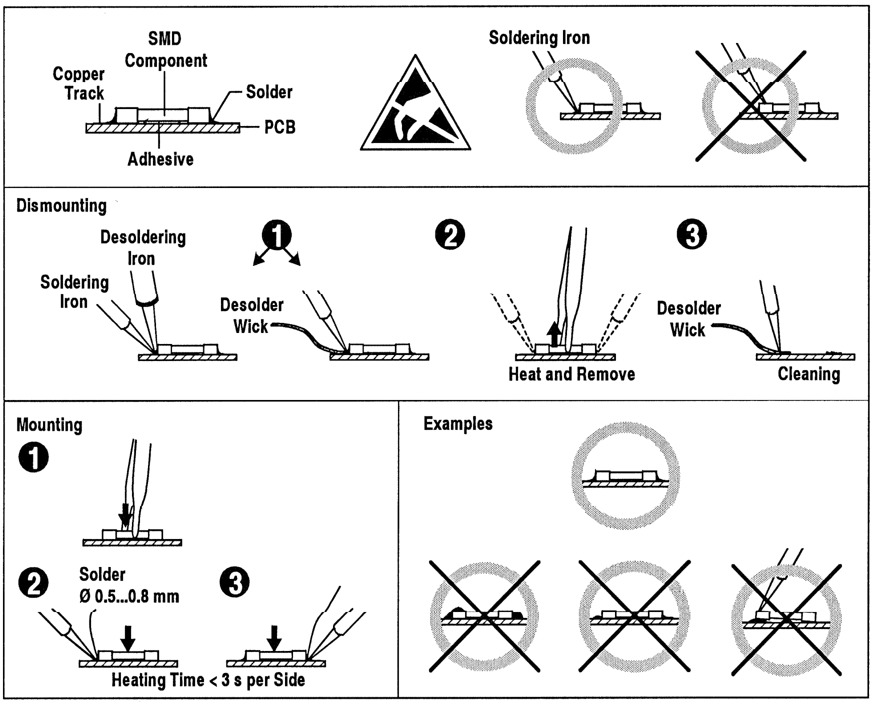
- *Explosion hazard* from lithium batteries, electrolytic capacitors and power semiconductors (watch the component's polarity. Do not short battery terminals. Replace batteries only by the same type).
- *Implosion hazard* from evacuated display units.
- *Radiation hazard* from laser units (non-ionizing), picture tubes (ionizing).
- *Caustic effect* of display units (LCD) and components containing liquid electrolyte.

Such components should only be handled by trained personnel who are properly protected (e.g. safety goggles, gloves).

E1 SMD Components

Studer does not keep any commercially available SMD components in stock. For repair the corresponding devices should be purchased locally. The specifications of special components can be found in the service manual.

SMD components should only be replaced by skilled specialists using appropriate tools. No warranty claims will be accepted for circuit boards that have been damaged. Proper and improper SMD soldering joints are illustrated below.



F Disposal

Disposal of Packing Materials

The packing materials have been selected with environmental and disposal issues in mind. All packing material can be recycled. Recycling packing saves raw materials and reduces the volume of waste.

If you need to dispose of the transport packing materials, please try to use recyclable means.

Disposal of Used Equipment

Used equipment contains valuable raw materials as well as materials that must be disposed of professionally. Please return your used equipment via an authorized specialist dealer or via the public waste disposal system, ensuring any material that can be recycled is.

Please take care that your used equipment cannot be abused. To avoid abuse, delete sensitive data from any data storage media. After having disconnected your used equipment from the mains supply, make sure that the mains connector and the mains cable are made useless.

G Declarations of Conformity

G1 Class A Equipment - FCC Notice

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide a reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

Caution: *Any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment. Also refer to relevant information in this manual.*

G2 CE Declaration of Conformity

The manufacturer,
RELEC SA,
CH-1400 Yverdon,
declare under his sole responsibility that the products
Studer A1, Active Studio Monitor
(serial no. 190916 and up)
Studer A3, Active Studio Monitor
(serial no. 183701 and up)
Studer A5, Active Studio Monitor
(serial no. 181700 and up)
to which this declaration relates, according to following regulations of EU directives and amendments

- Low Voltage (LVD):
  73/23/EEC + 93/68/EEC
- Electromagnetic Compatibility (EMC):
  89/336/EEC + 92/31/EEC + 93/68/EEC

are in conformity with the following standards or other normative documents:

- Safety:
  Class I equipment, EN 60065:1993
- EMC:
  EN 55103-1/-2:1996, electromagnetic environments E2 and E4.

Yverdon, March 31, 1999

Alain Roux, Director

Appendix 1: Air Temperature and Humidity

General

Normal operation of the unit or system is warranted under the following ambient conditions defined by *EN 60721-3-3, set IE32, value 3K3.*
This standard consists of an extensive catalogue of parameters, the most important of which are: ambient temperature +5...+40 °C, relative humidity 5...85% (i.e., no formation of condensation or ice); absolute humidity 1...25 g/m³; rate of temperature change < 0.5 °C/min. These parameters are dealt with in the following paragraphs.
Under these conditions the unit or system starts and works without any problem. Beyond these specifications, possible problems are described in the following paragraphs.

Ambient Temperature

Units and systems by Studer are generally designed for an ambient temperature range (i.e. temperature of the incoming air) of +5...+40 °C. When rack mounting the units, the intended air flow and herewith adequate cooling must be provided. The following facts must be considered:

- The admissible ambient temperature range for operation of the semiconductor components is 0 °C to +70 °C (commercial temperature range for operation).
- The air flow through the installation must provide that the outgoing air is always cooler than 70 °C.
- Average heat increase of the cooling air shall be 20 K, allowing for an additional maximum 10 K increase at the hot components.
- In order to dissipate 1 kW with this admissible average heat increase, an air flow of 2.65 m³/min is required.

Example: A rack dissipating *P = 800 W* requires an air flow of *0.8 * 2.65 m³/min* which corresponds to *2.12 m³/min.*

- If the cooling function of the installation must be monitored (e.g. for fan failure or illumination with spot lamps), the outgoing air temperature must be measured directly above the modules at several places within the rack. The trigger temperature of the sensors should be 65 to 70 °C.

Frost and Dew

The unsealed system parts (connector areas and semiconductor pins) allow for a minute formation of ice or frost. However, formation of dew visible with the naked eye will already lead to malfunctions. In practice, reliable operation can be expected in a temperature range above –15 °C, if the following general rule is considered for putting the cold system into operation:
If the air within the system is cooled down, the relative humidity rises. If it reaches 100%, condensation will arise, usually in the boundary layer between the air and a cooler surface, together with formation of ice or dew at sensitive areas of the system (contacts, IC pins, etc.). Once internal condensation occurs, trouble-free operation cannot be guaranteed, independent of temperature.

Before putting into operation, the system must be checked for internal formation of condensation or ice. Only with a minute formation of ice, direct evaporation (sublimation) may be expected; otherwise the system must be heated and dried while switched off.

A system without visible internal formation of ice or condensation should be heated up with its own heat dissipation, as homogeneously (and subsequently as slow) as possible; the ambient temperature should then always be lower than the one of the outgoing air.

If it is absolutely necessary to operate the cold system immediately within warm ambient air, this air must be dehydrated. In such a case, the absolute humidity must be so low that the relative humidity, related to the coldest system surface, always remains below 100%.

Ensure that the enclosed air is as dry as possible when powering off (i.e. before switching off in winter, aerate the room with cold, dry air, and remove humid objects as clothes from the room).

These relationships are visible from the following climatogram. For a controlled procedure, thermometer and hygrometer as well as a thermometer within the system will be required.

Example 1: An OB-van having an internal temperature of 20 °C and relative humidity of 40% is switched off in the evening. If temperature falls below +5 °C, dew or ice will be forming.

Example 2: An OB-van is heated up in the morning with air of 20 °C and a relative humidity of 40%. On all parts being cooler than +5 °C, dew or ice will be forming.

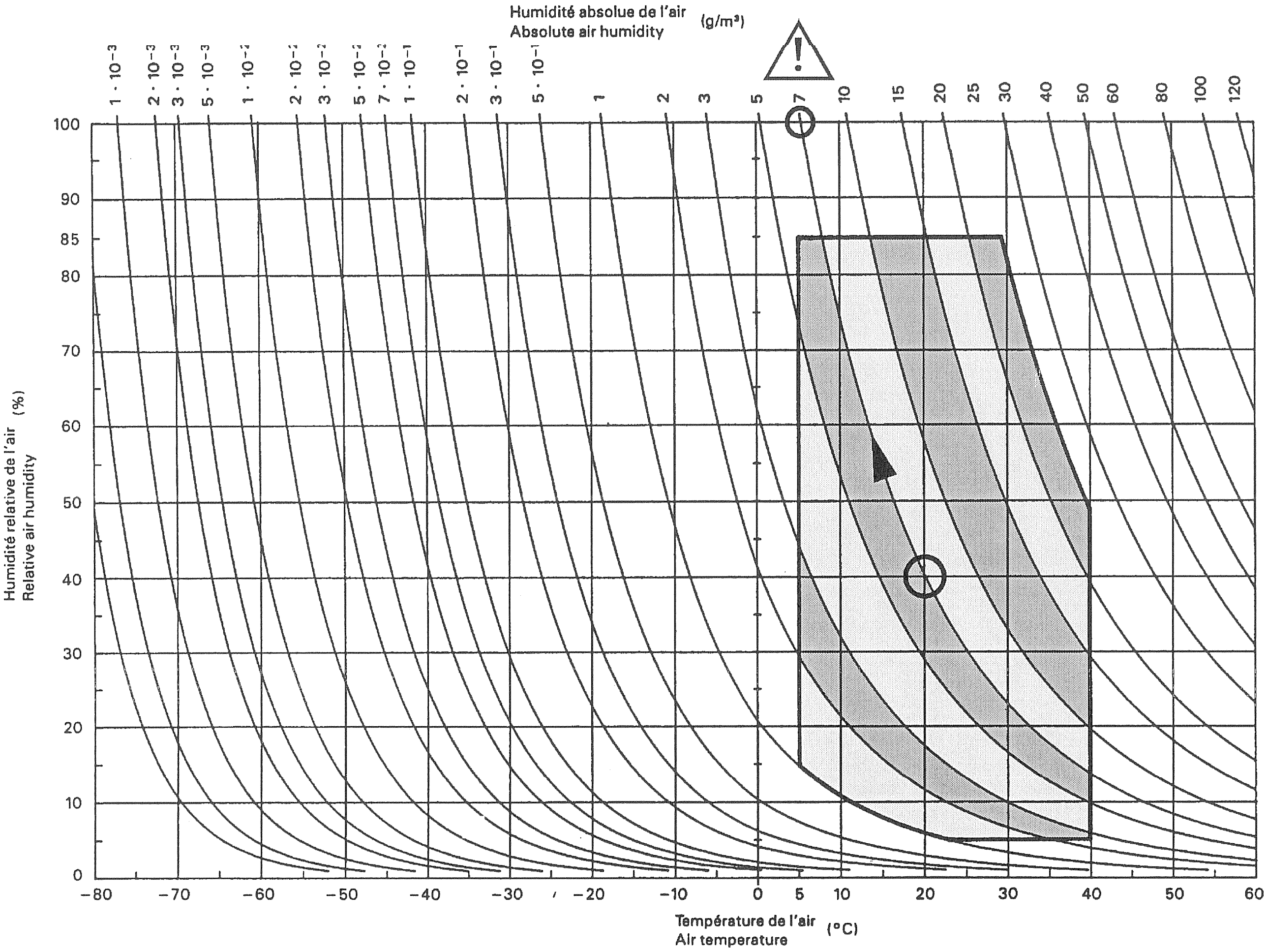
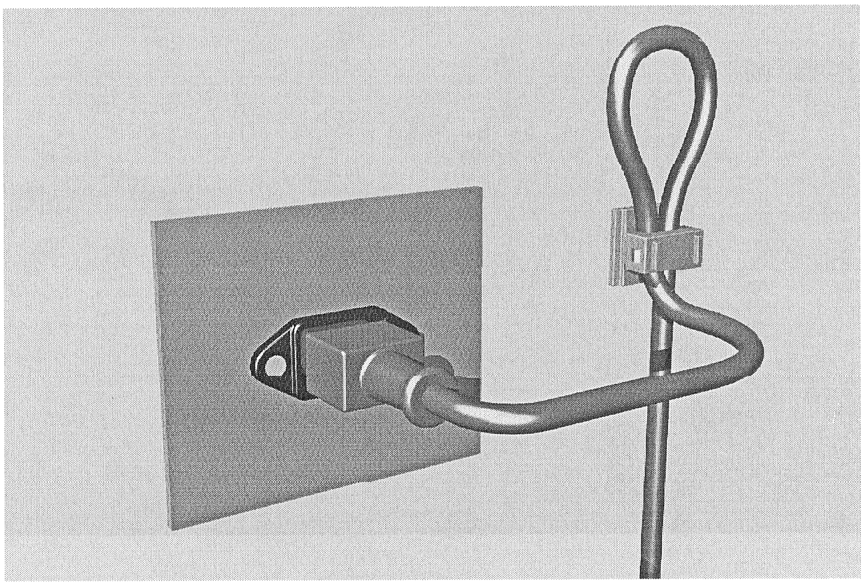


Figure B.3 – Climatogramme pour catégorie 3K3
Climatogram for class 3K3

Appendix 2: Mains Connector Strain Relief

For anchoring connectors without a mechanical lock (e.g. IEC mains connectors), we recommend the following arrangement:



Procedure: The cable clamp shipped with your unit is auto-adhesive. For mounting please follow the rules below:

- The surface to be adhered to must be clean, dry, and free from grease, oil, or other contaminants. Recommended application temperature range is 20...40 °C.
- Remove the plastic protective backing from the rear side of the clamp and apply it firmly to the surface at the desired position. Allow as much time as possible for curing. The bond continues to develop for as long as 24 hours.
- For improved stability, the clamp should be fixed with a screw. For this purpose, a self-tapping screw and an M4 bolt and nut are included.
- Place the cable into the clamp as shown in the illustration above and firmly press down the internal top cover until the cable is fixed.

Appendix 3: Software License

Use of the software is subject to the Studer Professional Audio Software License Agreement set forth below. Using the software indicates your acceptance of this license agreement. If you do not accept these license terms, you are not authorized to use this software.

Under the condition and within the scope of the following Terms and Conditions, Studer Professional Audio GmbH (hereinafter "Studer") grants the right to use programs developed by Studer as well as those of third parties which have been installed by Studer on or within its products. References to the license programs shall be references to the newest release of a license program installed at the Customer's site.

Programs Covered by the Agreement

License Programs of Studer

The following Terms and Conditions grant the right to use all programs of Studer that are part of the System and/or its options at the time of its delivery to the Customer, as well as the installation software on the original data disk and the accompanying documentation ("License Material"). In this Agreement the word "Programs" shall have the meaning of programs and data written in machine code.

Using the software indicates your acceptance of this license agreement. If you do not accept these license terms, you are not authorized to use this software.

Programs of Third Parties

Programs of third parties are all programs which constitute part of the System and/or its options at the time of delivery to the Customer but have not been developed by Studer. The following conditions are applicable to programs of third parties:

- The right to use third parties' programs is governed by the License Agreement attached hereto (if applicable), which is an integral part of this Agreement. The Customer shall sign any and all License Agreements for all further programs of third parties installed on the system. The Customer shall be deemed to have received all License Agreements upon delivery of the system and/or its options.
- Studer shall accept no responsibility or liability for, and gives no warranties (express or implied) as to the programs of third parties. The Customer waives any and all claims versus Studer for any consequential damages, which might occur due to defects of these programs.

Right of Use

Principle

Studer grants the Customer the non-exclusive right to use the License Material in one copy on the system and/or its options as laid down by the Sales Agreement concluded between the parties and all Terms and Conditions which shall be deemed to form and be read and construed as part of the Sales Agreement. This right is assignable according to the "Assignability" paragraph hereinafter.

Customized Configurations

The Customer is not entitled to alter or develop further the License Material except within the expressly permitted configuration possibilities given by the software installed on the system or elsewhere. All altered programs, including but not limited to the products altered within the permitted configuration possibilities, are covered by this License Agreement.

Reverse Engineering

Reverse engineering is only permitted with the express consent of Studer. The consent of Studer can be obtained but is not limited to the case in which the interface-software can not be provided by Studer. In any case Studer has to be informed immediately upon complete or partial reverse engineering.

Copying the License Material

The Customer is entitled to make one copy of all or parts of the License Material as is necessary for the use according to this Agreement, namely for backup purposes. The Customer shall apply the copyright of Studer found on the License Material onto all copies made by him. Records shall be kept by the Customer regarding the amount of copies made and their place of keeping. The responsibility for the original program and all copies made lies with the Customer. Studer is entitled to check these records on first request. Copies not needed anymore have to be destroyed immediately.

Disclosure of License Material

The License Material is a business secret of Studer. The Customer shall not hand out or in any way give access to parts or the complete License Material to third parties nor to publish any part of the License Material without prior written consent of Studer. The Customer shall protect the License Material and any copies made according to the paragraph above by appropriate defense measures against unauthorized access. This obligation of non-disclosure is a perpetual obligation.
Third parties are entitled to have access to the License Material if they use the License Material at the Customer's site in compliance with this Agreement.
Under no circumstance are third parties entitled to have access to the installation software on the original data media. The Customer shall safeguard the original data media accordingly.

Assignability

The rights granted to the Customer according to this License Agreement shall only be assignable to a third party together with the transfer of the system and/or its options and after the prior written consent of Studer.

Rights to License Material

With the exception of the right of use granted by this License Agreement all proprietary rights to the License Material, especially the ownership and the intellectual property rights (such as but not limited to patents and copyright) remain with Studer even if alterations, customized changes or amendments have been made to the License Material.
Studer's proprietary rights are acknowledged by the Customer. The Customer shall undertake no infringements and make no claims of any patent, registered design, copyright, trade mark or trade name, or other intellectual property right.

Warranty, Disclaimer, and Liability

For all issues not covered herewithin, please refer to the "General Terms and Conditions of Sale and Delivery" that are part of the sales contract.

CONTENTS

1 WELCOME!

We are happy to welcome you in the circle of the users of Studer's A series active speakers, and we felicitate you on your selection. Thanks to Studer's experience collected during more than 40 years of business in the professional audio products field, you may expect that the performance of your new unit will fulfill your highest demands.

1.1 Basics

With the A series, Studer has created a family of active speaker systems. With exterior dimensions kept at a minimum, but nevertheless with high sound pressure levels, these speakers are suited for many different applications. For audition rooms and continuity cubicles, for the editing studio and control rooms, for use in mobile applications or OB vans, the A series offers ideal problem-oriented solutions.

The Studer A series active speakers can be adjusted to any individual requirement by means of various controls. Differences in operating levels or differences due to speaker placement can be compensated thanks to the variable input sensitivity and the bass roll-off controls. For horizontal placement, the A5's mid-range/tweeter unit can be rotated by ±90° after loosening four screws.

To meet professional standards, the A series is equipped with an XLR-compatible connector and electronically balanced line input (A1) or transformer-balanced line input (A3 and A5).

The most important characteristics of the A series active speakers can be summarized as follows:

- Active 2- or 3-way speakers for high sound pressure levels in near-field applications or medium- and large-sized monitoring rooms.
- Suited for all commonly used operating levels, input sensitivity continuously adjustable.
- Low distortion rating; the magnetic flux is stabilized by damping the coil reaction.
- Exceptional damping of the individual systems by negative output impedance of the power amplifiers.
- Matched signal propagation delay between the individual transducers through separate electronic delay lines.
- Group delay compensated band-pass filters.

Negative output impedance:

A speaker diaphragm should accurately follow the electrical excitation. In the Studer A series active speakers, this is achieved with negative output impedance in all power amplifiers, which efficiently attenuates undesired echo oscillations of the diaphragm. Each of the frequency ranges features its own power amplifier with negative output impedance. This forces the diaphragm to exactly follow the input signal, and undesired responses (diaphragm and enclosure echoes) are suppressed. Percussive signals in particular (e.g. applause) are reproduced very accurately.
This principle is also an essential prerequisite for other improvements:

- Utilization of optimum crossover network techniques
- Other distortion reduction measures.

Helmholtz resonator

A cavity with an external opening is referred to as Helmoltz resonator. If a driven diaphragm is added to this system, the well-known "bass reflex" enclosure is obtained, having the advantage of significantly more energy gain in the bass reflex resonance area. The transmission range can thus be expanded toward the low end without overloading the speaker.
In combination with the negative output impedance, it is possible to consider this arrangement strictly as a Helmholtz resonator again, being easily compensated for the bass reflex drawbacks by electronic means. Such a combination achieves clean bass reproduction down to frequencies amazingly low for the given enclosure size.

Group-delay-compensated filters

The evaluation of a speaker cannot simply be based on one single point of the room, but the entire radiation behavior must be considered.
The division of the frequency spectrum, unfortunately made necessary by various reasons such as Doppler effect, partial oscillations of the diaphragms, etc., creates additional problems.
If the individual speaker systems are arranged vertically, the horizontal radiation characteristic depends almost exclusively on the quality of the chassis. In the vertical direction, however, a bundled aggregate signal is obtained. If the partial signals are not in phase with each other – either due to different acoustic propagation times or phase rotation in the crossover – the radiation lobe changes its direction in the transition zones. If the ear is not accurately positioned, dips or even peaks in the frequency response can strongly influence the sound impression and the localization of the sound source.

Delay compensation

The distance from the point of origin of the sound to the speaker surface varies because the individual speaker systems have different mounting depth. With wide-band signals, this normally leads to dispersion (i.e. the individual frequency components arrive at the listening position at different times).
In the Studer A series active speakers, these differences in the transit time of the audio signals are compensated by analog delay circuits maintaining the necessary delay up to frequencies above the audio range.
Time delay compensation, negative output impedance of the power amplifiers, and a sophisticated crossover design offering steep filter characteristics *and* phase linearity, all together leads to the excellent impulse behavior of the A series and to their greatly improved reproduction of transient music signals.

Ideally suited for surround sound

A unique feature of the A-Series studio monitors is that different speaker types can be mixed for setting up a surround system. The simple reason for this is the group-delay compensation.
Usually, combining different speaker types with uncompensated group-delay can cause quite unpleasant phase-domain effects, resulting in sound sources being placed in wrong positions. Parts of a signal panned to the right side could then be localized behind the listener or in other undesired positions. The different A-Series studio monitors feature identical phase response over the whole frequency spectrum and therefore give an accurate sound source positioning.

1.2 Safety and Connections

1.2.1 Utilization for the Purpose Intended

The Studer A series active speakers are designed for professional use. It is presumed that the units are operated only by trained personnel; servicing must be performed by qualified experts.
The electrical connections may be connected only to the appropriate voltages and signals specified in this manual. Please consult the Safety and EMC sections at the very beginning of this manual.

1.2.2 Unpacking and Inspection

Your new unit is shipped in a special packing which protects it against mechanical shock during transit. Care should be exercised when unpacking so that its surfaces do not get marred.
Verify that the content of the packing agrees with the items listed on the enclosed shipping list. Check the condition of the equipment for signs of shipping damage. If there should be any complaints please immediately notify the forwarding agent and your nearest Studer distributor.
Please retain the packing material because it offers the best protection in case your unit ever needs to be transported.

1.2.3 Installation

Before any connection: Check the line voltage selector setting before connecting the unit to the mains. The voltage selector is located inside the fuse holder next to the power inlet. The unit can be operated on mains voltages of 115 or 230 V_{AC}, 50 to 60 Hz. Also check for correct value of the primary fuse:

A1		**230 V**: T 1.6 A L 250 V (5 × 20 mm)
		115 V: T 3.15 A L 250 V (5 × 20 mm)
	USA and Canada:	***115 V:*** *3.2 A slow blow UL/CSA (5 × 20 mm)*
A3		**230 V**: T 0.8 A L 250 V (5 × 20 mm)
		115 V: T 1.6 A L 250 V (5 × 20 mm)
	USA and Canada:	**115 V:** 1.6 A slow blow UL/CSA (5 × 20 mm)
A5		**230 V**: T 0.5 A L 250 V (5 × 20 mm)
		115 V: T 1.0 A L 250 V (5 × 20 mm)
	USA and Canada:	**115 V:** 1.0 A slow blow UL/CSA (5 × 20 mm)

Mains cable: Depending on your country, the A Series Active Monitor Speakers come with an IEC mains cable or a female IEC 320/C13 mains cable socket. This socket has to be connected to an appropriate mains cable by a trained technician with respect to your local regulations. Refer to the "Installation" section at the beginning of this manual.

Danger! *Repair work may only be performed by a trained service technician. The primary fuse must be replaced by a spare fuse of exactly the same type.*
The unit must not be opened by the user because of the risk of a severe electric shock hazard!

Humidity: Do not use the units near any source of moisture or in excessively humid environments.

Ventilation: *In order to guarantee adequate air circulation, the unit's rear side must not be mounted closer than 6 cm from a wall.*

Magnetic radiation: *Do not mount the A5 and A3 units closer than 40 cm from a video or computer monitor.*
Thanks to low magnetic dispersion drivers and additional screening, the A1 units can be operated also next to video or computer monitors, or measuring instruments.

Mounting facilities: Four tapped M6 inserts are located on the bottom of the A5 and A3 units. They can be used for mounting it on a base plate, a wall-mount kit or a stand (refer to section 2.2, Options).
The A5 cannot be mounted with a ceiling mounting kit. When mounted on a stand or wall-mount, please make sure that the tilting angle in either direction does not exceed 30°!
The A1 is shipped with a threaded mounting bracket for easy installation on a microphone stand.

Location: The A series has been aligned for free placement, i.e. not close to walls or in edges. Ideal mounting distances are 1...2 m from walls and at least 60 cm from the floor. If operation of the A5 or A3 units near room boundaries is required, the resulting bass boost can be compensated with the ROLL OFF control.
On the A1 unit the ROLL OFF control is not available, because this type and size of loudspeaker usually is not operated near room boundaries.

2 GENERAL

2.1 Scope of Delivery

The Studer A series active speakers are shipped with an operating manual (order no. 10.27.4551), and either an IEC 320/C13 socket or an IEC mains cable, depending on your country.

2.2 Options

Order No.

Wall-mount kit (for A5 and A3) **20.020.230.04**
(OmniMount) with adjustable tilt.
Caution: The maximum tilting angle of the A5 must not exceed 30°!

Floor stand (for A5 and A3) **20.020.230.21**
Moveable floor stand complete with 4 castors, rugged aluminium design. Adjustable column height.
Maximum carrying capacity 40 kg.

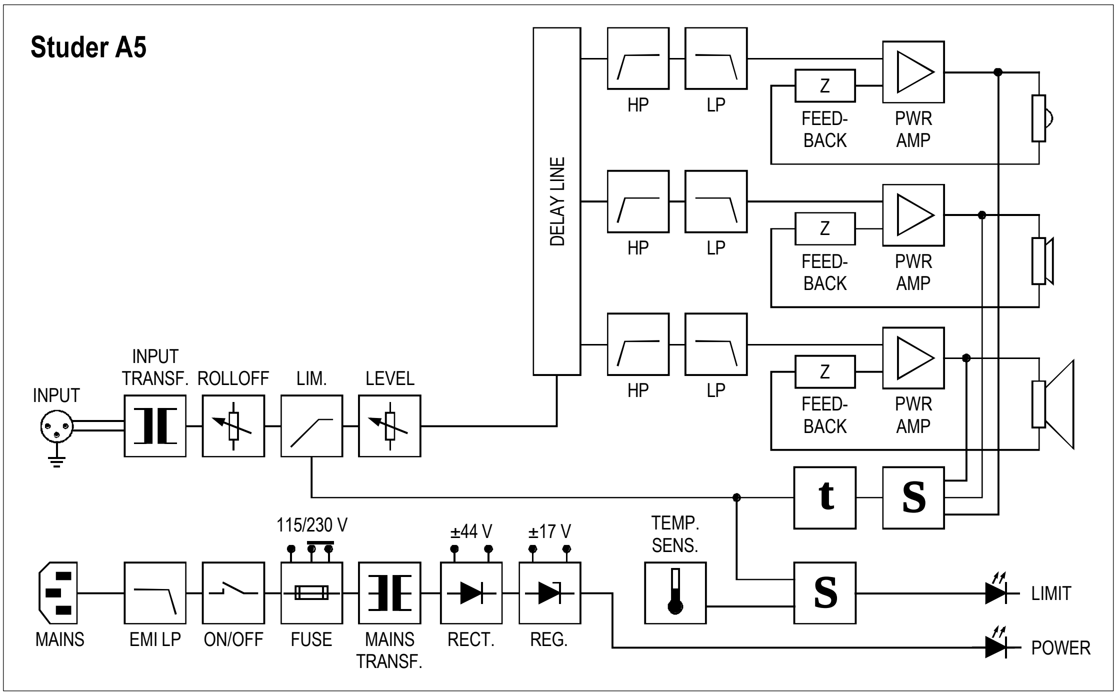
Floor stand (for A5 and A3) **10.705.214.60**
Foldable tripod floor stand. Adjustable column height (1.25...2.3 m).
Maximum carrying capacity 50 kg.

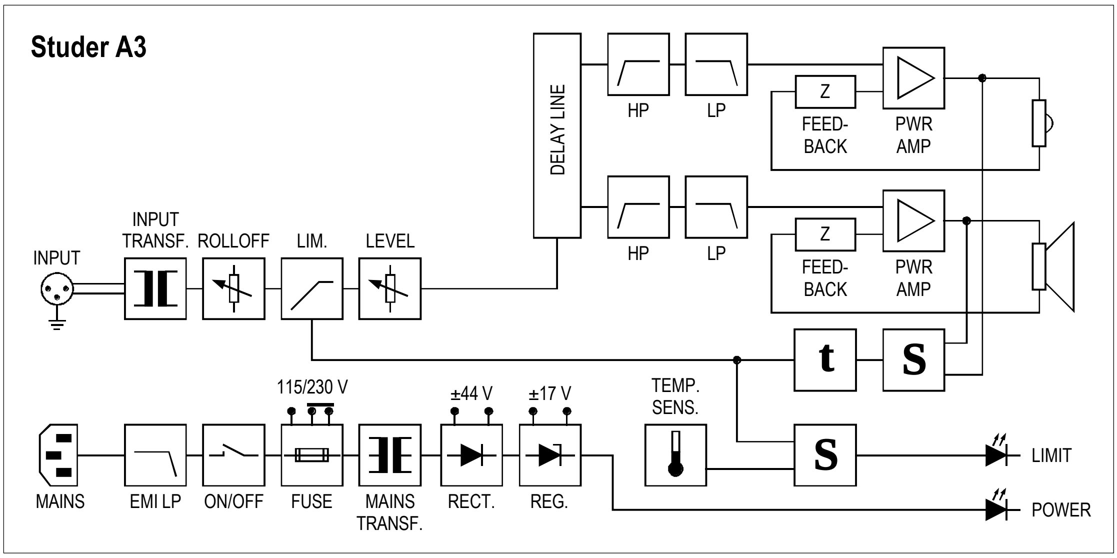
Woofer protection grille (for A1) **15.258.211.00**
Set for one A1 speaker, containing a protection grille, mounting hardware, and instruction sheet.

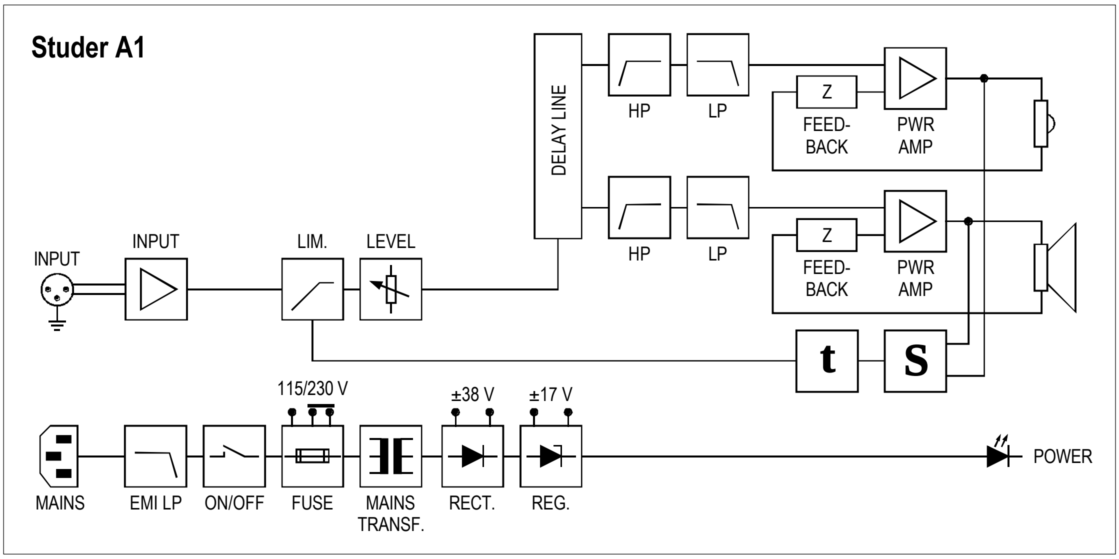
Operating Instructions (additional manual) **10.27.4551**

Operating and Service Instructions **10.27.4540**

2.3 Block Diagrams







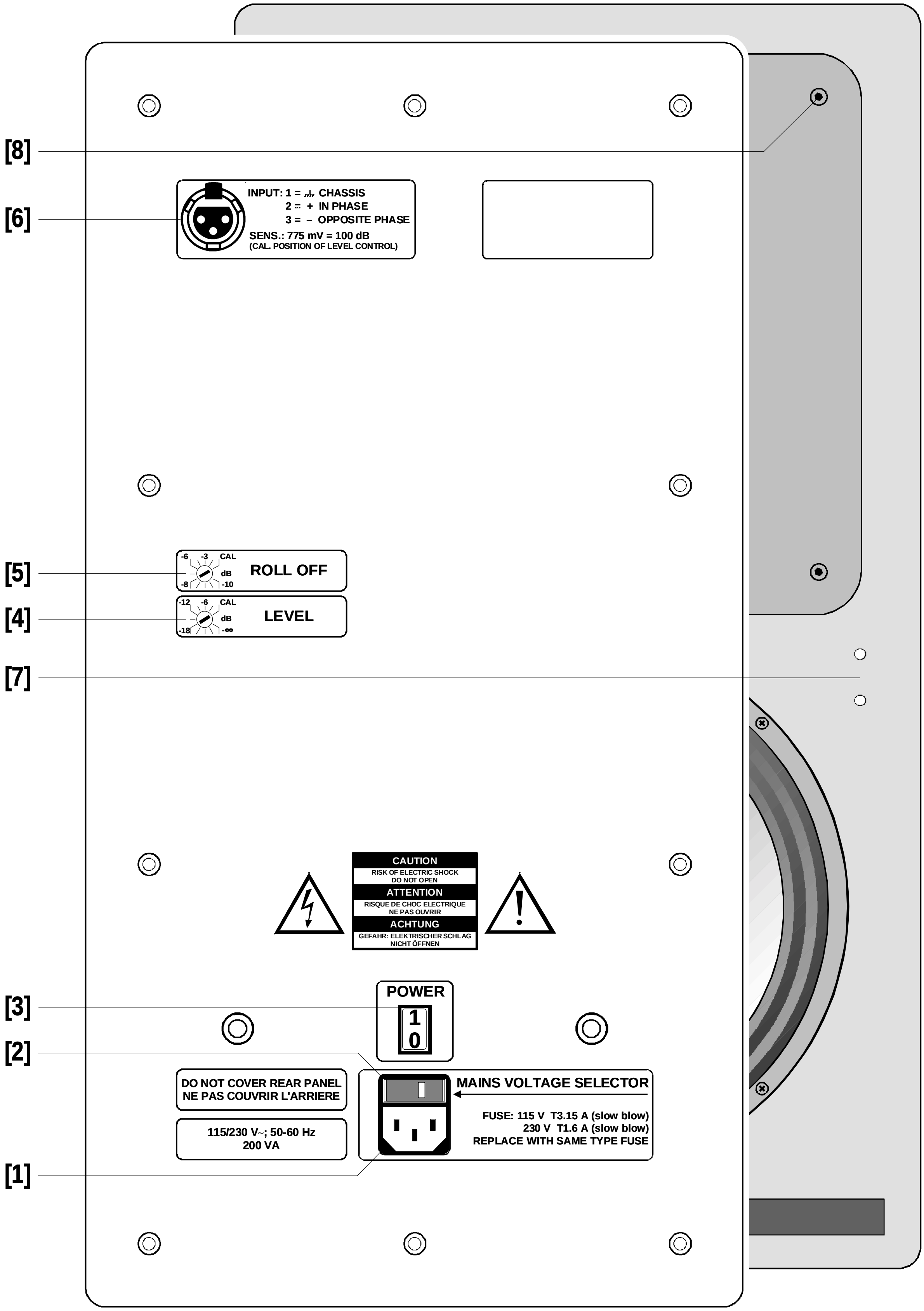
2.4 Technical Specifications (preliminary, subject to change without notice)

	A5	A3	A1
Input	transformer-balanced		electronically balanced
Input impedance	balanced, 5 kΩ	balanced, 5 kΩ	balanced, 12 kΩ
Input sensitivity for 100 dB SPL @ 1 m	0.775 V		
Signal-to-noise ratio	–100 dBA		
Max. input voltage	24 Vpp		20 Vpp
Continuous max. SPL, 1 m	110 dB	108 dB	101 dB
Program max. SPL, 1 m (short term RMS)	118 dB	114 dB	106 dB
Frequency response, –6 dB	38...23000 Hz	43...23000 Hz	58...22000 Hz
Frequency response	±1.5 dB (50 Hz...20 kHz)	±2 dB (48 Hz...20 kHz)	±2.5 dB (65 Hz...18 kHz)
Distortion THD @ 90 dB SPL/1 m	< 1% (50 Hz...20 kHz)	< 1.2% (48 Hz...20 kHz)	< 1% (75 Hz...15 kHz)
Dispersion (P.N. 4...16 kHz at –6 dB)	90° x 90° (H x V)	90° x 90° (H x V)	100° x 100° (H x V)
System	3-way	2-way	2-way
Crossover frequency	450 Hz, 3 kHz	2.2 kHz	3.5 kHz
Woofer ext./diaphragm	∅ 250 mm / ∅ 205 mm	∅ 215 mm / ∅ 170 mm	∅ 142 mm / ∅ 102 mm
Midrange ext./diaphragm	∅ 142 mm / ∅ 102 mm	-	-
Tweeter ext./diaphragm	∅ 100 mm / ∅ 25 mm	∅ 100 mm / ∅ 25 mm	∅ 70 mm / ∅ 20 mm
Input connector	1 x XLR 3f		
Dimensions W x H x D [mm]	320 x 590 x 380	250 x 400 x 305	162 x 242 x 170
Net weight	29 kg	12.8 kg	5 kg
Mains	115/230 V (50/60 Hz)		
Power inlet	IEC 320/C14		
Power consumption	18...200 VA	10...100 VA	7...70 VA
Relative humidity (average / max.)	< 75% / < 90%		
Ambient temperature	5...40° C		
Safety standard	Protection class I according to EN 60065: 1992, IEC 65: 1985.		
EMC standard	EN 55103-1/-2; 1996, electromagnetic environments E2 and E4.		

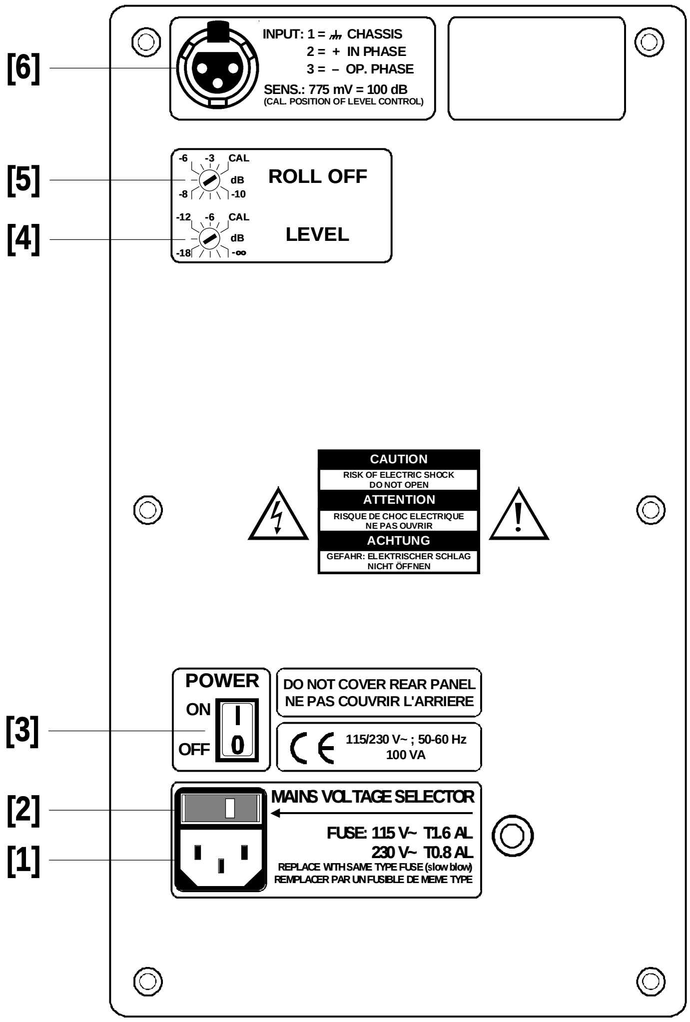
3 OPERATION

3.1 Connectors, controls

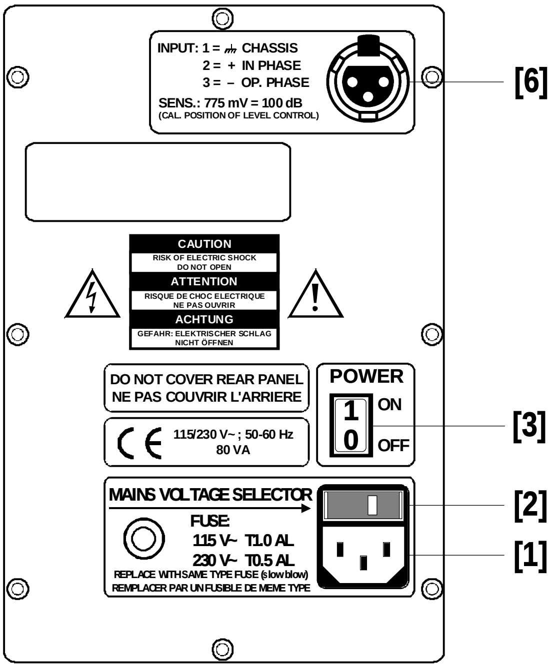
A5:



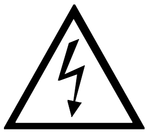
A3:


INPUT: 1 = CHASSIS
2 = + IN PHASE
3 = – OP. PHASE
SENS.: 775 mV = 100 dB
(CAL. POSITION OF LEVEL CONTROL)
ROLL OFF
LEVEL
CAUTION
RISK OF ELECTRIC SHOCK
DO NOT OPEN
ATTENTION
RISQUE DE CHOC ELECTRIQUE
NE PAS OUVRIR
ACHTUNG
GEFAHR: ELEKTRISCHER SCHLAG
NICHT ÖFFNEN
POWER
ON
OFF
DO NOT COVER REAR PANEL
NE PAS COUVRIR L'ARRIERE
115/230 V~ ; 50-60 Hz
100 VA
MAINS VOLTAGE SELECTOR
FUSE: 115 V~ T1.6 AL
230 V~ T0.8 AL
REPLACE WITH SAME TYPE FUSE (slow blow)
REMPLACER PAR UN FUSIBLE DE MEME TYPE
[6]
[5]
[4]
[3]
[2]
[1]

A1:


INPUT: 1 = CHASSIS
2 = + IN PHASE
3 = – OP. PHASE
SENS.: 775 mV = 100 dB
(CAL. POSITION OF LEVEL CONTROL)
CAUTION
RISK OF ELECTRIC SHOCK
DO NOT OPEN
ATTENTION
RISQUE DE CHOC ELECTRIQUE
NE PAS OUVRIR
ACHTUNG
GEFAHR: ELEKTRISCHER SCHLAG
NICHT ÖFFNEN
DO NOT COVER REAR PANEL
NE PAS COUVRIR L'ARRIERE
POWER
ON
OFF
115/230 V~ ; 50-60 Hz
80 VA
MAINS VOLTAGE SELECTOR
FUSE:
115 V~ T1.0 AL
230 V~ T0.5 AL
REPLACE WITH SAME TYPE FUSE (slow blow)
REMPLACER PAR UN FUSIBLE DE MEME TYPE
[6]
[3]
[2]
[1]

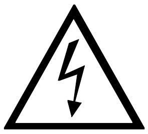
[1] IEC mains connector



Appliance inlet IEC 320/C14 for connection to a 3-pole AC power outlet with protective ground.
Supply voltage (selectable): 115 or 230 V_{AC}; frequency 50...60 Hz.

For connecting to the mains, please consult the Safety section at the very beginning of this manual.
Make sure that the voltage selector setting matches your local line voltage!

[2] Mains fuse, voltage selector



The voltage selector is contained within the fuse holder; its setting can be changed only while the power is switched off. To change the setting, first pull out the black fuse holder cover, then pull out the grey fuse holder. Insert it into the fuse holder cover again after having rotated it by 180 degrees. Check for correct setting before plugging in the fuse holder cover: The set voltage value is indicated in the small window in the fuse holder cover.
The primary fuse must be replaced by a spare fuse of exactly the same type and value!

[3] POWER

Power on/off switch.

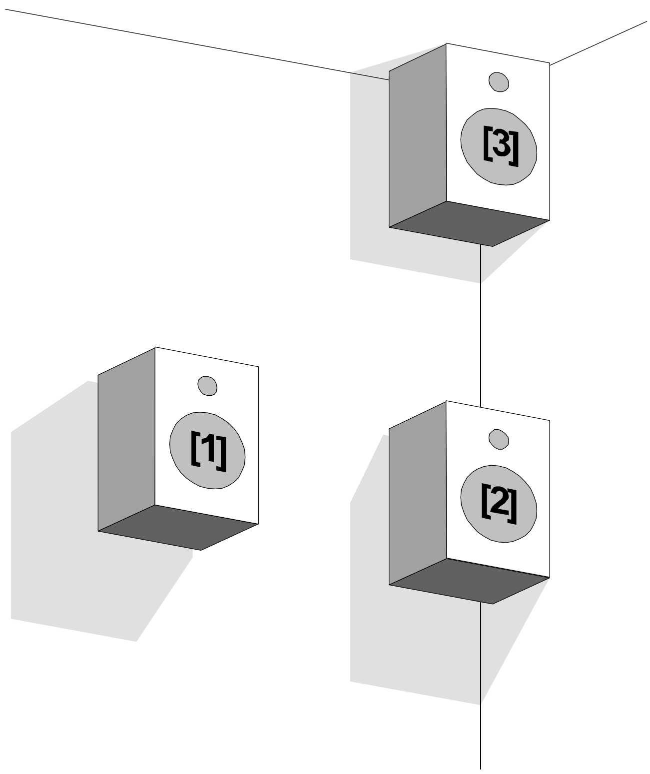
[4] LEVEL

Potentiometer for matching the input sensitivity to your standard line level.

Note: *For the A1, this control is located on the front panel.*

[5] ROLL OFF *(A3 and A5 only)*

Continuously adjustable bass cut filter, allows attenuation of the low frequencies in order to compensate for boundary reflections when the unit is mounted close to one (approx. –3 dB setting, fig. [1]), to two (approx. –6 dB setting, fig. [2]), or to three room boundaries (approx. –10 dB setting, fig. [3]).



[6] INPUT

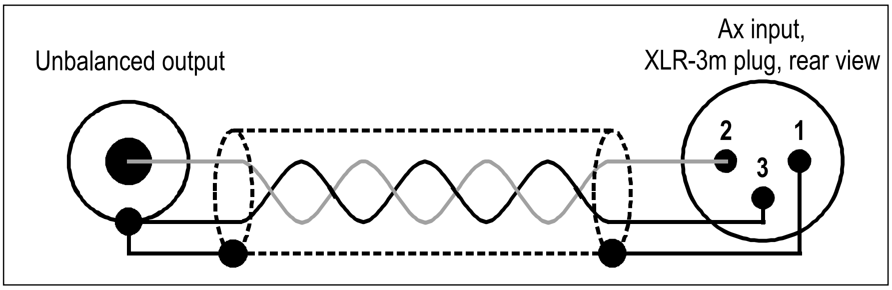
Transformer-balanced (A5 and A3) or electronically balanced (A1) audio input on female 3-pin XLR connector.

Pin assignment:

Pin	Signal
1	Ground
2	Input +
3	Input –
-	Chassis

Polarity: A positive voltage on pin 2 causes a positive diaphragm deflection (i.e., the woofer's diaphragm moves towards the listener).

Note: The A series speakers can also be driven by unbalanced sources (Hi-Fi). In that case, use a cable according to the diagram below.



[7] Pilot LEDs

All A Series speakers feature a green Power On LED.

The A1 speaker is overload-protected by a limiter function *without* LED indicator.

On the A3 and A5 speakers, the red Alarm LED on the front panel indicates as follows:

Status	Red Alarm LED status	Audio output
Normal operation conditions	dark	No limiting or muting
Chassis overload (limiter active)	flickering	Output is attenuated to a safe level until input signal is reduced.
Overheat detection (above approx. 65...75° C)	continuously on	Output is muted until amplifier is cooled down.

[8] Midrange/tweeter unit *(A5 only)*

If the A5 cannot be set up vertically (which in fact is the recommended position), its midrange/tweeter assembly can be rotated by ±90 degrees.
To do so, switch the speaker off and unplug the mains connection; loosen the 4 mounting screws (Allen screwdriver no. 4) of the midrange/tweeter assembly. Because it fits quite tightly, you can use one of the four recesses located at the circumference of the midrange speaker to pull out the assembly carefully.
Reinsert it after having turned it by the required angle, and re-tighten the four screws in order to get a sealed joint again.

4 SERVICE INSTRUCTIONS

4.1 General

Important! Repair work may only be performed by a trained service technician. The primary fuse must be replaced by a spare fuse of exactly the same type and rating. The unit must not be opened by the user – risk of a severe electrical shock hazard!

- During servicing, *never* short any two terminals.
- The settings of an assembled and aligned unit may slightly differ from the ones of the aligned PCB.
- If acoustical measurements are performed with an MLS system, insatisfactory results will be obtained unless obstacles are at a distance larger than the current wavelength. *For more information on frequency response measurements, please refer to the Appendix, section 4.6 .*
- In case of incorrect manipulation and/or adjustment, the manufacturer cannot be made liable for failure or insatisfactory results.

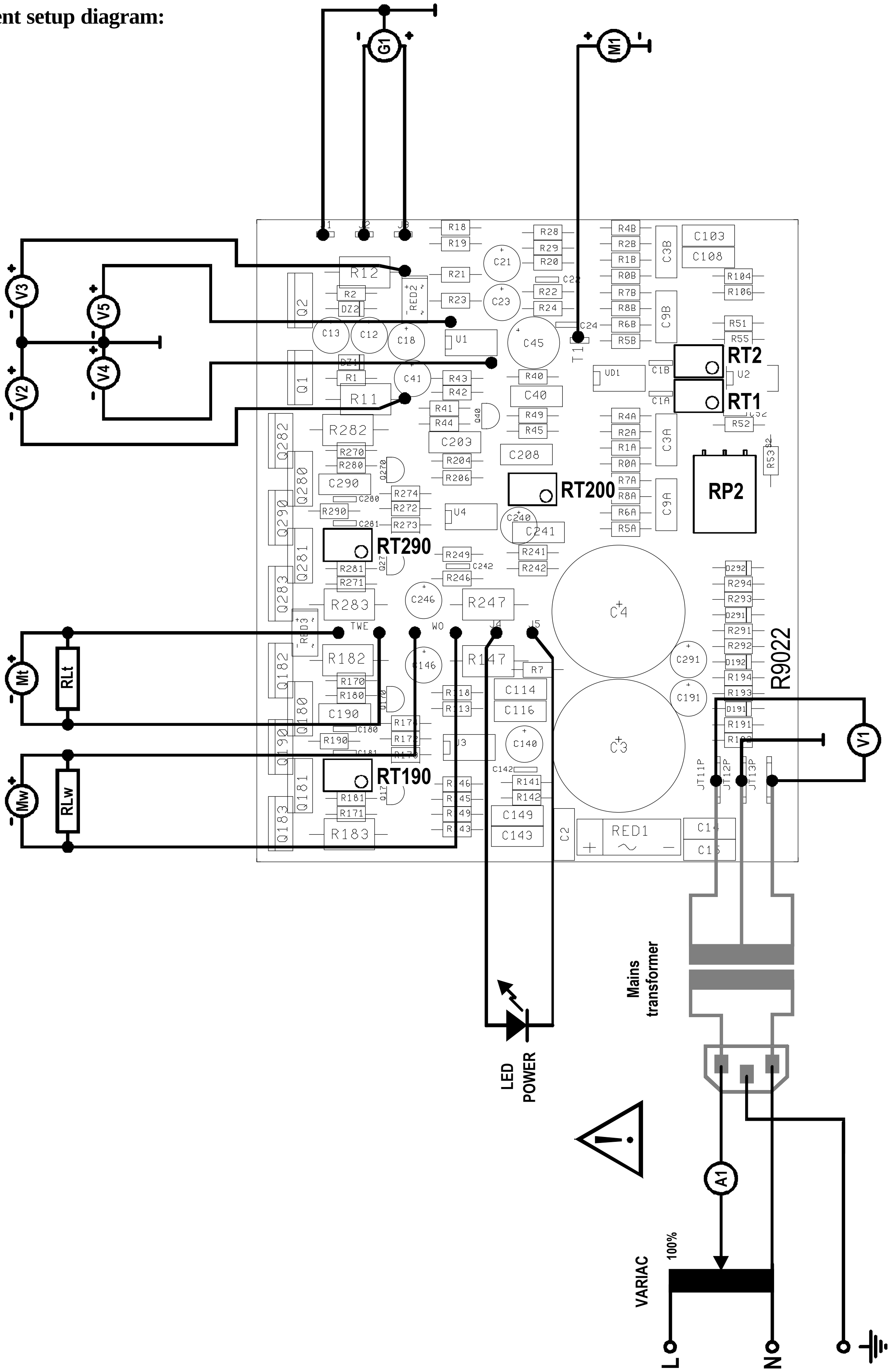
4.2 Spare Parts

Item	Order no. A1	Order no. A3	Order no. A5
Primary fuse ***(230 V)*** (5 × 20 mm)	51.01.0114 *(T 0.5 A L 250 V)*	51.01.0116 *(T 0.8 A L 250 V)*	51.01.0119 *(T 1.6 A L 250 V)*
Primary fuse ***(115 V)*** (5 × 20 mm)	51.01.0117 *(T 1.0 A L 250 V)*	51.01.0119 *(T 1.6 A L 250 V)*	51.01.0122 *(T 3.15 A L 250 V)*
Primary fuse ***(USA/Canada)*** (5 × 20 mm)	51.01.1017 *(1.0 A slow blow UL/CSA)*	51.01.1020 *(1.6 A slow blow UL/CSA)*	51.01.1026 *(3.2 A slow blow UL/CSA)*
Woofer unit	15.258.210.00	15.258.110.00	15.258.010.00
Mid-range unit	-----	-----	15.258.020.00
Tweeter unit	15.258.240.00	15.258.140.00	15.258.040.00
* Complete backpanel/heat-sink assembly, including power supply and amplifiers	* 15.258.230.00	* 15.258.130.00	* 15.258.030.00
Backpanel only, silk screened	15.258.220.00	15.258.120.00	15.258.050.00
Mains transformer	15.258.221.00	15.258.121.00	15.258.121.00 (2 pcs. used)
* Power amplifier, preadjusted	* 15.258.222.00	* 15.258.122.00	* 15.258.052.00
Mounting bracket	15.258.223.00	-----	-----
Enclosure body, empty	15.258.229.00	15.258.129.00	15.258.059.00
Woofer protection grille, mounting kit	15.258.211.00	-----	-----

*** Important note:** *When ordering a complete backpanel/amplifier assembly or a power amplifier unit, it is mandatory to declare the speaker type and serial number (as indicated on the speaker's backpanel).* Only if these conditions are met, the manufacturer can ensure that the desired spare part is shipped with correct pre-alignments.

4.3 A1 Service

Measurement setup diagram:



4.3.1 A1: Settings on the PCB

4.3.1.1 A1: Required Test Tools

T1 Variable mains transformer (variac)
A1 True-RMS AC ammeter
V1 True-RMS AC voltmeter
V2…V5 Digital DC voltmeter
G1 Sine-wave generator with balanced output (min. 20 Hz…20 kHz, < 0.02% THD)
M1, Mw, Mt Voltmeter, THD meter, phase meter
RLw, RLt Dummy load resistors, 10 Ω, approx. 10 W

Note: G1, M1, Mw, Mt can be replaced by a universal audio test system (Audio-Precision System One or equivalent)

4.3.1.2 A1: Initial Settings

Note: *Replacement backpanel assemblies or amplifier units come factory-pre-adjusted. Adjustment of the quiescent current is therefore not necessary after replacement, checking is recommended nevertheless.*

- Unplug the speaker cables from the PCB, *do not* connect any load to the amplifier outputs. *Make sure that none of the cable ends contacts the PCB;*
- Set the level potentiometer to CAL position (fully counterclockwise);
- Set trimmer potentiometers RT190 and RT290 (quiescent current) to min. position (fully counterclockwise);
- Variac set to min. (0 V_{AC});
- Power switch to ON position.

4.3.1.3 A1: Powering Up

- Visually check the PCB and the solder joints and repair, if necessary;
- Check the mains voltage
- Check or insert the primary fuse
- Connect the generator according to the diagram;
- Slowly increase the variac output while checking the primary current
- The green Power LED illuminates;
- Increase the variac output until V1 is 56 V_{AC}.

230 V_{AC}	115 V_{AC}
T 0.5 A L 250 V	T 1.0 A L 250 V
< 40 mA_{AC}	< 80 mA_{AC}

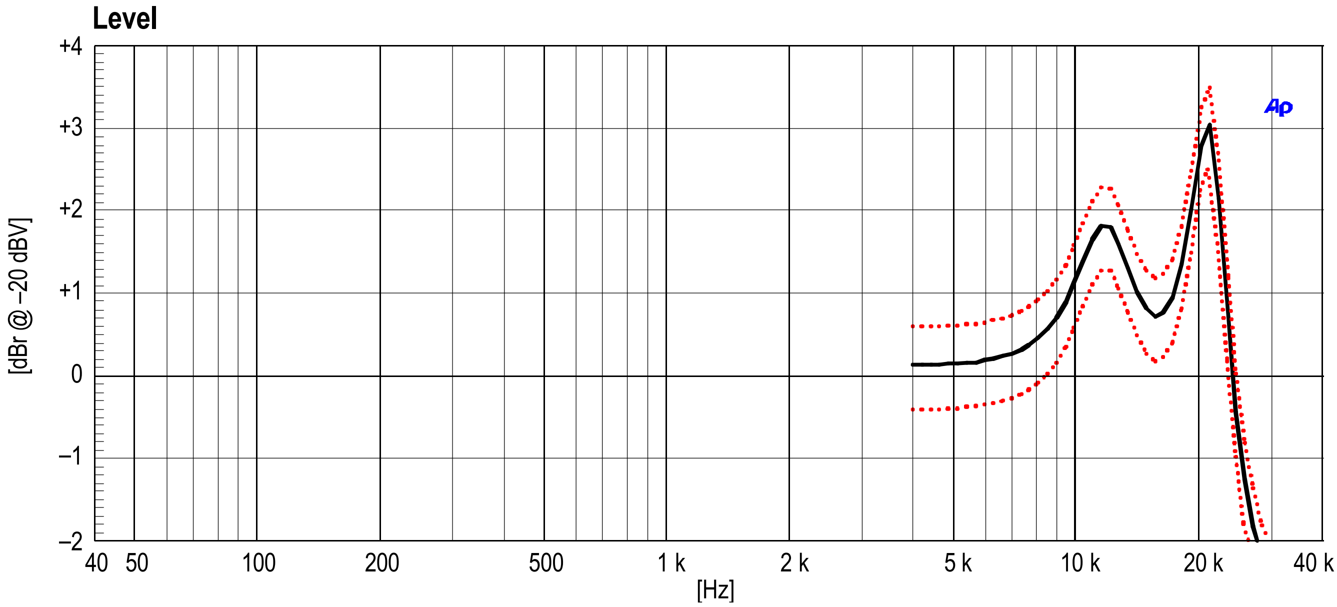
4.3.1.4 A1: Supply Voltages

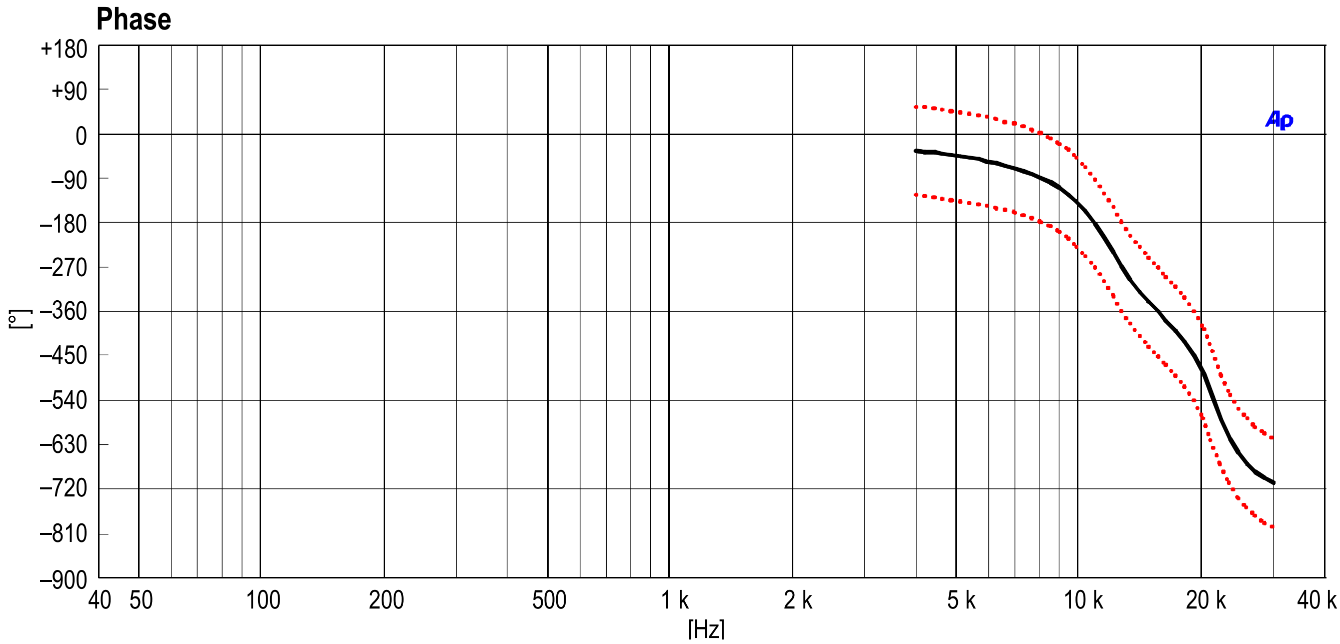
Steps		Generator		Measurement			
No.	**Description**	**Id**	**Value**	**Test pos.**	**Type**	**Value**	**Limits**
1	Supply check	G1	0 V	V2	V_{DC}	–38 V_{DC}	±3 V
2	Supply check	G1	0 V	V3	V_{DC}	+38 V_{DC}	±3 V
3	IC supply check	G1	0 V	V4	V_{DC}	–17.4 V_{DC}	±0.6 V
4	IC supply check	G1	0 V	V5	V_{DC}	+17.4 V_{DC}	±0.6 V

4.3.1.5 A1: Input Gain Check and EQ Preadjustments

These preadjustments must be performed only if RT1 and RT2 are completely out of range; these settings will be fine-adjusted on the assembled unit, also refer to section 4.3.2.5.

Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	Input gain check	G1	–33 dBV/200 Hz/sine wave	M1	Level	–20.0 dBV	±0.3 dB
2	RT1 adjust	G1	–33 dBV/12.2 kHz/sine wave	M1	Level	–18.2 dBV	±0.5 dB
3	RT2 adjust	G1	–33 dBV/21 kHz/sine wave	M1	Level	–17.0 dBV	±0.5 dB
4	Repeat steps 2 and 3 until all values are within the given limits						

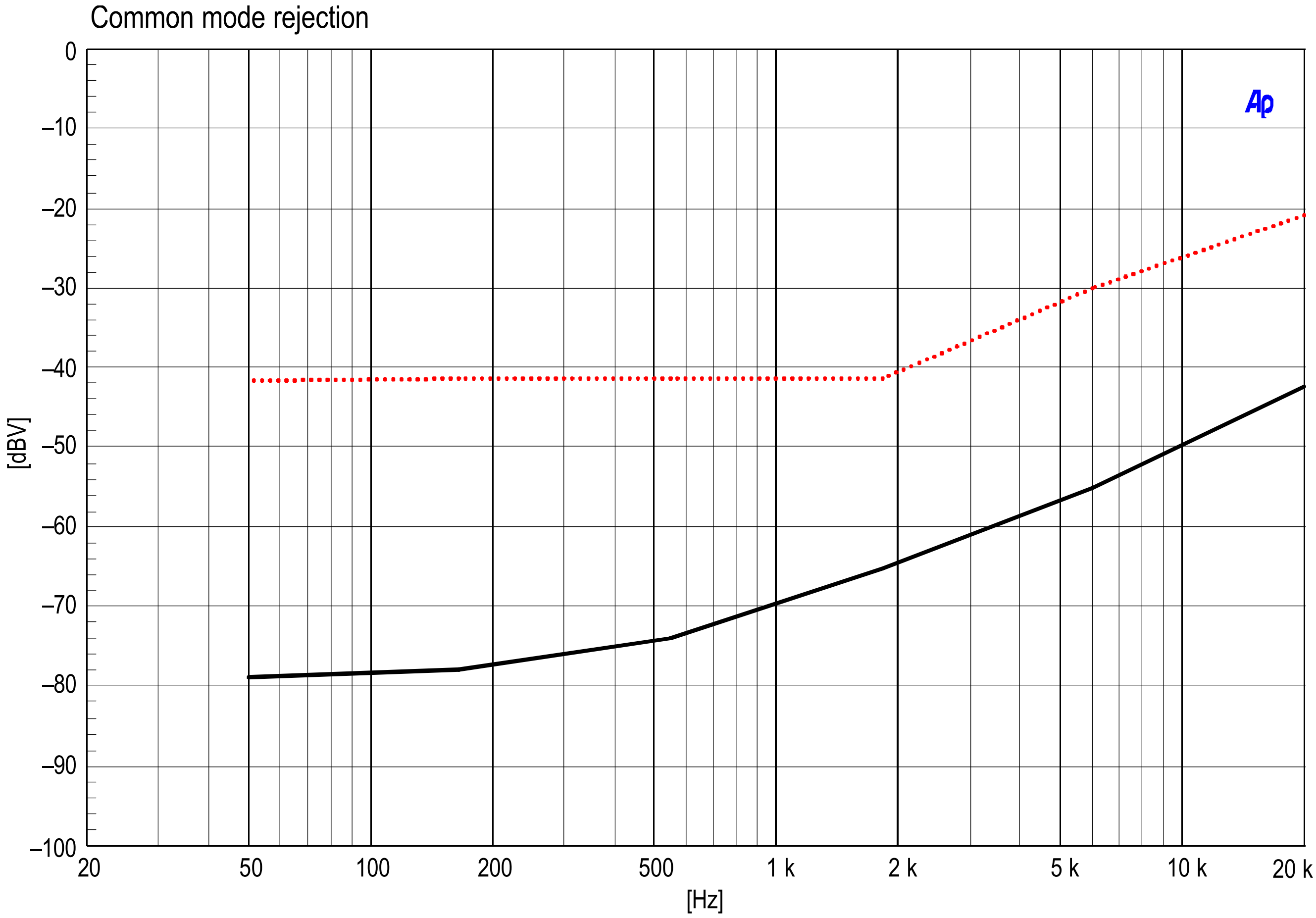




4.3.1.6 A1: Input Common Mode Rejection Ratio (CMRR)

- Connect the generator in common mode to the input – i.e. "hot" generator output to both input terminals no. 2 (+) *and* 3 (–), "cold" generator output to input terminal no. 1 (GND).

Steps		Generator		Measurement			
No.	**Description**	**Id**	**Value**	**Test pos.**	**Type**	**Value**	**Limits**
1	CMRR 50 Hz	G1	0 dBV/50 Hz/sine wave	M1	Level	< –42 dBV	
2	CMRR 1 kHz	G1	0 dBV/1 kHz/sine wave	M1	Level	< –42 dBV	
3	CMRR 10 kHz	G1	0 dBV/10 kHz/sine wave	M1	Level	< –26 dBV	



4.3.1.7 A1: Quiescent Current Setting

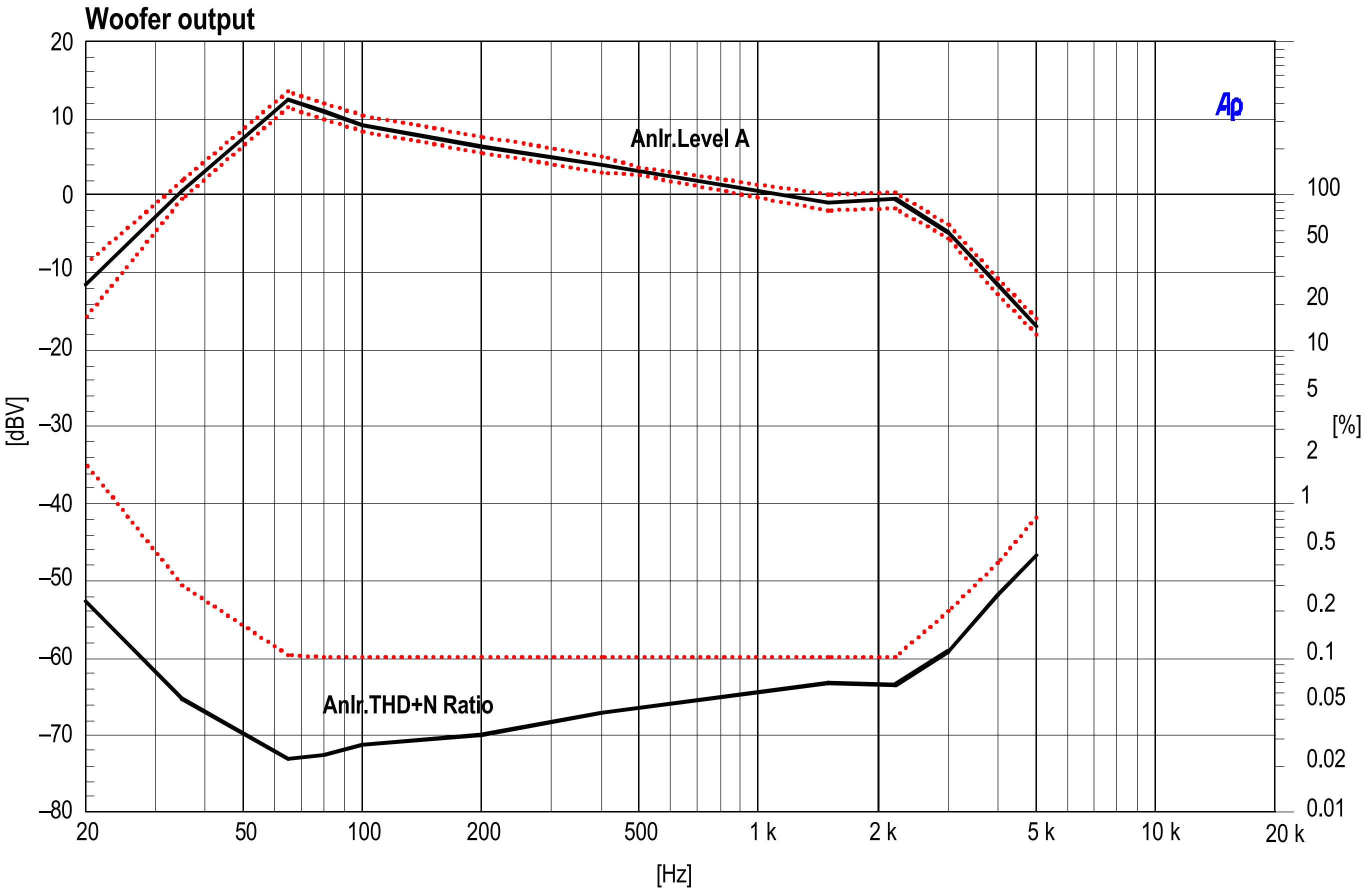
Procedure:

1. Measure the primary current:
   $A1_1$ = 30…40 mA_{AC} (for 230 V), or 60…80 mA_{AC} (for 115 V),
   and note the measured value;
2. Adjust RT290 (turn carefully clockwise) for a reading of:
   $A1_2 = A1_1$ + 3 mA_{AC} (for 230 V), or $A1_1$ + 6 mA_{AC} (for 115 V),
   and note the measured value;
3. Adjust RT190 (turn carefully clockwise) for a reading of:
   $A1_3 = A1_2$ + 3 mA_{AC} (for 230 V), or $A1_2$ + 6 mA_{AC} (for 115 V),
   and note the measured value;
4. Connect both dummy load resistors (10 Ω/10 W each) and check the primary current again:
   $A1_4 = A1_3$ ±0.5 mA_{AC} (for 230 V), or $A1_3$ ±1 mA_{AC} (for 115 V).

4.3.1.8 A1: Woofer Amplifier Output

- Connect only the RLw dummy load (10 Ω)

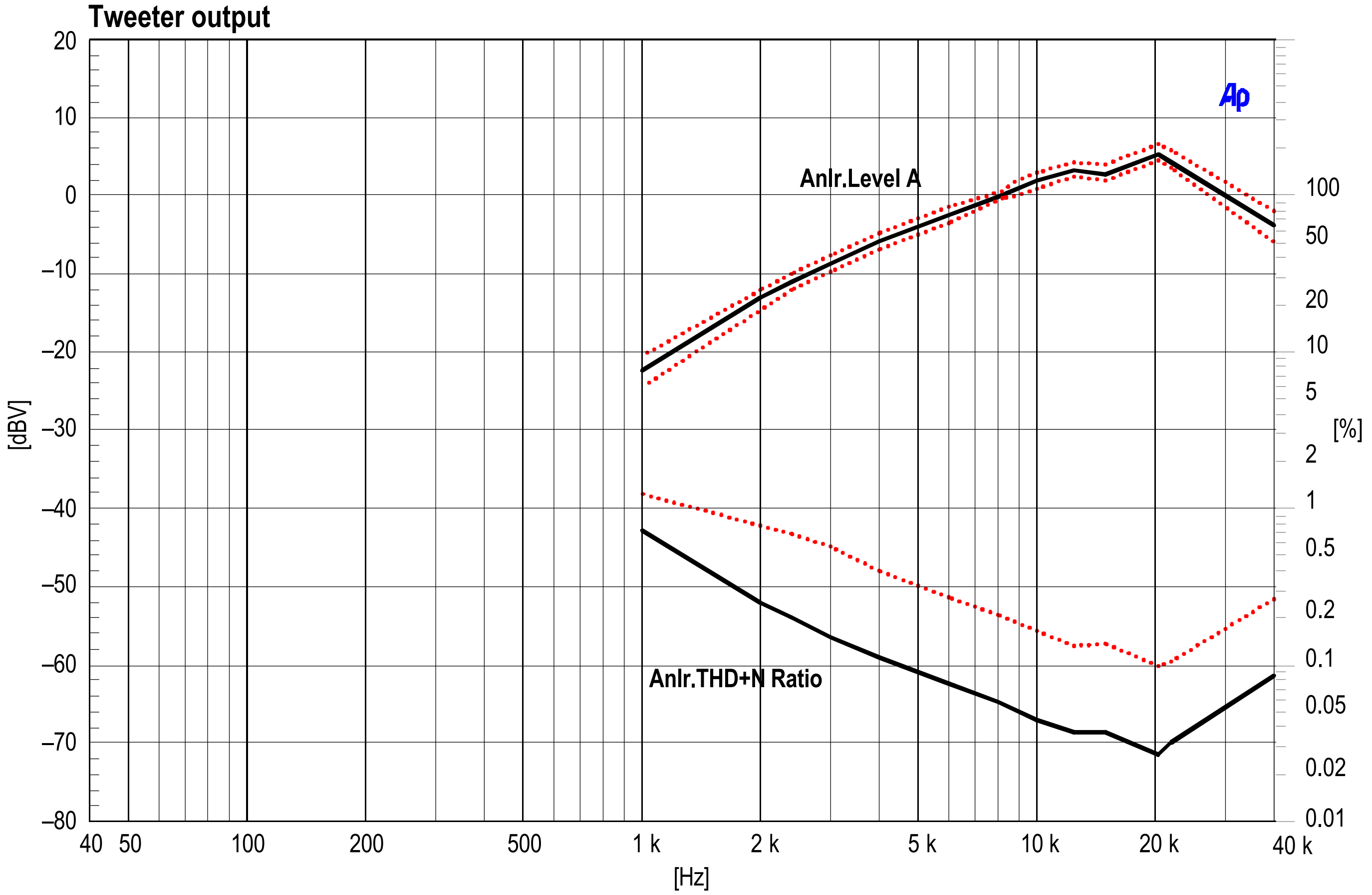
Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	Woofer output level	G1	–20 dBV/500 Hz/sine wave	Mw	Level	+3.5 dBV	±0.25 dB
2	Woofer output THD	G1	–20 dBV/500 Hz/sine wave	Mw	THD + N	< 0.1 %	< 0.1 %



4.3.1.9 A1: Tweeter Amplifier Output

- Connect only the RLt dummy load (10 Ω)

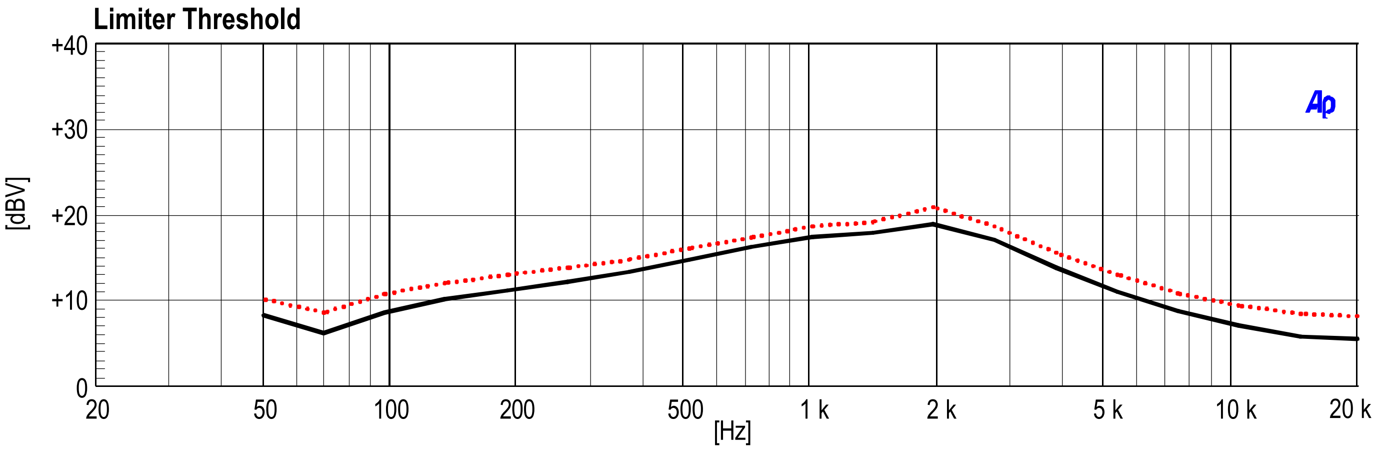
Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	Tweeter output level	G1	–20 dBV/8.1 kHz/sine wave	Mt	Level	0 dBV	±0.25 dB
2	Tweeter output THD	G1	–20 dBV/8.1 kHz/sine wave	Mt	THD + N	< 0.1 %	< 0.1 %



4.3.1.10 A1: Limiter Threshold

- Disconnect all dummy load resistors.

Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	HF limiter	G1	+10 dBV/10 kHz/sine wave	M1 *	Level	+8.5 dBV	±2 dBV
2	LF limiter	G1	+10 dBV/100 Hz/sine wave	M1 *	Level	+7.3 dBV	±2 dBV
* The Mw and Mt output levels must be reduced.							



4.3.2 A1: Checks on the Assembled Unit

4.3.2.1 A1: Required Test Tools

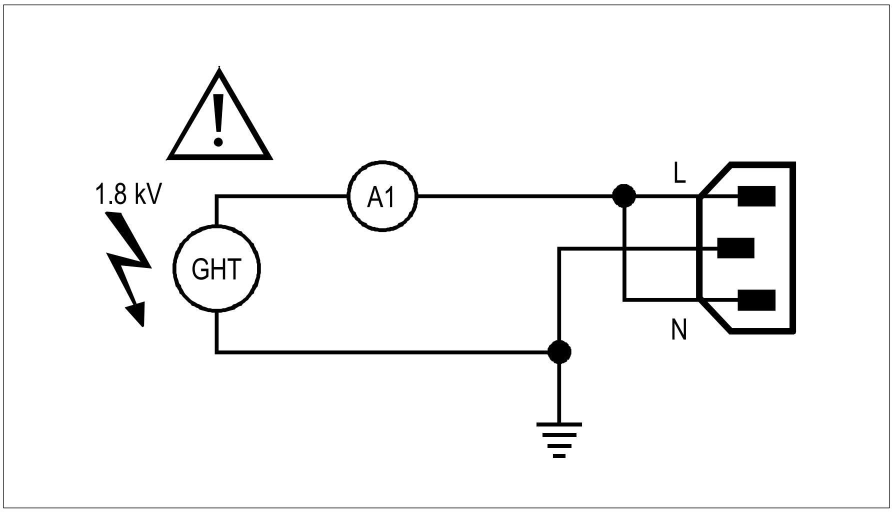
C Anechoic room;
A1 True-RMS AC ammeter;
GHT High-voltage generator 1.8 kV, 50 Hz, max. 10 mA;
G1 Sweep sine-wave generator with balanced output (AudioPrecision System One or equivalent);
M1 Measurement microphone Brüel & Kjær BK4133 + preamp BK2639 or equivalent;
M2 Measurement amplifier Brüel & Kjær BK2610 or equivalent
M3 Level/THD/phase analyzer (AudioPrecision System One or equivalent);
P1 Phase meter with adjustable propagation delay compensation on reference input.

4.3.2.2 A1: Initial Settings

- Set the level potentiometer to CAL position (fully counterclockwise);
- Set power switch to ON.

4.3.2.3 A1: Insulation Check

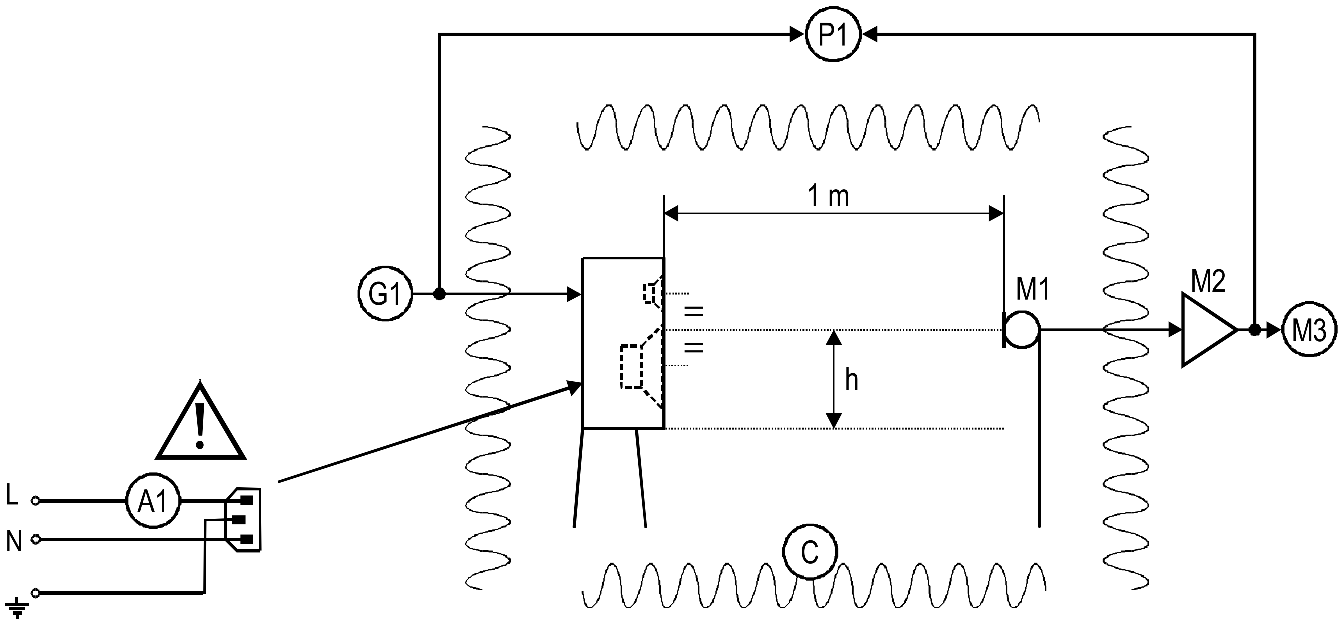
- Connect the HV generator to the mains input connector according to the diagram below:



- Apply 1.8 kV for 5 seconds;
- The leakage current must not exceed 5 mA.

4.3.2.4 A1: Measurement Setup in the Anechoic Room

- Setup the loudspeaker;
- Setup the measurement microphone:
  - Distance to the baffle 1 m,
  - Equidistant from the two vertical edges,
  - Equidistant from the centers of woofer and tweeter units (i.e., h = 16 cm), and
  - Perpendicular to the baffle;
- Connect your unit to the mains, set power switch to ON, check the current consumption (< 50 mA_{AC} for 230 V);
- Connect generator G1 with correct signal polarity.

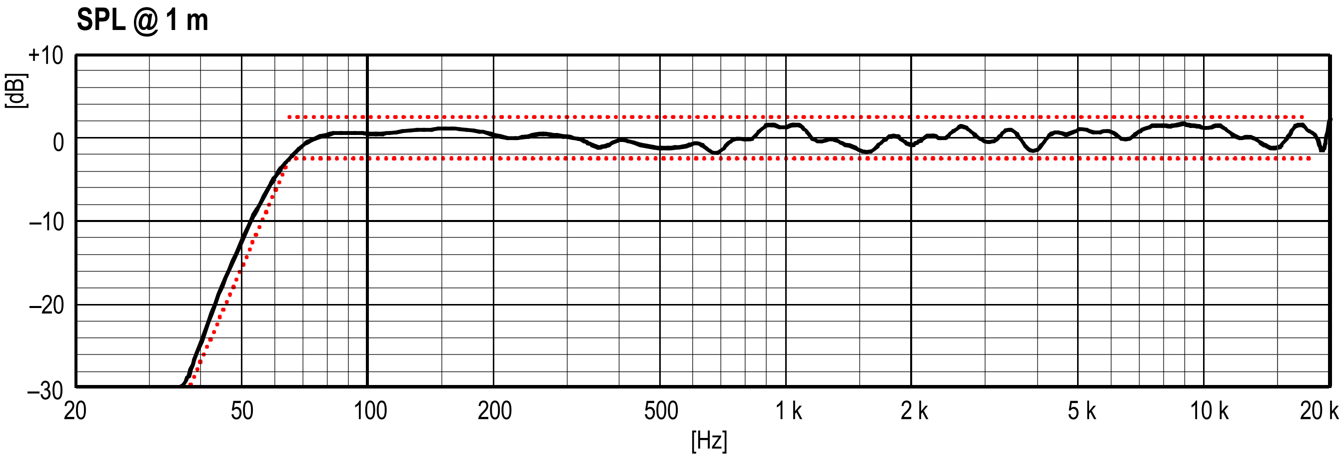


Note: *For more information on frequency response measurements, please refer to section 4.6 .*

4.3.2.5 A1: SPL and EQ Fine-Adjustment

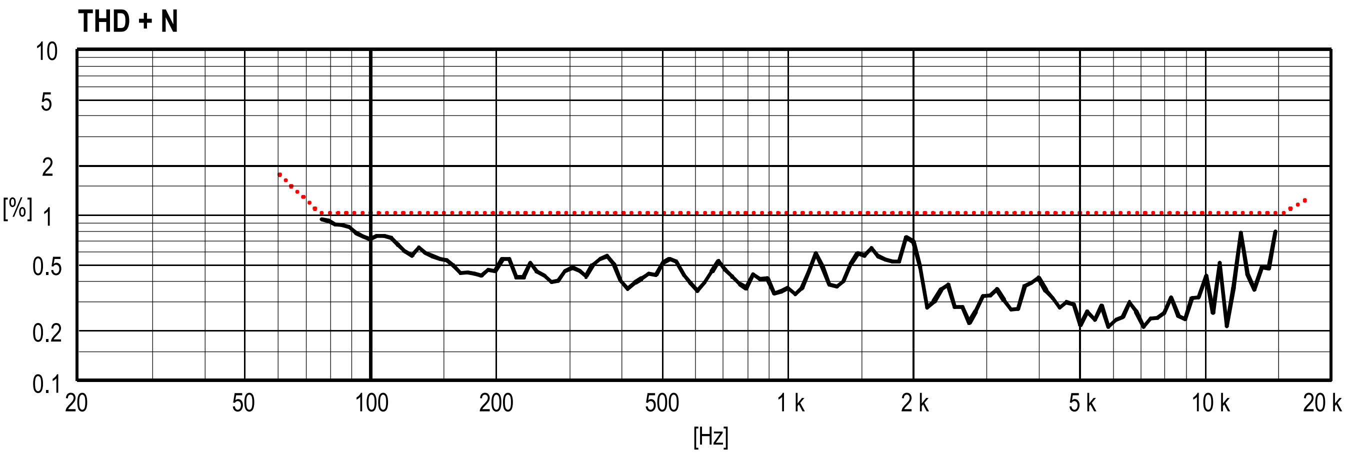
- Set balanced generator to 245 mVRMS (i.e. –12.2 dBV or –10 dBu);
- Plot frequency response sweep @ 1 m: tolerance according to the graph below;
- EQ fine-adjustment possibilities:
  1. Overall tweeter level (4…20 kHz) with trimmer potentiometer RT200
  2. Tweeter level @ 12.2 kHz with trimmer potentiometer RT1
  3. Tweeter level @ 20 kHz with trimmer potentiometer RT2.

Note: Basic setting of RT1 and RT2: refer to section 4.3.1.5.



4.3.2.6 A1: Distortion Check

- Set balanced generator to 245 mVRMS (i.e. –12.2 dBV or –10 dBu);
- Plot a 20 Hz…20 kHz THD sweep @ 1 m: < 1% (75 Hz…15 kHz).



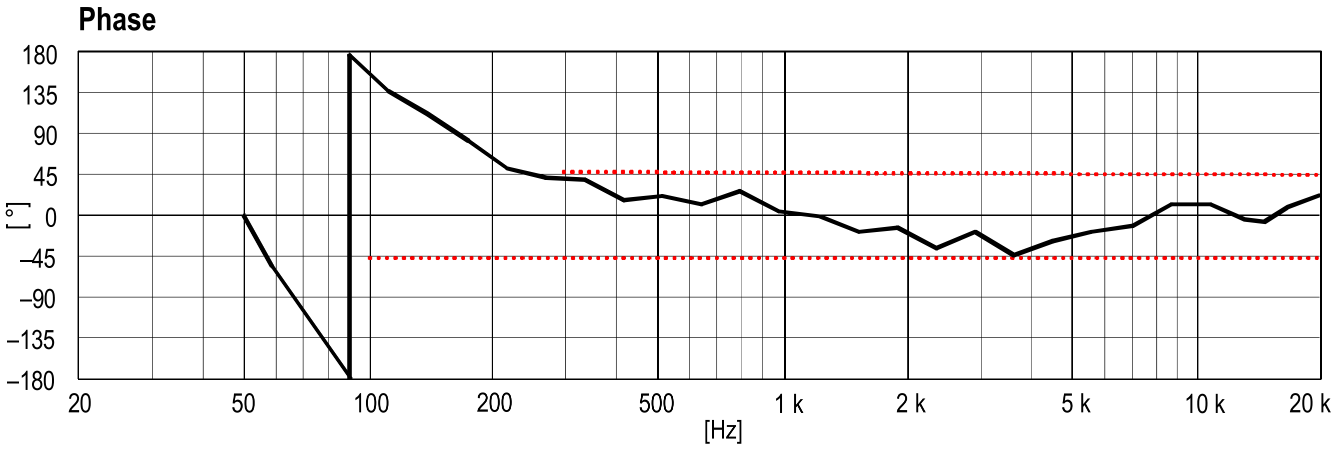
4.3.2.7 A1: Polarity Check

- Place the measurement microphone at a distance of 10 cm from the baffle and exactly in the center of the woofer.

Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	System polarity	G1	–14 dBV (245 mV$_{RMS}$)/120 Hz/sine wave	P1*	Phase	0°	±20°
***Note:** *Without compensation, the microphone Brüel & Kjær BK4133+2639 is inverting*							

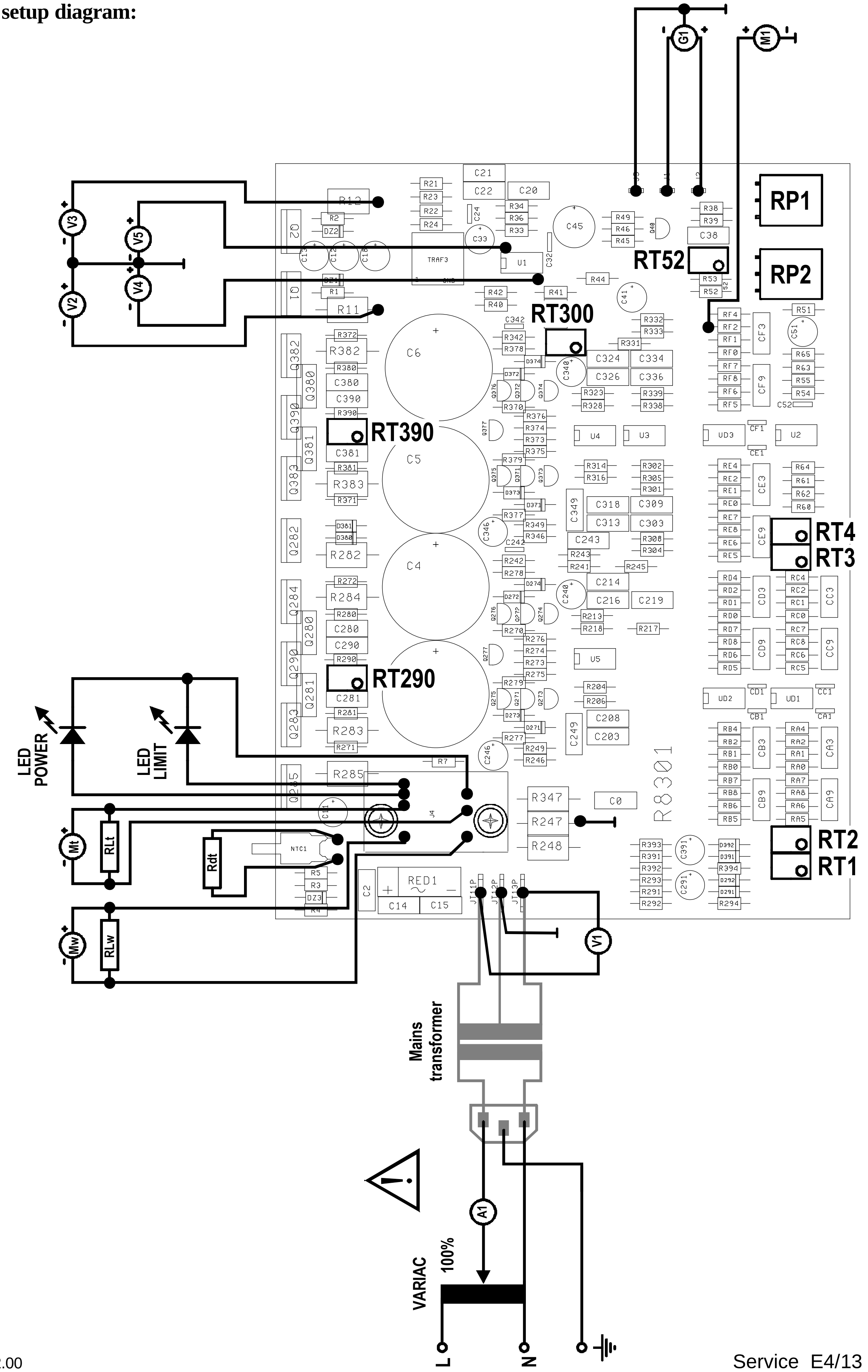
4.3.2.8 A1: Overall Phase Check

- Place the measurement microphone again on-axis, according to 4.3.2.4, distance 0.806 m;
- Set the phasemeter propagation delay time to 2.91 ms (corresponding to a distance of 1 m);
- Set balanced generator to 245 mVRMS (i.e. –12.2 dBV or –10 dBu);
- Plot a phase sweep 20 Hz…20 kHz according to the graph below;
- If the result is above the tolerance, increase the microphone distance, or if the result is below the tolerance, decrease the microphone distance, and repeat the phase sweep.



4.4 A3 Service

Measurement setup diagram:



4.4.1 A3: Settings on the PCB

4.4.1.1 A3: Required Test Tools

T1	Variable mains transformer (variac)
A1	True-RMS AC ammeter
V1	True-RMS AC voltmeter
V2…V5	Digital DC voltmeter
G1	Sine-wave generator with balanced output (min. 20 Hz…20 kHz, < 0.02% THD)
M1, Mw, Mt	Voltmeter, THD meter, phase meter
RLw, RLt	Dummy load resistors, 10 Ω, approx. 10 W
Rdt	Fixed resistor, 22 kΩ, for overheat protection check

Note: G1, M1, Mw, Mt can be replaced by a universal audio test system (Audio-Precision System One or equivalent)

4.4.1.2 A3: Initial Settings

Note: *Replacement backpanel assemblies or amplifier units come factory-pre-adjusted. Adjustment of the quiescent current is therefore not necessary after replacement, checking is recommended nevertheless.*

- Unplug the speaker cables from the PCB, *do not* connect any load to the amplifier outputs. *Make sure that none of the cable ends contacts the PCB;*
- Set the level potentiometer to CAL position (fully counterclockwise);
- Set the roll-off potentiometer to CAL position (fully counterclockwise);
- Set trimmer potentiometers RT290 and RT390 (quiescent current) to min. position (fully counterclockwise);
- Variac set to min. (0 V_{AC});
- Power switch to ON position.

4.4.1.3 A3: Powering Up

- Visually check the PCB and the solder joints and repair, if necessary;
- Check the mains voltage
- Check or insert the primary fuse
- Connect the generator according to the diagram;
- Slowly increase the variac output while checking the primary current
- The green Power LED illuminates;
- Increase the variac output until V1 is 64 V_{AC}.

	230 V_{AC}	115 V_{AC}
Mains voltage	230 V_{AC}	115 V_{AC}
Primary fuse	T 0.8 A L 250 V	T 1.6 A L 250 V
Primary current	< 50 mA_{AC}	< 100 mA_{AC}

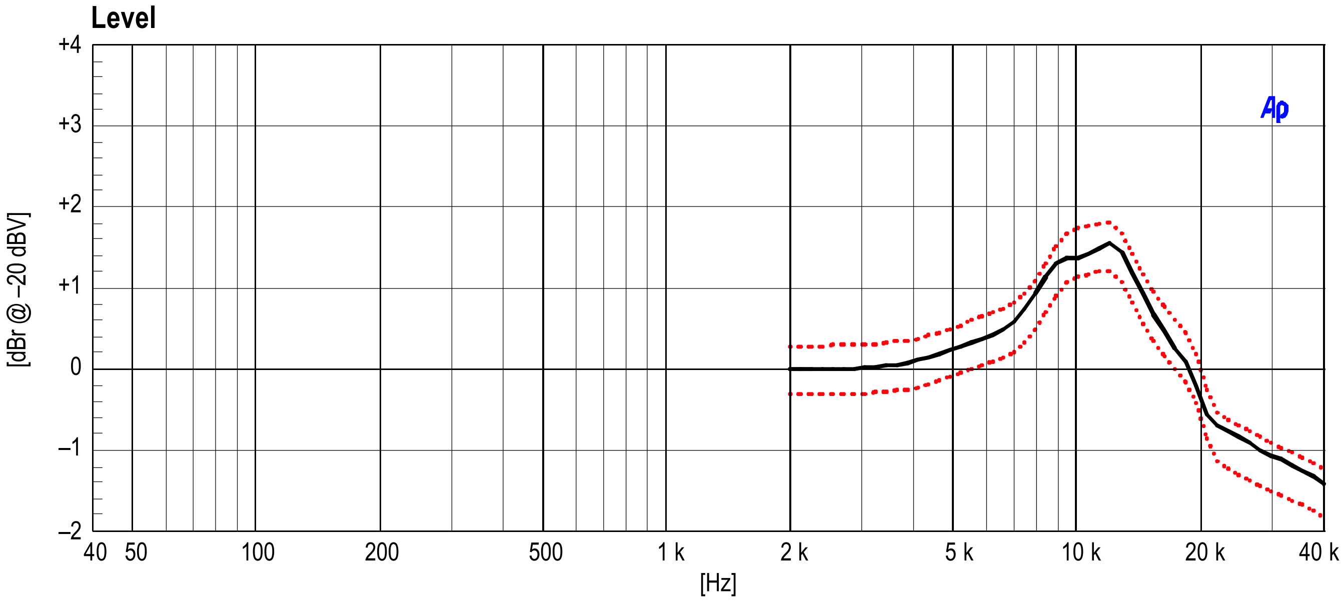
4.4.1.4 A3: Supply Voltages

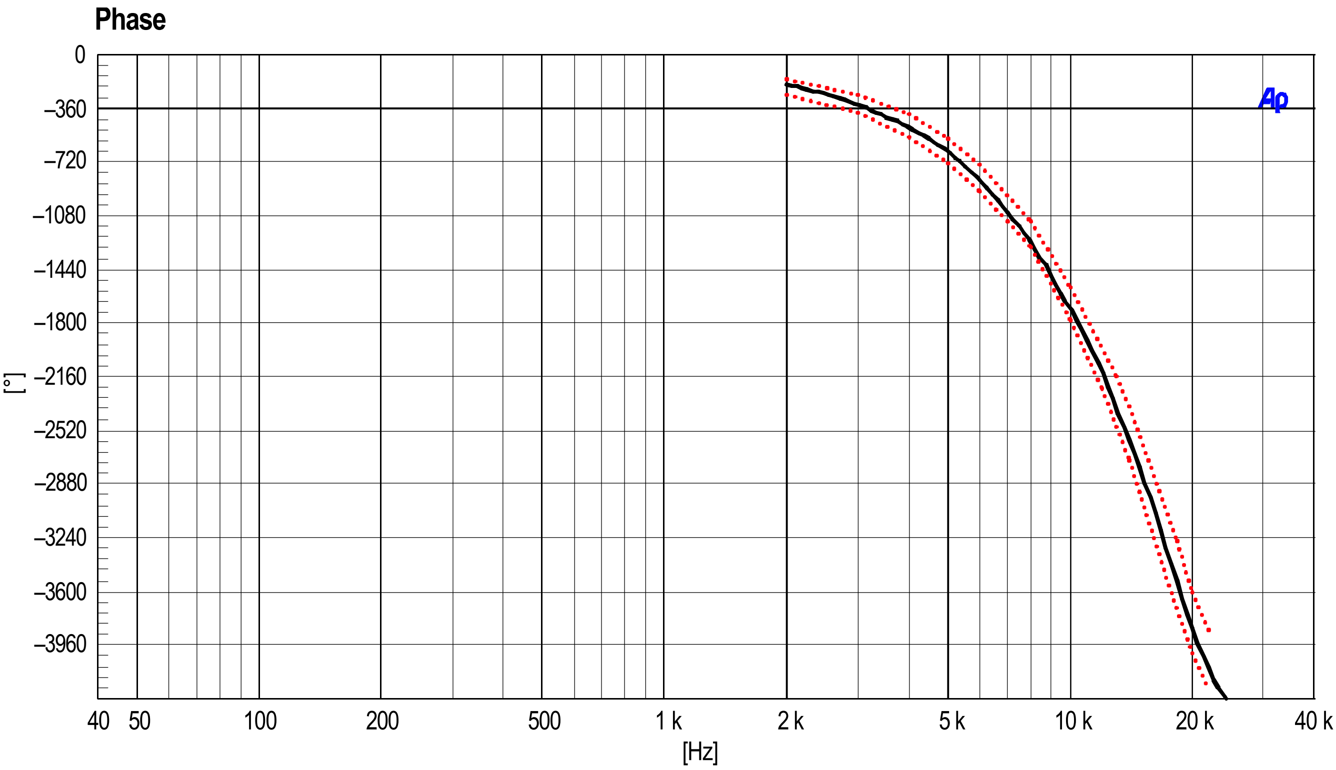
Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	Supply check	G1	0 V	V2	V_{DC}	–44 V_{DC}	±3 V
2	Supply check	G1	0 V	V3	V_{DC}	+44 V_{DC}	±3 V
3	IC supply check	G1	0 V	V4	V_{DC}	–17.4 V_{DC}	±0.6 V
4	IC supply check	G1	0 V	V5	V_{DC}	+17.4 V_{DC}	±0.6 V

4.4.1.5 A3: Input Gain Check and EQ Preadjustments

These preadjustments must be performed only if RT1 through RT4 are completely out of range; these settings will be fine-adjusted on the assembled unit, also refer to section 4.4.2.5.

Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	RT52 input gain adjust	G1	–29.6 dBV/60 Hz/sine wave	M1	Level	–20.0 dBV	±0.5 dB
2	Roll-off check	G1	–29.6 dBV/60 Hz/sine wave	M1	Level	–29.0 dBV	±0.5 dB
3	RT1 adjust	G1	–29.6 dBV/6.0 kHz/sine wave	M1	Level	–19.6 dBV	±0.5 dB
4	RT2 adjust	G1	–29.6 dBV/9.0 kHz/sine wave	M1	Level	–18.7 dBV	±0.5 dB
5	RT3 adjust	G1	–29.6 dBV/12.5 kHz/sine wave	M1	Level	–18.5 dBV	±0.5 dB
6	RT4 adjust	G1	–29.6 dBV/20.0 kHz/sine wave	M1	Level	–20.3 dBV	±0.5 dB
7	Repeat steps 3 through 6 until all values are within the given limits						

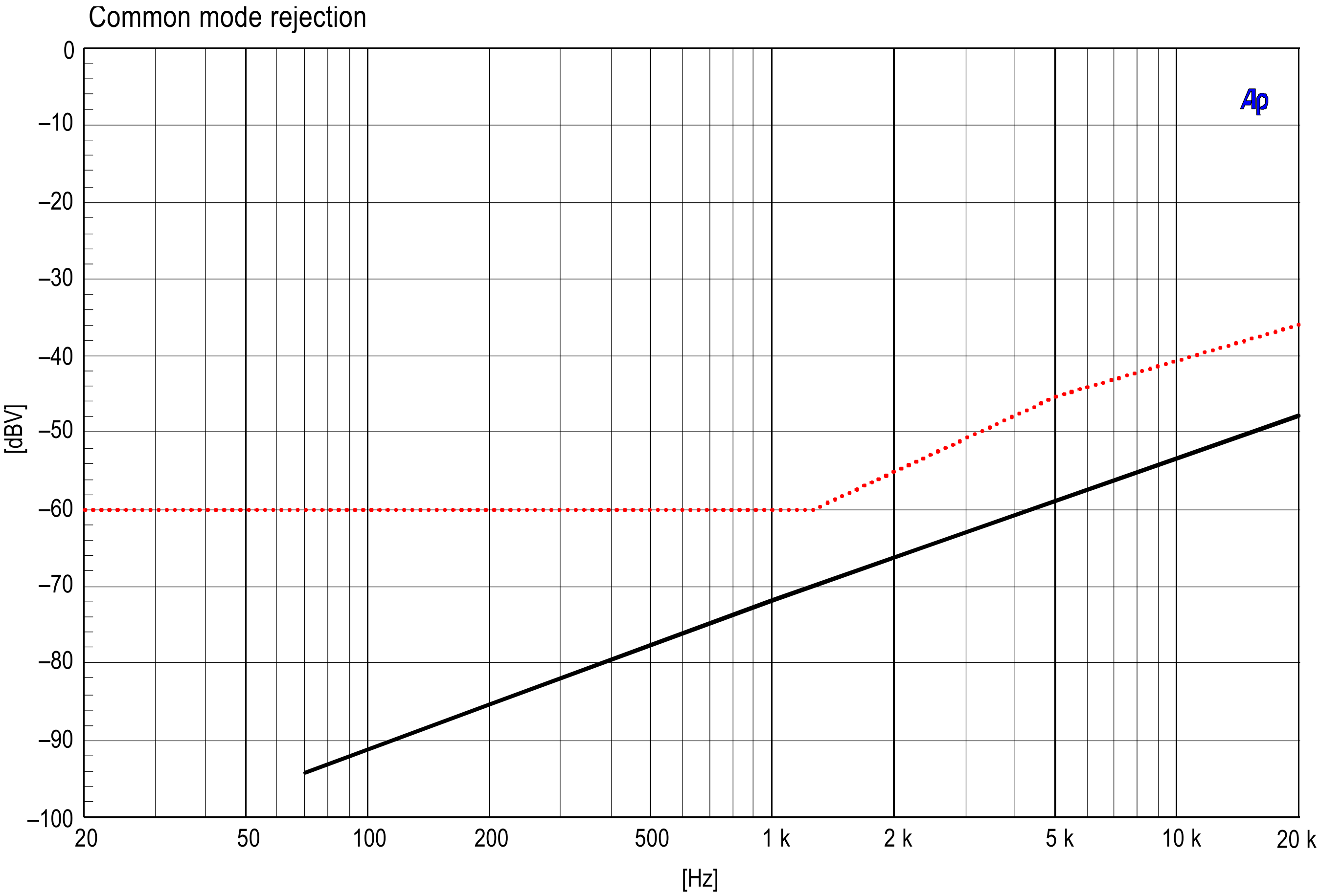




4.4.1.6 A3: Input Common Mode Rejection Ratio (CMRR)

- Connect the generator in common mode to the input – i.e. "hot" generator output to both input terminals no. 2 (+) *and* 3 (–), "cold" generator output to input terminal no. 1 (GND).

Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	CMRR 50 Hz	G1	0 dBV/50 Hz/sine wave	M1	Level	< –60 dBV	
2	CMRR 1 kHz	G1	0 dBV/1 kHz/sine wave	M1	Level	< –60 dBV	
3	CMRR 10 kHz	G1	0 dBV/10 kHz/sine wave	M1	Level	< –40 dBV	



4.4.1.7 A3: Quiescent Current Setting

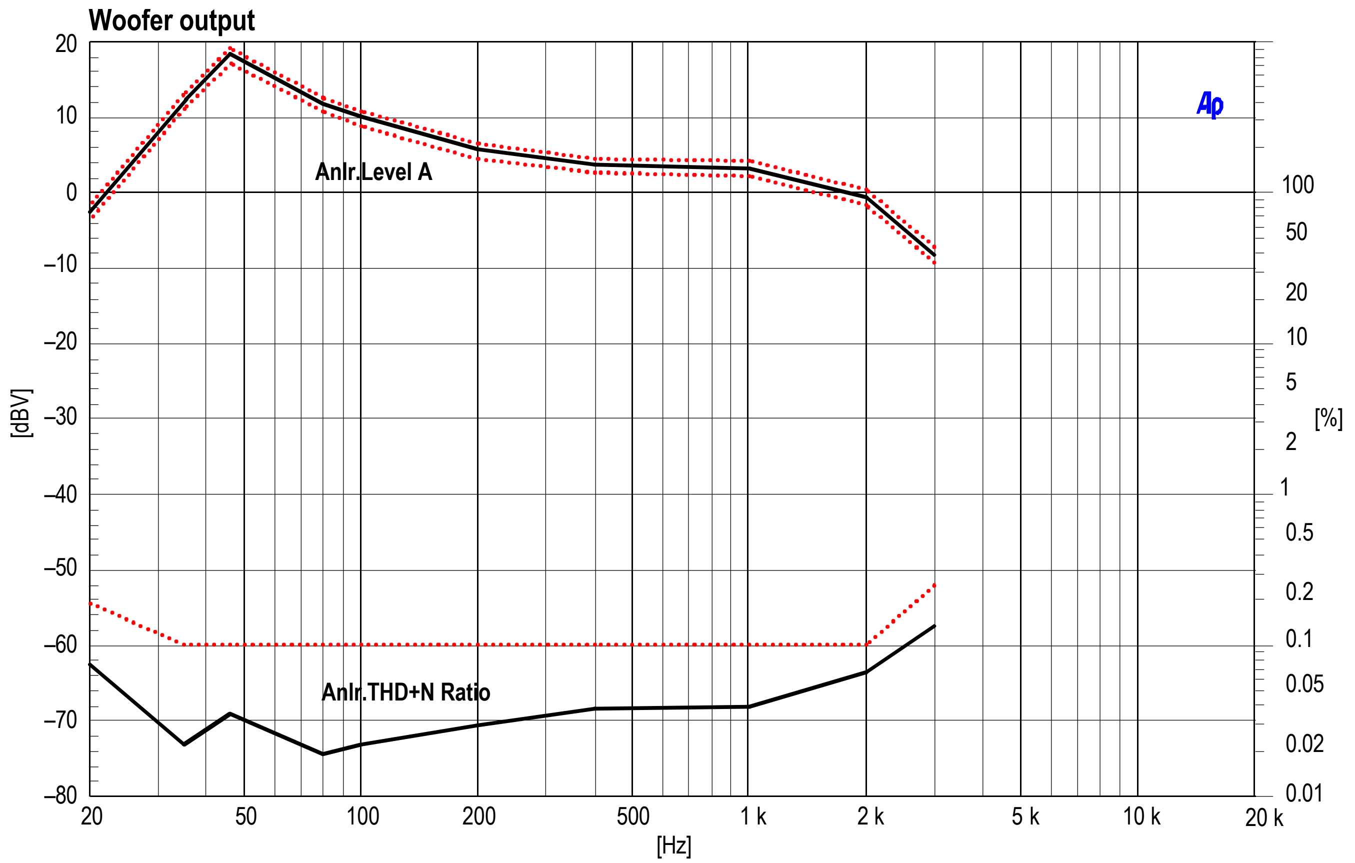
Procedure:

1. Measure the primary current:
   $A1_1$ = 40…50 mA_{AC} (for 230 V), or 80…100 mA_{AC} (for 115 V),
   and note the measured value;
2. Adjust RT390 (turn carefully clockwise) for a reading of:
   $A1_2 = A1_1$ + 3 mA_{AC} (for 230 V), or $A1_2 = A1_1$ + 6 mA_{AC} (for 115 V),
   and note the measured value;
3. Adjust RT290 (turn carefully clockwise) for a reading of:
   $A1_3 = A1_2$ + 6 mA_{AC} (for 230 V), or $A1_3 = A1_2$ + 12 mA_{AC} (for 115 V),
   and note the measured value;
4. Connect both dummy load resistors (10 Ω/10 W each) and check the primary current again:
   $A1_4 = A1_3$ ±0.5 mA_{AC} (for 230 V), or $A1_4 = A1_3$ ±1 mA_{AC} (for 115 V).

4.4.1.8 A3: Woofer Amplifier Output

- Connect only the RLw dummy load (10 Ω)

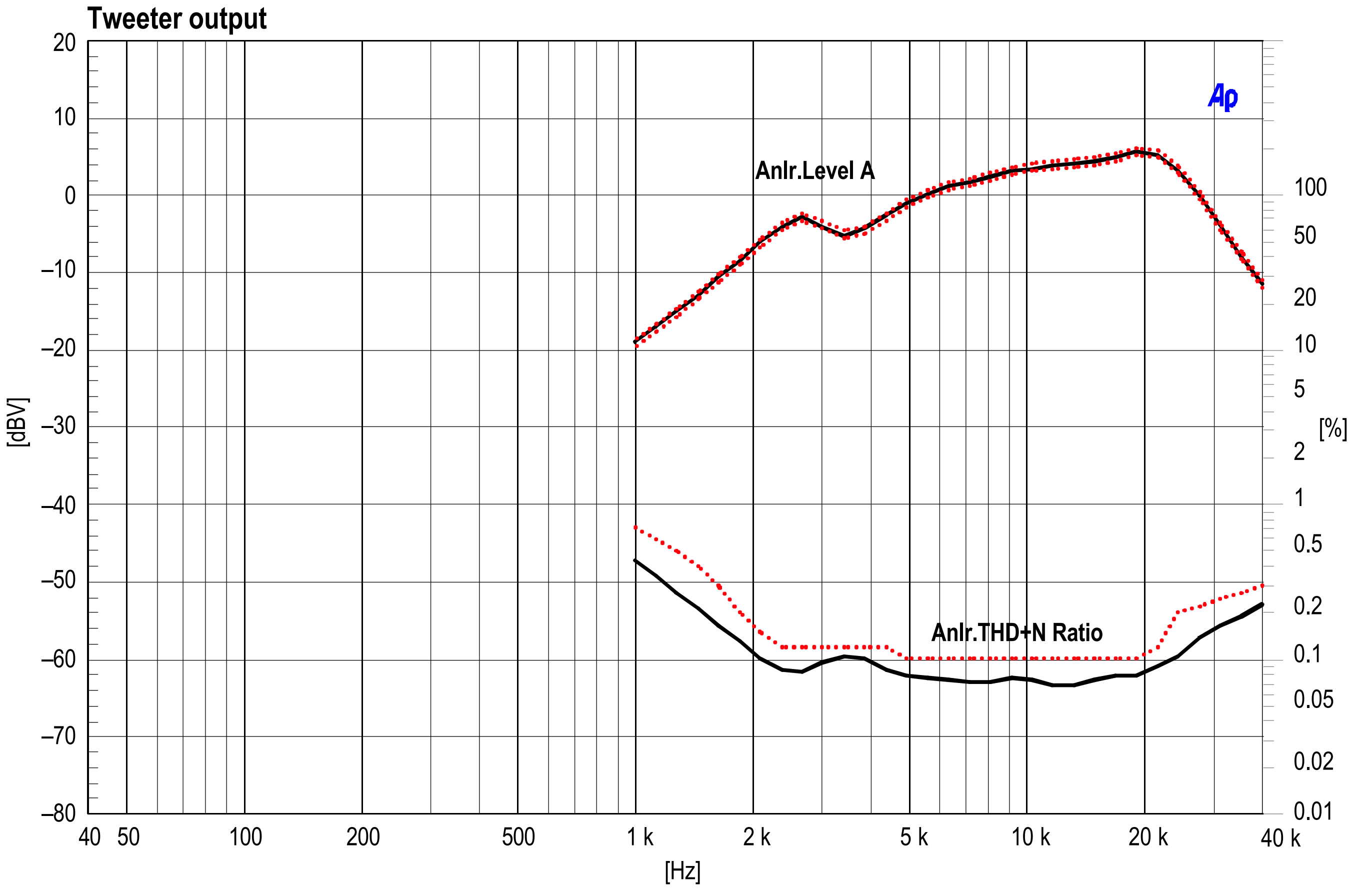
Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	Woofer output level	G1	–13.6 dBV/500 Hz/sine wave	Mw	Level	+3.5 dBV	±0.25 dB
2	Woofer output THD	G1	–13.6 dBV/500 Hz/sine wave	Mw	THD + N	< 0.1 %	< 0.1 %



4.4.1.9 A3: Tweeter Amplifier Output

- Connect only the RLt dummy load (10 Ω)

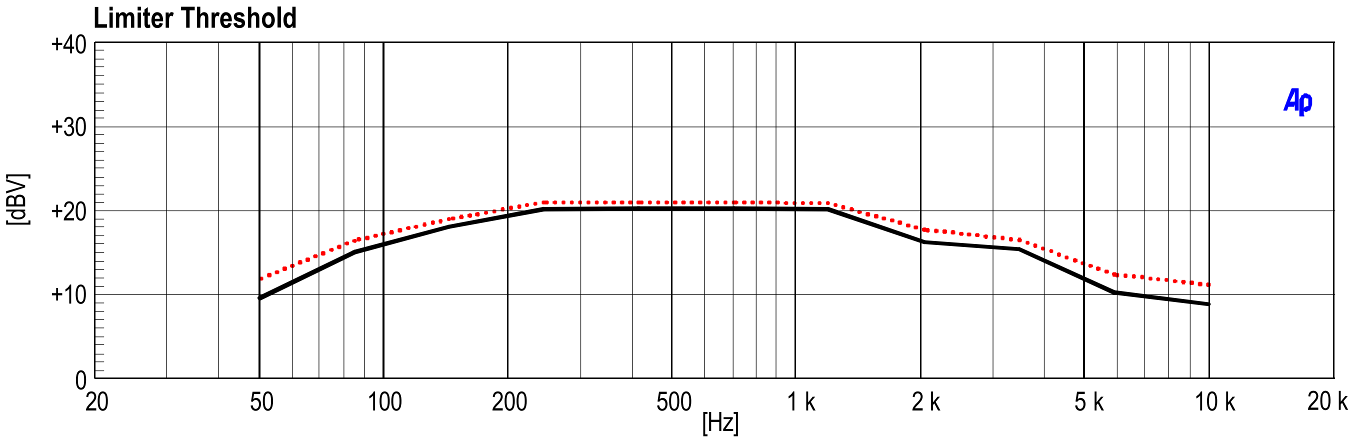
Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	Tweeter output level	G1	–16.8 dBV/5.5 kHz/sine wave	Mt	Level	0 dBV	±0.25 dB
2	Tweeter output THD	G1	–16.8 dBV/5.5 kHz/sine wave	Mt	THD + N	< 0.1 %	< 0.1 %



4.4.1.10 A3: Limiter Threshold

- Disconnect all dummy load resistors;

Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	HF limiter	G1	+15 dBV/10 kHz/sine wave	M1 *	Level	+15 dBV	±2 dBV
2	LF limiter	G1	+15 dBV/100 Hz/sine wave	M1 *	Level	+9.2 dBV	±2 dBV
* Red Alarm LED must be on, and the Mw and Mt output levels must be reduced.							



4.4.1.11 A3: Overheat Protection Check

- Connect Rdt (22 kΩ) according to the diagram in section 4.4;
- The red Alarm LED must come on;
- The Mw and Mt signals must be muted.

4.4.2 A3: Checks on the Assembled Unit

4.4.2.1 A3: Required Test Tools

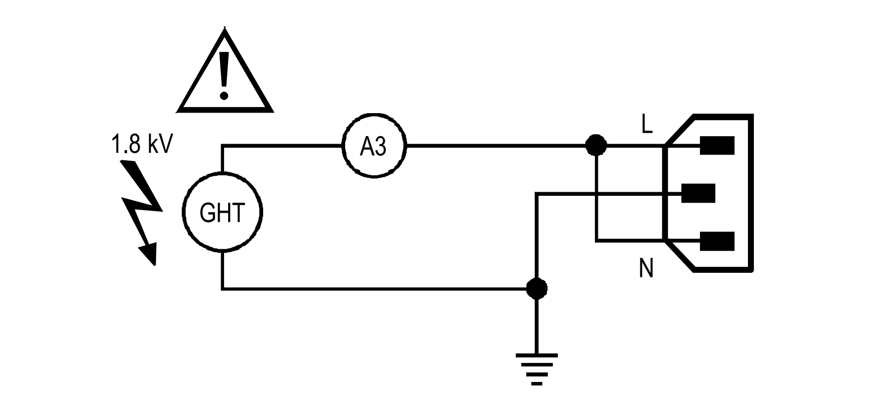
C Anechoic room;
A1 True-RMS AC ammeter;
GHT High-voltage generator 1.8 kV, 50 Hz, max. 10 mA;
G1 Sweep sine-wave generator with balanced output (AudioPrecision System One or equivalent);
M1 Measurement microphone Brüel & Kjær BK4133 + preamp BK2639 or equivalent;
M2 Measurement amplifier Brüel & Kjær BK2610 or equivalent
M3 Level/THD/phase analyzer (AudioPrecision System One or equivalent);
P1 Phase meter with adjustable propagation delay compensation on reference input.

4.4.2.2 A3: Initial Settings

- Set the level potentiometer to CAL position (fully counterclockwise);
- Set the roll-off potentiometer to CAL position (fully counterclockwise);
- Set power switch to ON.

4.4.2.3 A3: Insulation Check

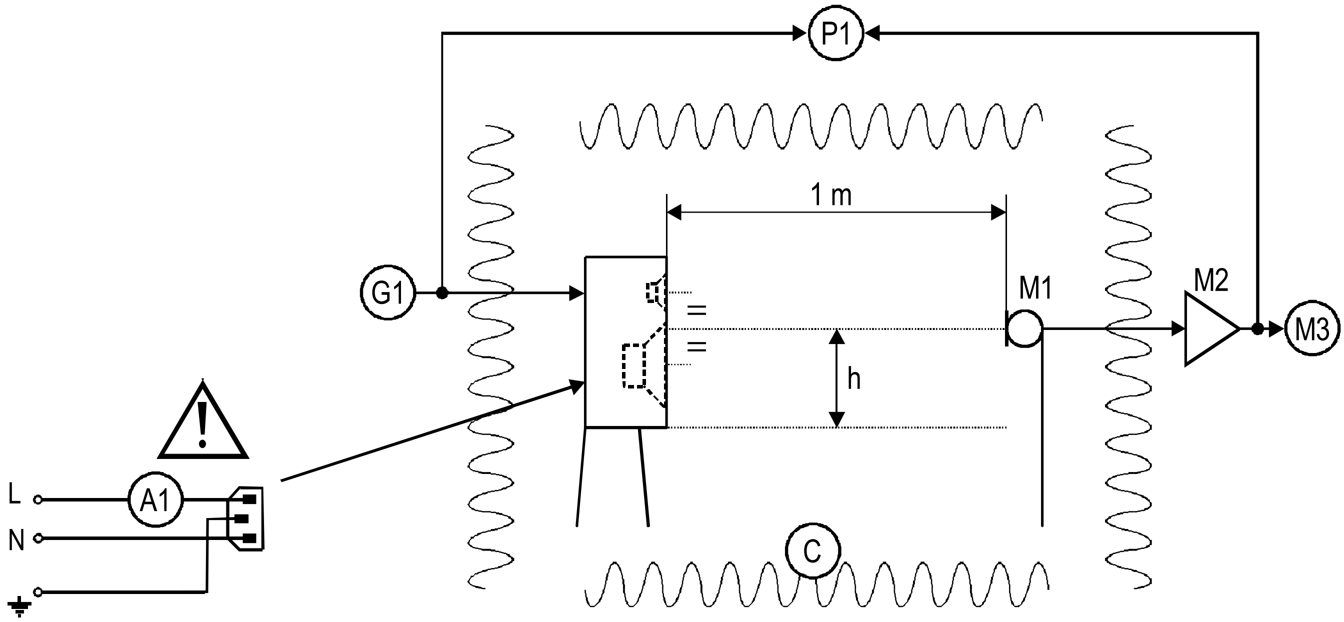
- Connect the HV generator to the mains input connector according to the diagram below:



- Apply 1.8 kV for 5 seconds;
- The leakage current must not exceed 5 mA.

4.4.2.4 A3: Measurement Setup in the Anechoic Room

- Setup the loudspeaker;
- Setup the measurement microphone:
  - Distance to the baffle 1 m,
  - Equidistant from the two vertical edges,
  - Equidistant from the centers of woofer and tweeter units (i.e., h = 23 cm), and
  - Perpendicular to the baffle;
- Connect your unit to the mains, set power switch to ON, check the current consumption (< 60 mA_{AC} for 230 V);
- Connect generator G1 with correct signal polarity.



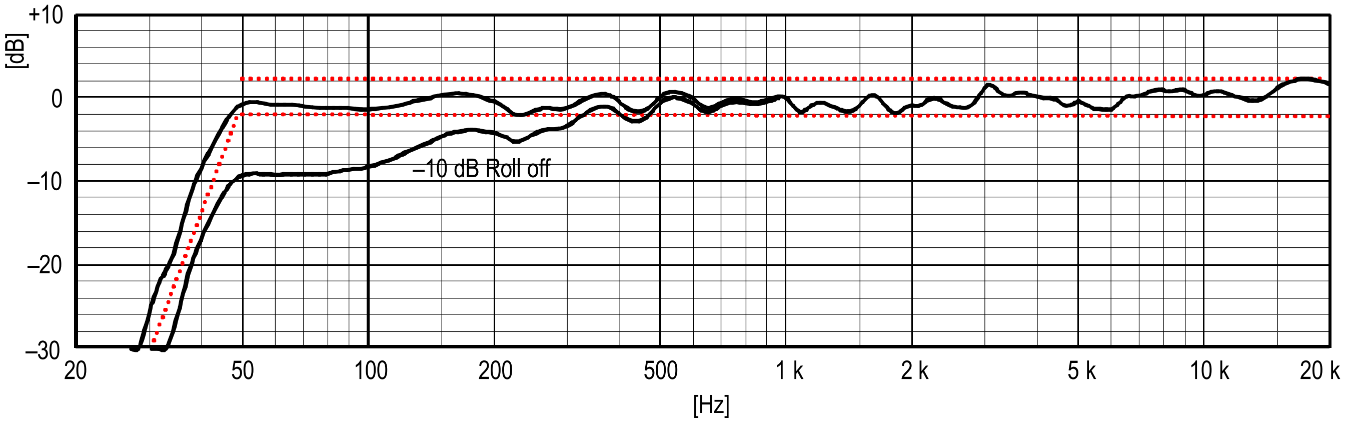
Note: *For more information on frequency response measurements, please refer to section 4.6 .*

4.4.2.5 A3: SPL and EQ Fine-Adjustment

- Set balanced generator to 255 mVRMS (i.e. –11.8 dBV or –9.7 dBu);
- Plot frequency response sweep @ 1 m: tolerance according to the graph below;
- EQ fine-adjustment possibilities:
  1. Overall tweeter level (2.2…20 kHz) with trimmer potentiometer RT300
  2. Tweeter level @ 6.0 kHz with trimmer potentiometer RT1
  3. Tweeter level @ 9.0 kHz with trimmer potentiometer RT2
  4. Tweeter level @ 12.5 kHz with trimmer potentiometer RT3
  5. Tweeter level @ 20.0 kHz with trimmer potentiometer RT4.

Note: Basic setting of RT1 through RT4: refer to section 4.4.1.5.

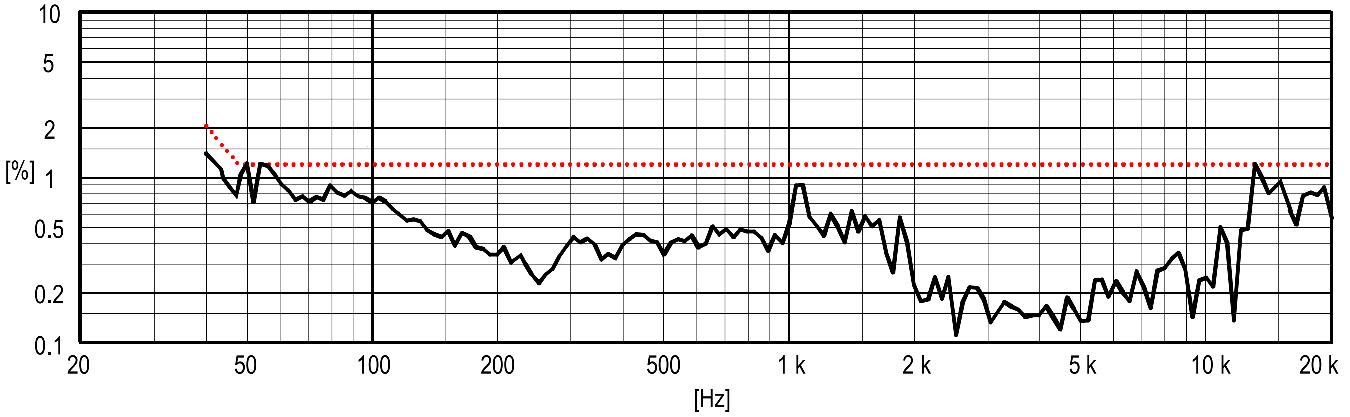
SPL @ 1 m



4.4.2.6 A3: Distortion Check

- Set balanced generator to 255 mVRMS (i.e. –11.8 dBV or –9.7 dBu);
- Plot a 20 Hz…20 kHz THD sweep @ 1 m: < 1.2% (48 Hz…20 kHz).

THD + N



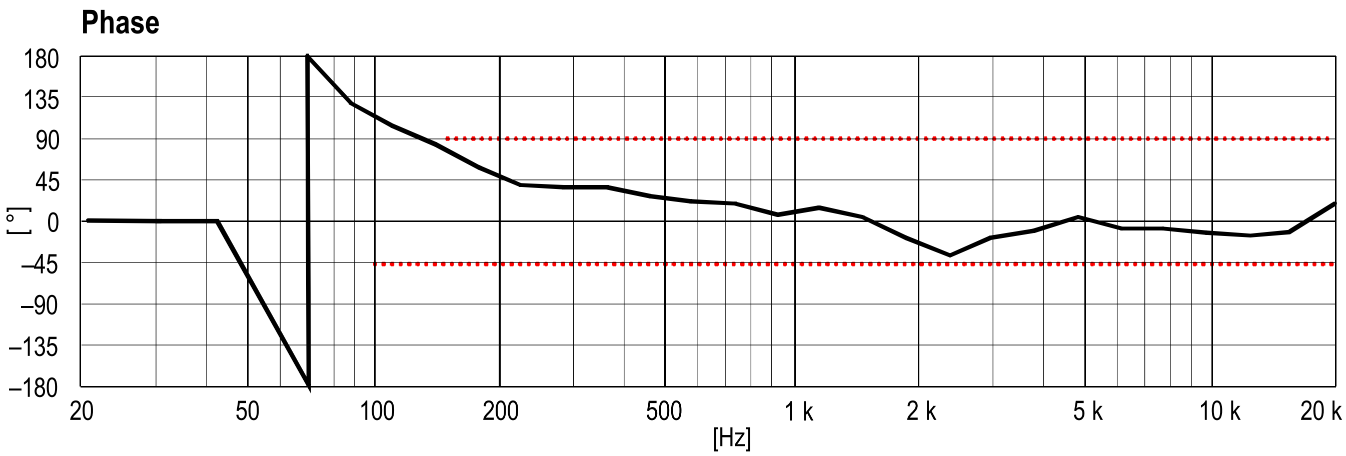
4.4.2.7 A3: Polarity Check

- Place the measurement microphone at a distance of 10 cm from the baffle and exactly in the center of the woofer.

Steps		Generator		Measurement			
No.	**Description**	**Id**	**Value**	**Test pos.**	**Type**	**Value**	**Limits**
1	System polarity	G1	–14 dBV (255 mV_{RMS})/120 Hz/sine wave	P1*	Phase	0°	±20°
***Note:** *Without compensation, the microphone Brüel & Kjær BK4133+2639 is inverting*							

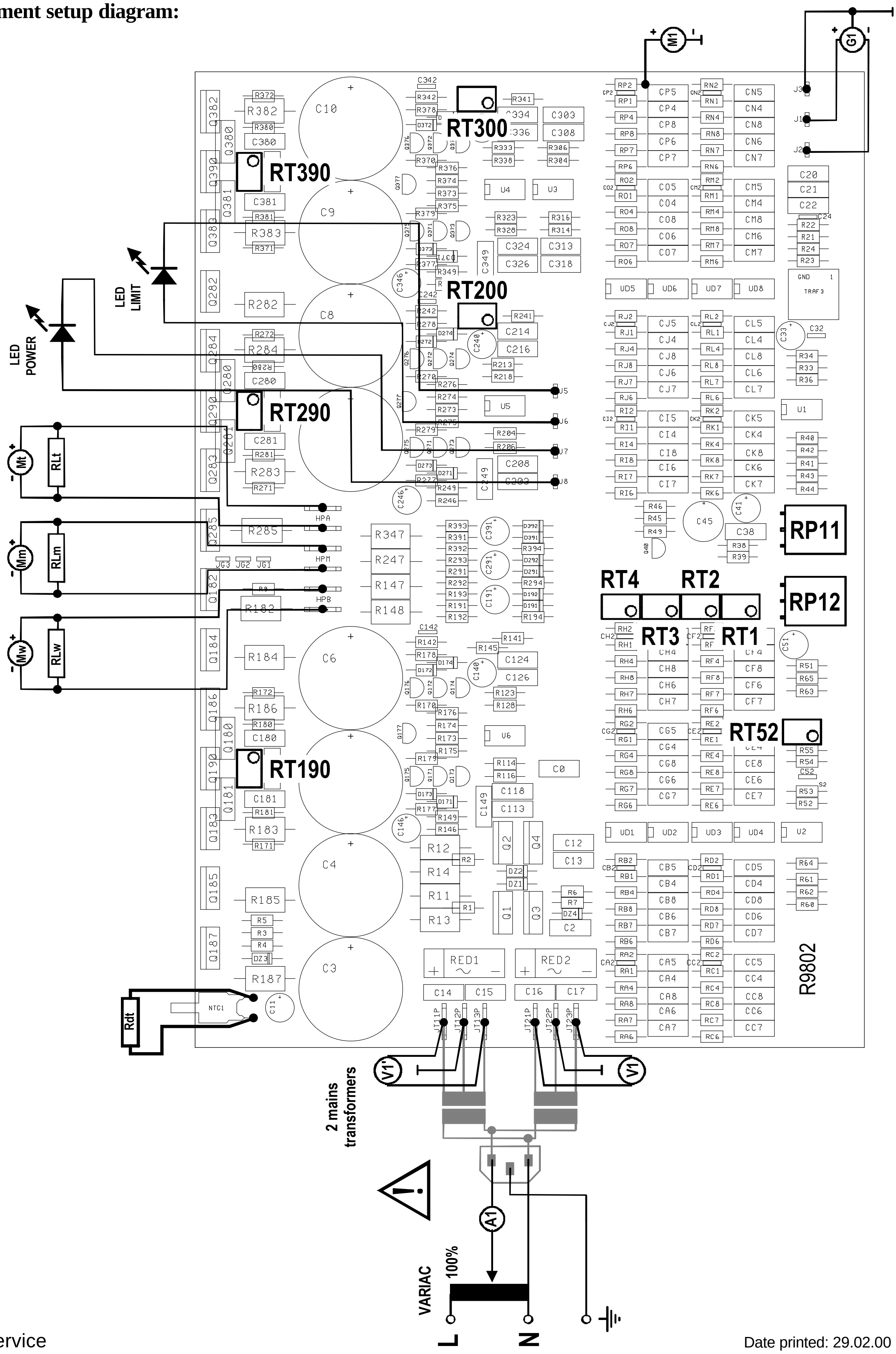
4.4.2.8 A3: Overall Phase Check

- Place the measurement microphone again on-axis, according to 4.4.2.4, distance 0.806 m;
- Set the phasemeter propagation delay time to 2.91 ms (corresponding to a distance of 1 m);
- Set balanced generator to 255 mVRMS (i.e. –11.8 dBV or –9.7 dBu);
- Plot a phase sweep 20 Hz…20 kHz according to the graph below;
- If the result is above the tolerance, increase the microphone distance, or if the result is below the tolerance, decrease the microphone distance, and repeat the phase sweep.



4.5 A5 Service

Measurement setup diagram:



4.5.1 A5: Settings on the PCB

4.5.1.1 A5: Required Test Tools

T1	Variable mains transformer (variac)
A1	True-RMS AC ammeter
V1, V1'	True-RMS AC voltmeter
V2…V5	Digital DC voltmeter
G1	Sine-wave generator with balanced output (min. 20 Hz…20 kHz, < 0.02% THD)
M1, Mw, Mt	Voltmeter, THD meter, phase meter
RLw, RLm, RLt	Dummy load resistors, 10 Ω, approx. 10 W
Rdt	Fixed resistor, 22 kΩ, for overheat protection check
Note:	G1, M1, Mw, Mt can be replaced by a universal audio test system (Audio-Precision System One or equivalent)

4.5.1.2 A5: Initial Settings

Note: *Replacement backpanel assemblies or amplifier units come factory-pre-adjusted. Adjustment of the quiescent current is therefore not necessary after replacement, checking is recommended nevertheless.*

- Unplug the speaker cables from the PCB, *do not* connect any load to the amplifier outputs. *Make sure that none of the cable ends contacts the PCB;*
- Set the level potentiometer to CAL position (fully counterclockwise);
- Set the roll-off potentiometer to CAL position (fully counterclockwise);
- Set trimmer potentiometers RT190, RT290, and RT390 (quiescent current) to min. position (fully counterclockwise);
- Variac set to min. (0 V_{AC});
- Power switch to ON position.

4.5.1.3 A5: Powering Up

- Visually check the PCB and the solder joints and repair, if necessary;
- Check the mains voltage
- Check or insert the primary fuse
- Connect the generator according to the diagram;
- Slowly increase the variac output while checking the primary current
- The green Power LED illuminates;
- Increase the variac output until V1 and V1' are 64 V_{AC}.

	230 V_{AC}	115 V_{AC}
Mains voltage	230 V_{AC}	115 V_{AC}
Primary fuse	T 1.6 A L 250 V	T 3.15 A L 250 V
Primary current	< 80 mA_{AC}	< 160 mA_{AC}

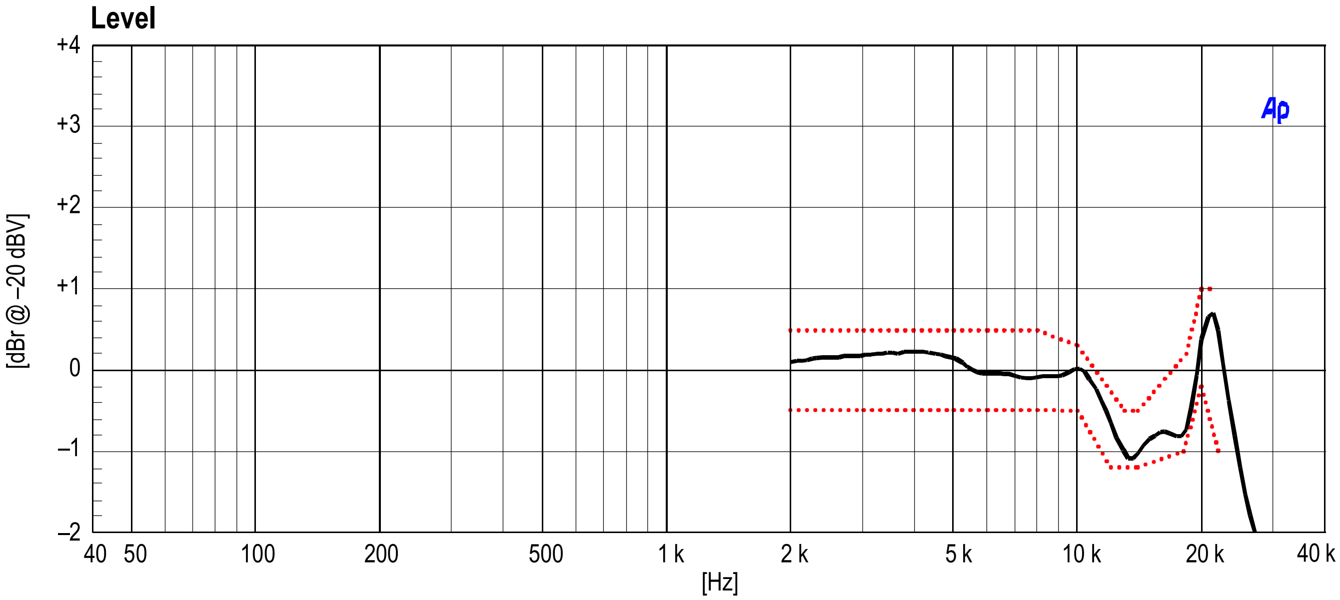
4.5.1.4 A5: Supply Voltages

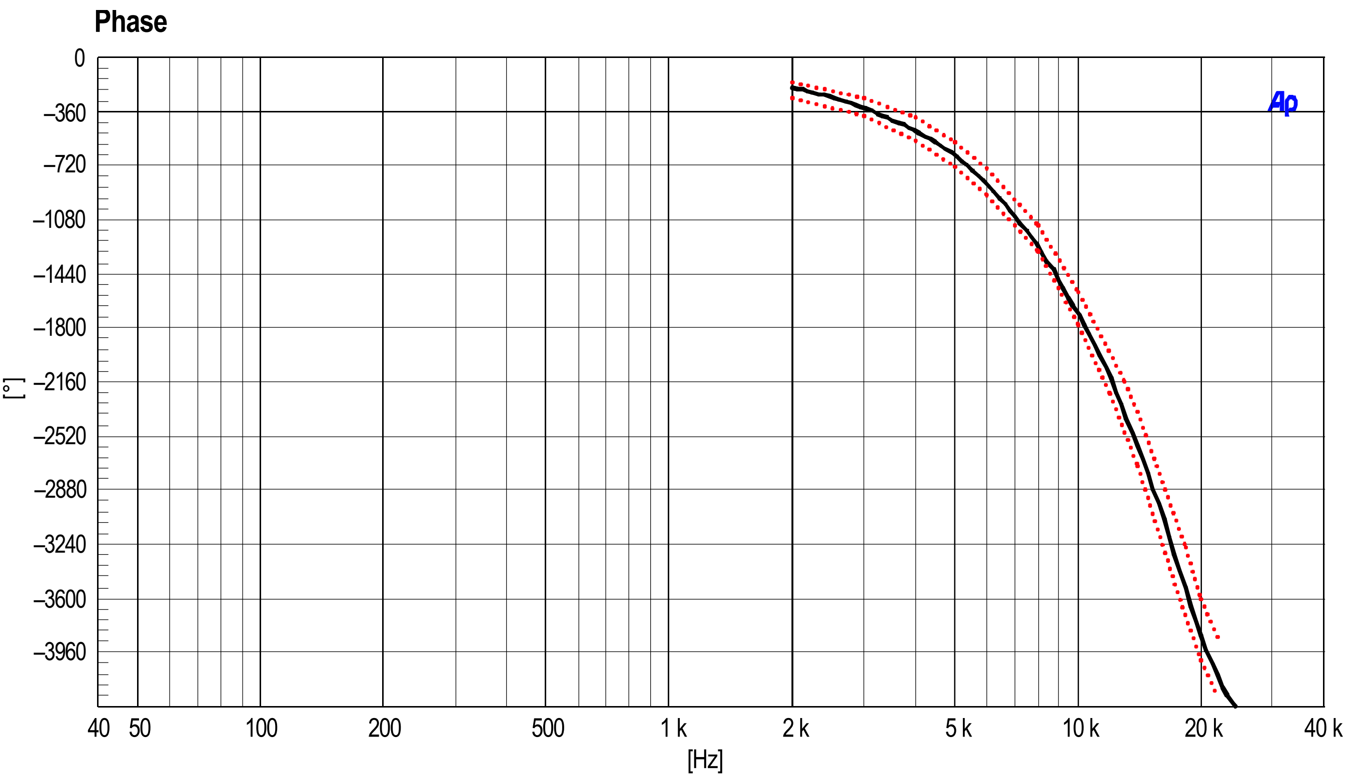
Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	Supply check	G1	0 V	V2	V_{DC}	–44 V_{DC}	±3 V
2	Supply check	G1	0 V	V3	V_{DC}	+44 V_{DC}	±3 V
3	IC supply check	G1	0 V	V4	V_{DC}	–17.4 V_{DC}	±0.6 V
4	IC supply check	G1	0 V	V5	V_{DC}	+17.4 V_{DC}	±0.6 V

4.5.1.5 A5: Input Gain Check and EQ Preadjustments

These preadjustments must be performed only if RT1 through RT4 are completely out of range; these settings will be fine-adjusted on the assembled unit, also refer to section 4.5.2.5.

Steps		Generator		Measurement			
No.	**Description**	**Id**	**Value**	**Test pos.**	**Type**	**Value**	**Limits**
1	RT52 input gain adjust	G1	–26.6 dBV/60 Hz/sine wave	M1	Level	–20.0 dBV	±0.5 dB
2	Roll-off check	G1	–26.6 dBV/60 Hz/sine wave	M1	Level	–29.0 dBV	±0.5 dB
3	RT1 adjust	G1	–26.6 dBV/6.8 kHz/sine wave	M1	Level	–19.6 dBV	±0.5 dB
4	RT2 adjust	G1	–26.6 dBV/8.7 kHz/sine wave	M1	Level	–20.0 dBV	±0.5 dB
5	RT3 adjust	G1	–26.6 dBV/14.7 kHz/sine wave	M1	Level	–21.0 dBV	±0.5 dB
6	RT4 adjust	G1	–26.6 dBV/22.0 kHz/sine wave	M1	Level	–19.8 dBV	±0.5 dB
7	Repeat steps 3 through 6 until all values are within the given limits						

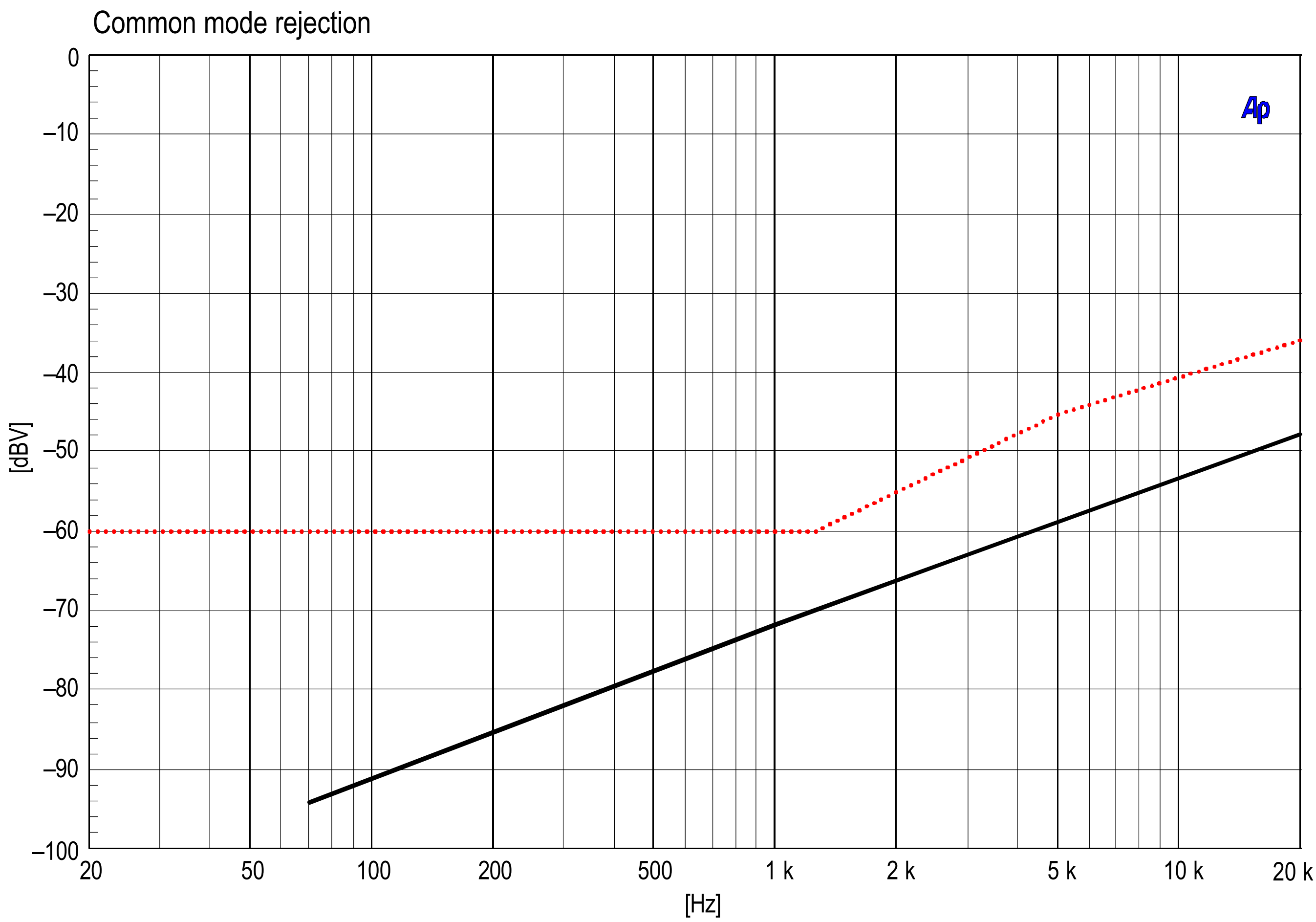




4.5.1.6 A5: Input Common Mode Rejection Ratio (CMRR)

- Connect the generator in common mode to the input – i.e. “hot” generator output to both input terminals no. 2 (+) *and* 3 (–), “cold” generator output to input terminal no. 1 (GND).

Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	CMRR 50 Hz	G1	0 dBV/50 Hz/sine wave	M1	Level	< –60 dBV	
2	CMRR 1 kHz	G1	0 dBV/1 kHz/sine wave	M1	Level	< –60 dBV	
3	CMRR 10 kHz	G1	0 dBV/10 kHz/sine wave	M1	Level	< –40 dBV	



4.5.1.7 A5: Quiescent Current Setting

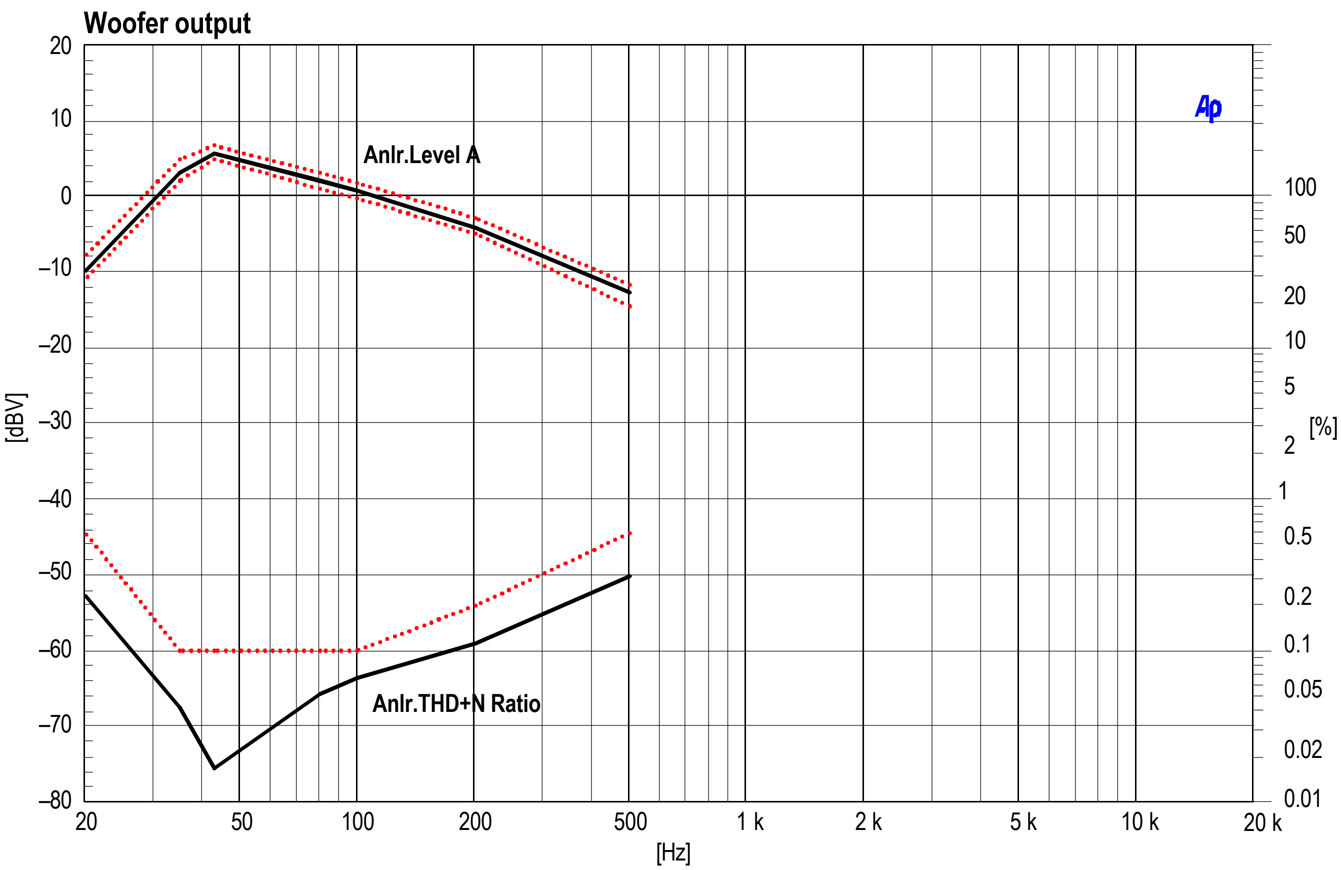
Procedure:

1. Measure the primary current:
   $A1_1$ = 70…80 mA_{AC} (for 230 V), or 140…160 mA_{AC} (for 115 V),
   and note the measured value;
2. Adjust RT390 (turn carefully clockwise) for a reading of:
   $A1_2 = A1_1$ + 4 mA_{AC} (for 230 V), or $A1_2 = A1_1$ + 8 mA_{AC} (for 115 V),
   and note the measured value;
3. Adjust RT290 (turn carefully clockwise) for a reading of:
   $A1_3 = A1_2$ + 8 mA_{AC} (for 230 V), or $A1_3 = A1_2$ + 16 mA_{AC} (for 115 V),
   and note the measured value;
4. Adjust RT190 (turn carefully clockwise) for a reading of:
   $A1_4 = A1_3$ + 12 mA_{AC} (for 230 V), or $A1_4 = A1_3$ + 24 mA_{AC} (for 115 V),
   and note the measured value;
5. Connect all 3 dummy load resistors (10 Ω/10 W each) and check the primary current again:
   $A1_5 = A1_4$ ±0.5 mA_{AC} (for 230 V), or $A1_5 = A1_4$ ±1 mA_{AC} (for 115 V)

4.5.1.8 A5: Woofer Amplifier Output

- Connect only the RLw dummy load (10 Ω)

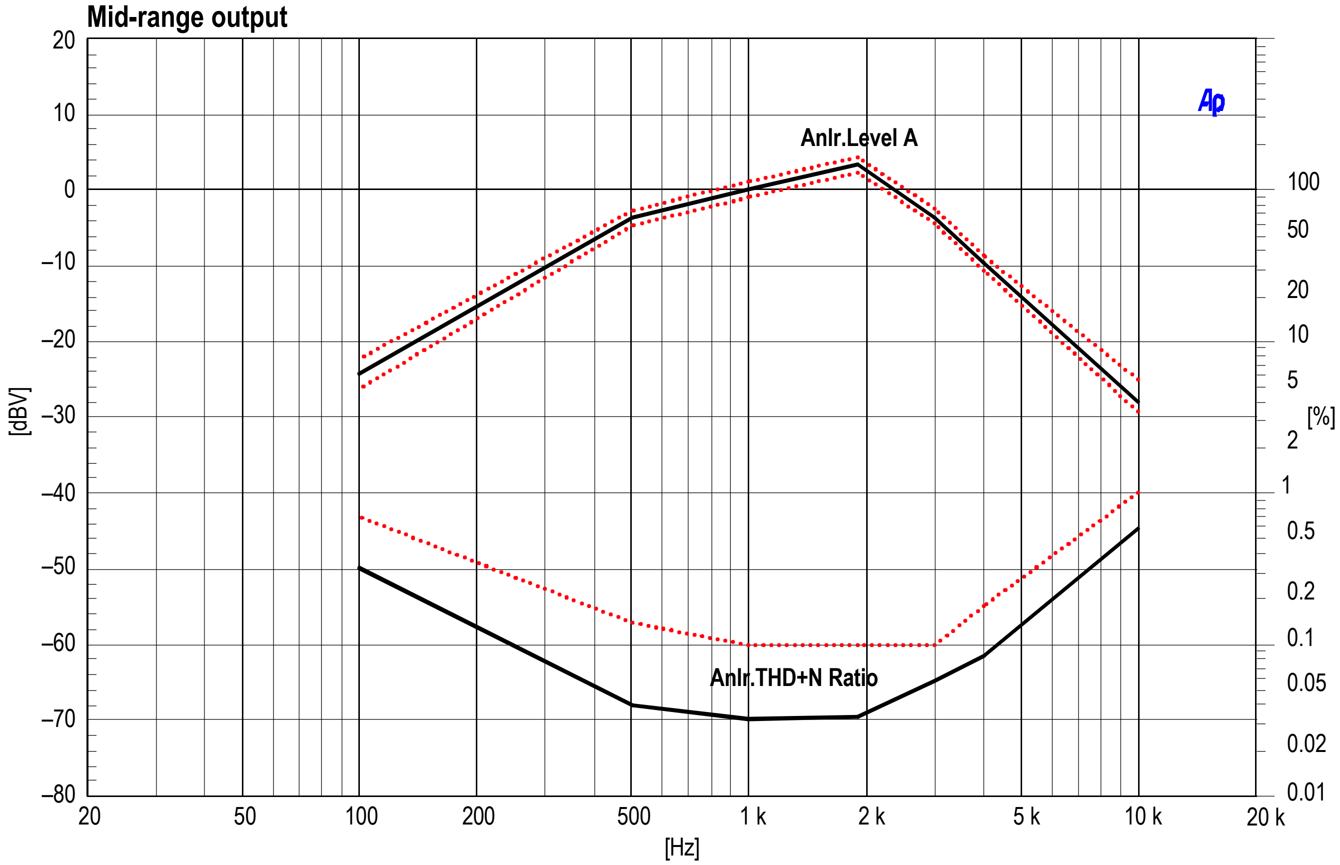
Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	Woofer output level	G1	–20.6 dBV/100 Hz/sine wave	Mw	Level	+3.5 dBV	±0.25 dB
2	Woofer output THD	G1	–20.6 dBV/100 Hz/sine wave	Mw	THD + N	< 0.1 %	< 0.1 %



4.5.1.9 A5: Mid-range Amplifier Output

- Connect only the RLm dummy load (10 Ω)

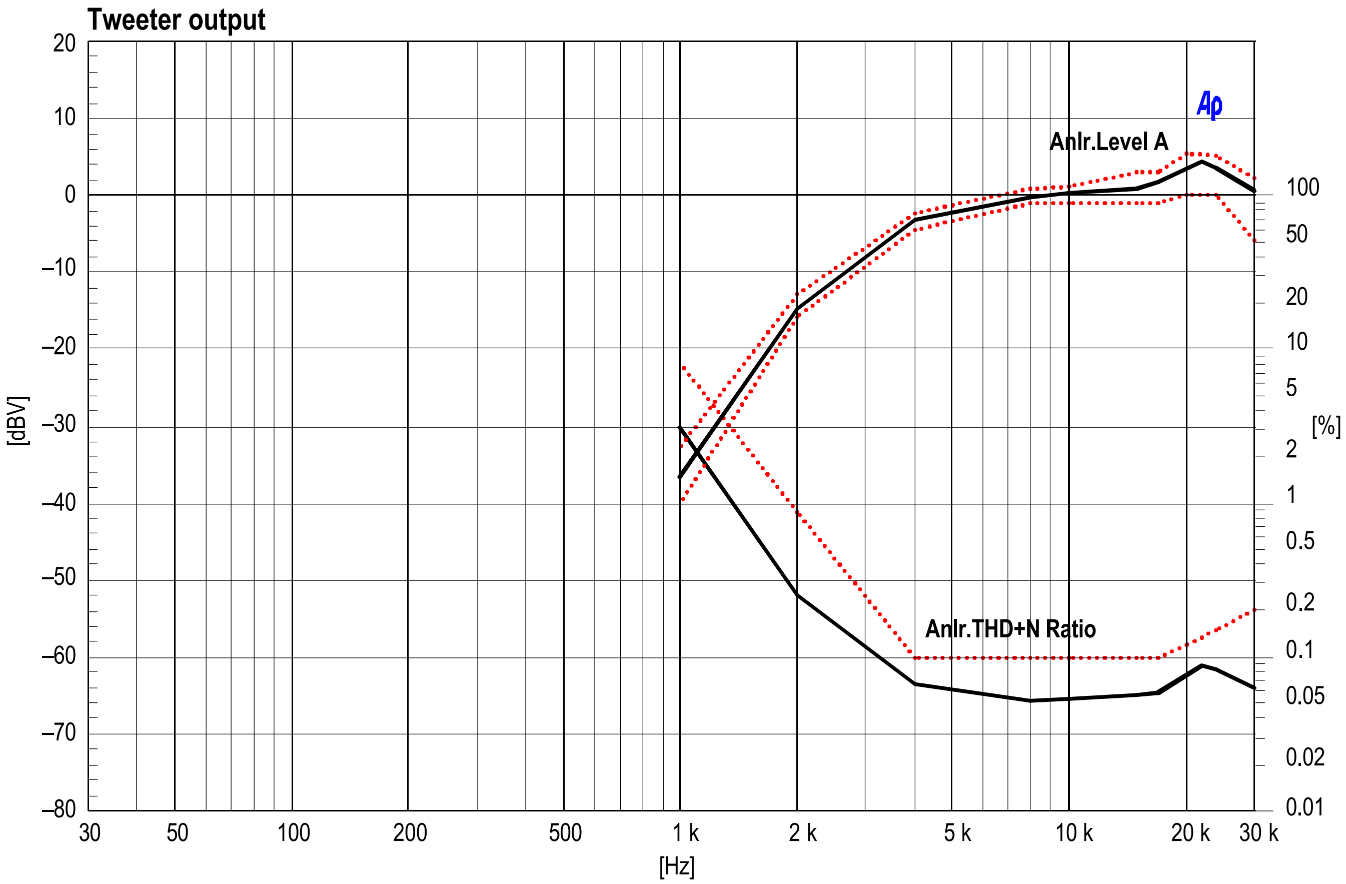
Steps		Generator		Measurement			
No.	**Description**	**Id**	**Value**	**Test pos.**	**Type**	**Value**	**Limits**
1	Mid-range output level	G1	–17 dBV/1 kHz/sine wave	Mm	Level	0 dBV	±0.25 dB
2	Mid-range output THD	G1	–17 dBV/1 kHz/sine wave	Mm	THD + N	< 0.1 %	< 0.1 %



4.5.1.10 A5: Tweeter Amplifier Output

- Connect only the RLt dummy load (10 Ω)

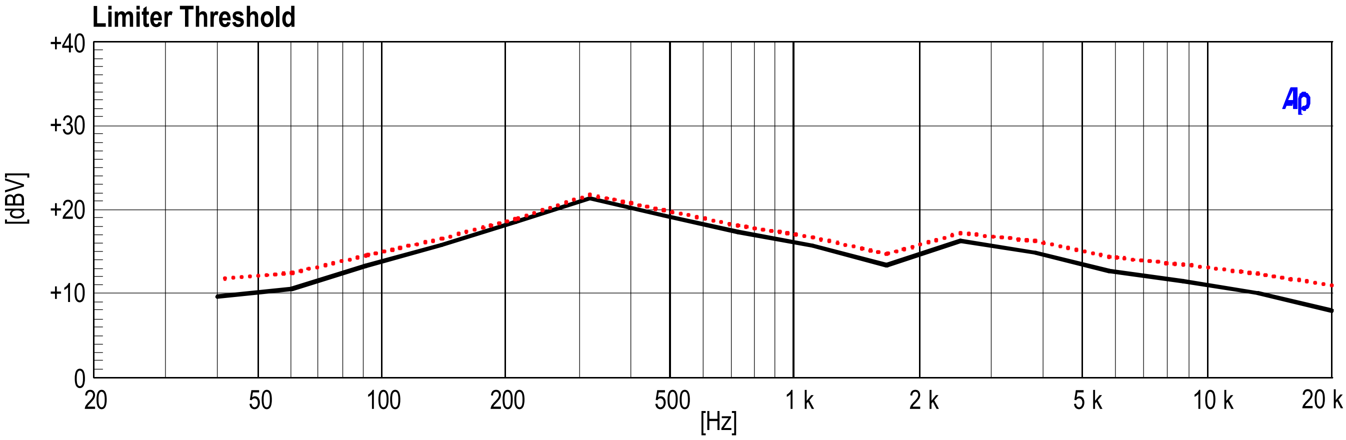
Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	Tweeter output level	G1	–15.6 dBV/8.8 kHz/sine wave	Mt	Level	0 dBV	±0.25 dB
2	Tweeter output THD	G1	–15.6 dBV/8.8 kHz/sine wave	Mt	THD + N	< 0.1 %	< 0.1 %



4.5.1.11 A5: Limiter Threshold

- Disconnect all dummy load resistors;

Steps		Generator		Measurement			
No.	Description	Id	Value	Test pos.	Type	Value	Limits
1	HF limiter	G1	+15 dBV/10 kHz/sine wave	M1 *	Level	+12 dBV	±1 dBV
2	MF limiter	G1	+15 dBV/1 kHz/sine wave	M1 *	Level	+16 dBV	±1 dBV
3	LF limiter	G1	+15 dBV/100 Hz/sine wave	M1 *	Level	+14 dBV	±1 dBV
* Red Alarm LED must be on, and the Mw, Mm, and Mt output levels must be reduced.							



4.5.1.12 A5: Overheat Protection Check

- Connect Rdt (22 kΩ) according to the diagram in section 4.5;
- The red Alarm LED must come on;
- The Mw, Mm, and Mt signals must be muted.

4.5.2 A5: Checks on the Assembled Unit

4.5.2.1 A5: Required Test Tools

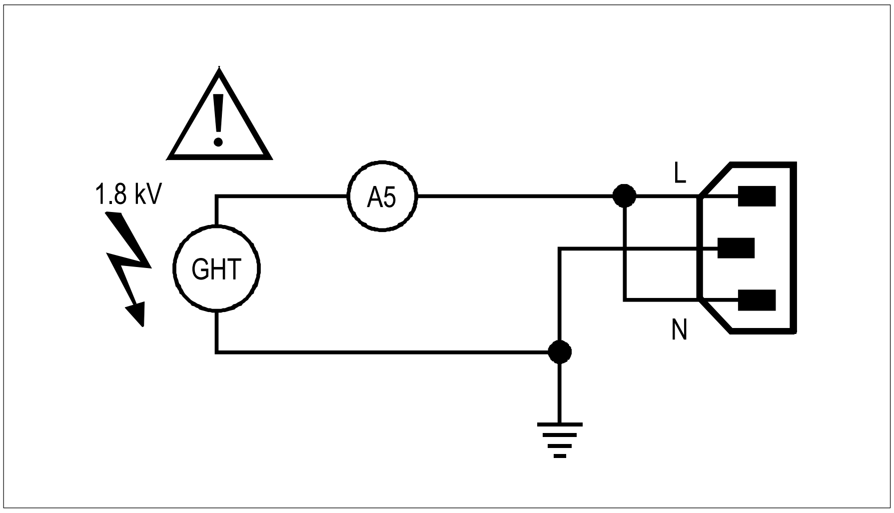
C Anechoic room;
A1 True-RMS AC ammeter;
GHT High-voltage generator 1.8 kV, 50 Hz, max. 10 mA;
G1 Sweep sine-wave generator with balanced output (AudioPrecision System One or equivalent);
M1 Measurement microphone Brüel & Kjær BK4133 + preamp BK2639 or equivalent;
M2 Measurement amplifier Brüel & Kjær BK2610 or equivalent
M3 Level/THD/phase analyzer (AudioPrecision System One or equivalent);
P1 Phase meter with adjustable propagation delay compensation on reference input.

4.5.2.2 A5: Initial Settings

- Set the level potentiometer to CAL position (fully counterclockwise);
- Set the roll-off potentiometer to CAL position (fully counterclockwise);
- Set power switch to ON.

4.5.2.3 A5: Insulation Check

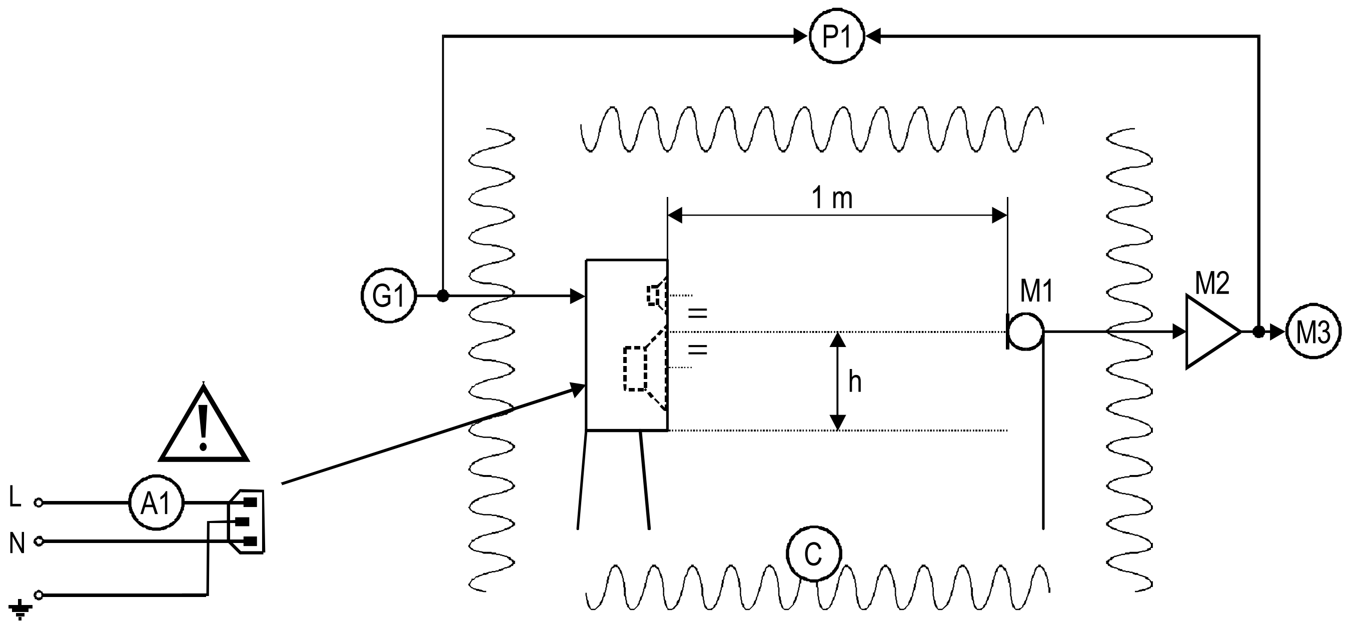
- Connect the HV generator to the mains input connector according to the diagram below:



- Apply 1.8 kV for 5 seconds;
- The leakage current must not exceed 5 mA.

4.5.2.4 A5: Measurement Setup in the Anechoic Room

- Setup the loudspeaker;
- Setup the measurement microphone:
  - Distance to the baffle 1 m,
  - Equidistant from the two vertical edges,
  - Equidistant from the centers of mid-range and tweeter units (i.e., h = 45 cm), and
  - Perpendicular to the baffle;
- Connect your unit to the mains, set power switch to ON, check the current consumption (< 95 mA_{AC} for 230 V);
- Connect generator G1 with correct signal polarity.

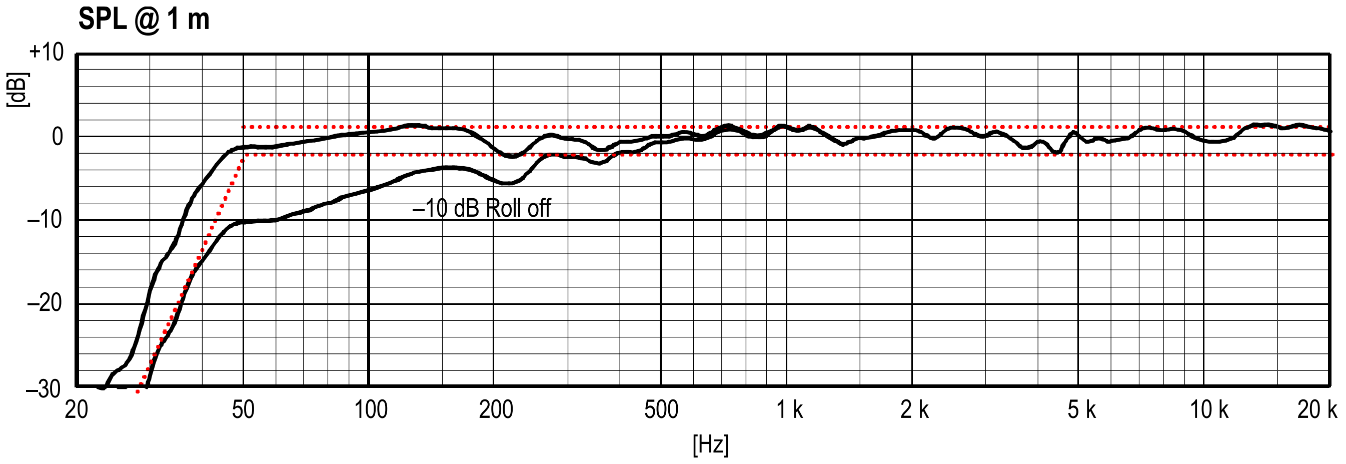


Note: *For more information on frequency response measurements, please refer to section 4.6 .*

4.5.2.5 A5: SPL and EQ Fine-Adjustment

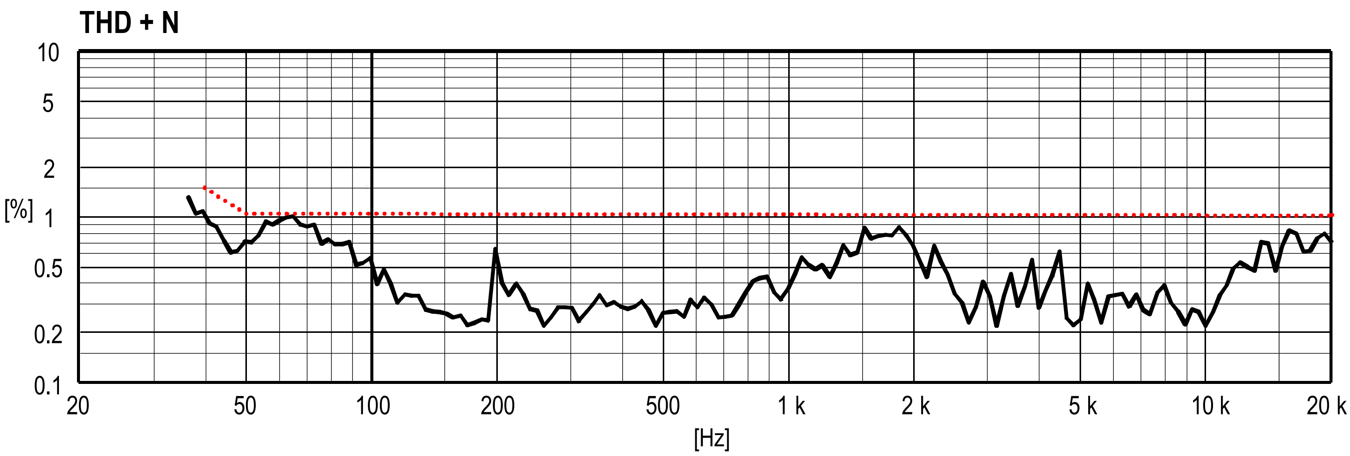
- Set balanced generator to 250 mVRMS (i.e. –12.0 dBV or –9.8 dBu);
- Plot frequency response sweep @ 1 m: tolerance according to the graph below;
- EQ fine-adjustment possibilities:
  1. Overall tweeter level (3…20 kHz) with trimmer potentiometer RT300
  2. Overall mid-range level (450 Hz…3 kHz) with trimmer pot RT200
  3. Tweeter level @ 6.8 kHz with trimmer potentiometer RT1
  4. Tweeter level @ 8.8 kHz with trimmer potentiometer RT2
  5. Tweeter level @ 14.7 kHz with trimmer potentiometer RT3
  6. Tweeter level @ 22.0 kHz with trimmer potentiometer RT4.

Note: Basic setting of RT1 through RT4: refer to section 4.5.1.5.



4.5.2.6 A5: Distortion Check

- Set balanced generator to 250 mVRMS (i.e. –12.0 dBV or –9.8 dBu);
- Plot a 20 Hz…20 kHz THD sweep @ 1 m: tolerance according to the graph below.



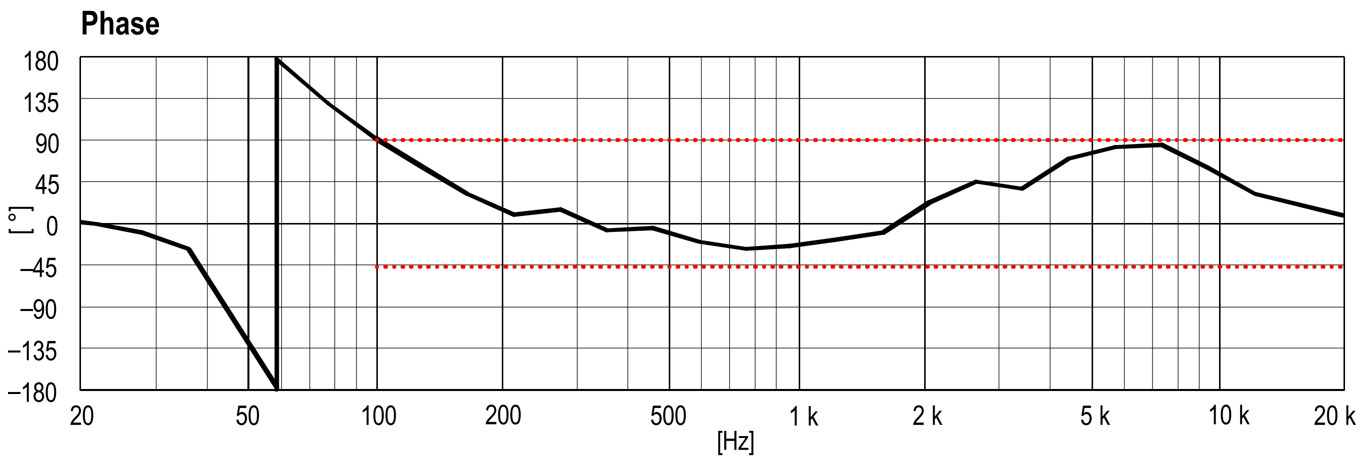
4.5.2.7 A5: Polarity Check

- Place the measurement microphone at a distance of 10 cm from the baffle and exactly in the center of the woofer.

Steps		Generator		Measurement			
No.	**Description**	**Id**	**Value**	**Test pos.**	**Type**	**Value**	**Limits**
1	System polarity	G1	–14 dBV (250 mV_{RMS})/120 Hz/sine wave	P1*	Phase	0°	±20°
***Note:** Without compensation, the microphone Brüel & Kjær BK4133+2639 is inverting*							

4.5.2.8 A5: Overall Phase Check

- Place the measurement microphone again on-axis, according to 4.5.2.4, distance 0.806 m;
- Set the phasemeter propagation delay time to 2.91 ms (corresponding to a distance of 1 m);
- Set balanced generator to 250 mVRMS (i.e. –12.0 dBV or –9.8 dBu);
- Plot a phase sweep 20 Hz…20 kHz according to the graph below;
- If the result is above the tolerance, increase the microphone distance, or if the result is below the tolerance, decrease the microphone distance, and repeat the phase sweep.



4.6 Appendix: Frequency Response Measurements

(Most parts of the following paragraphs are reprinted with kind permission of *Audio Precision, Inc.*, http://www.audioprecision.com)

4.6.1 General

Frequency response measurement of loudspeakers is a much more complex topic than response measurements on amplifiers or most other electronic audio products. Nearfield effects cause the response measured with close microphone spacing to vary from that with distant microphone placement. Loudspeakers are directional, so the response varies as the microphone is moved off the speaker axis. Unless the loudspeaker is being measured in an expensive anechoic chamber or in essentially free space outdoors, reflections of the sound waves will also arrive at the microphone and create standing wave patterns with cancellations and reinforcements. Multi-way loudspeaker systems, ported loudspeaker systems, and systems with some of the drivers facing the sides or rear of the cabinet all create a problem for measurement microphone placement – just where should the microphone be located so that it receives acoustical output which is a proper combination of the various drivers and ports? Furthermore, the end use of the speaker will not be in an anechoic chamber or laying on its back outdoors with listeners suspended above it – so what is the proper environment in which to measure it?

4.6.2 Standing Waves, Reflections, and Smoothing

Neither an anechoic chamber nor outdoor free-space testing are practical for production testing. In most test locations, acoustical reflections and ambient acoustical noise are facts of life. Particularly at the higher frequencies, the acoustical energy arriving at the microphone is a combination of the direct signal from speaker to microphone plus a large number of reflections from walls, ceiling, floor, human operators, etc. In a typical office or laboratory environment when using high-frequency sinewave signals (10 kHz, for example), movement of a human being several feet away from the microphone can cause several dB change in the measured value. Changes in the order of a few inches in microphone or loudspeaker placement can cause response curve variations of many dB at high frequencies. Even at fixed speaker and microphone locations and with no people moving within a reasonable distance, a response curve may show individual sharp peaks and dips of 10…20 dB due to standing wave effects.

For reasonable results, some degree of acoustical treatment of the measurement location should be done. Commercially-available sound absorption materials should be applied to wall, ceiling, and floor surfaces. It may be effective to design the shape of the test chamber as something other than a rectangle to avoid high-intensity single-bounce reflections from the back wall into the measurement microphone.

Since it is not economically practical to provide a true anechoic chamber for most testing, speaker measurements in a reflective space are almost invariably smoothed by one technique or another to improve measurement repeatability and reduce the visible effect of reflections to a value more consistent with a human’s ability to hear them. Even simple analog measurement techniques, where no “smoother” appears as such on a block diagram, do in fact typically smooth due to the sweep rates and measurement response times used. Measurement instruments have some finite time constant or response time; they cannot instantaneously follow a rapidly-changing signal amplitude. If the measurement instrument has frequency selectivity (spectrum analyzer or tracking filter), the response time is even slower due to the energy storage or ringing effect of the tuned filter. When the stimulus signal is swept rapidly, the measurement instrument simply cannot follow the more rapid, extreme variations and the displayed result is smoothed – peaks are reduced and dips are filled in.

4.6.3 MLS Technology for Frequency Response Measurements

Loudspeaker frequency response measurement under free-space conditions without requiring an anechoic room is an important application of Maximum Length Sequence (MLS) test systems (such as *Audio Precision™ System One + DSP™* or *System One Dual Domain™*, both using the MLS.TST program, or *MLSSA™*, a PC-based audio test system).

Nevertheless, the setup dimensions given in sections 4.3.2.2, 4.4.2.2, and 4.5.2.2 must be strictly followed.

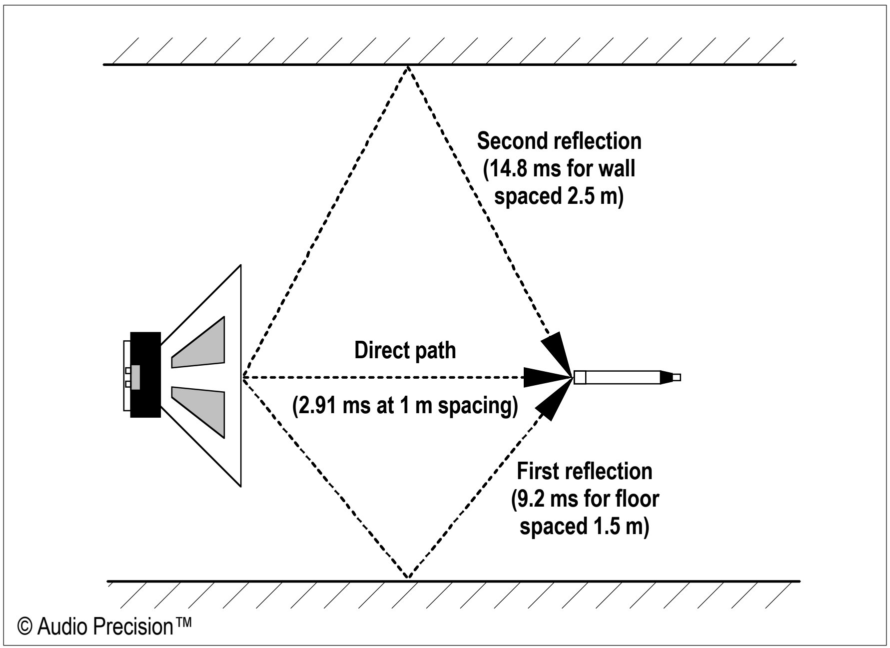
MLS testing permits time-selective measurements in which one signal, such as the direct sound from a loudspeaker, may be separated from another similar signal, such as a room reflection. The time window may be adjusted to allow measurement of any arrival in a complex reverberation pattern. These signals may be examined in the time domain (showing “energy” as a function of time) or in the frequency domain (amplitude and phase vs frequency). Impulse responses may be saved for further analysis.

A Maximum Length Sequence (MLS) is a special digital noise signal. For typical loudspeaker measurement applications, this digital signal is converted to the analog domain in the D/A converter and fed to a power amplifier which drives the loudspeaker under test. A measurement microphone is used to pick up the acoustical signal and return it to the analog input. The MLS system then performs a cross-correlation between the received and transmitted signals to obtain the impulse response which is stored in memory. The impulse response may be displayed on the computer, permitting the user to select the portion of impulse response of interest. This portion may be transformed into the frequency domain to study both magnitude and phase response versus frequency.

These properties are of obvious use when measurement loudspeakers or other electroacoustic devices. The time-selective capability permits separating the device-under-test response from that of the room in which the measurements are made. Alternately, the room itself may be measured, studying the reflection characteristics of each surface in the room or of the room taken as a whole.

4.6.4 Quasi-Anechoic Measurements and Low-Frequency Limitations

Other techniques exist which provide measurement capability similar to maximum length sequence analysis. These include Time Delay Spectrometry (TDS) and impulse testing. They all provide quasi-anechoic frequency response measurements of the loudspeaker alone, unaffected by room reflections. All share the limitation that this anechoic response is useful only above a critical frequency determined by the physical dimensions of the test environment. In the illustration below, for example, the direct signal arrives 2.91 ms after it leaves the loudspeaker and the first reflection arrives 9.2 ms after leaving the speaker. An anechoic measurement, by any of these techniques, must ignore reflections and therefore can only look at about 6.3 ms of pure first-arrival signal before the first reflection. Meaningful amplitude measurements cannot be made without acquiring at least one full cycle of signal, and accurate measurements require several cycles. For the 6.3 ms example, the frequency corresponding to this time span is about 160 Hz. If useful frequency response is desired down to 35 Hz, for example, then the portion of signal to be converted must be a minimum of 1/35 s (28 ms) and ideally closer to 1/10 s (100 ms). In the example as well as in most realistic actual rooms, this longer time necessarily includes several reflections and the response is no longer anechoic.



True anechoic response with even moderate accuracy down to 35 Hz would require that the first reflection path to be at least 28 ms longer than the direct signal path. This requires a room with the nearest reflecting surface at least 5 m away. This calls for a room with a 10 m high ceiling with the speaker and microphone on 5 m tall stands!

4.6.5 MLS Advantages

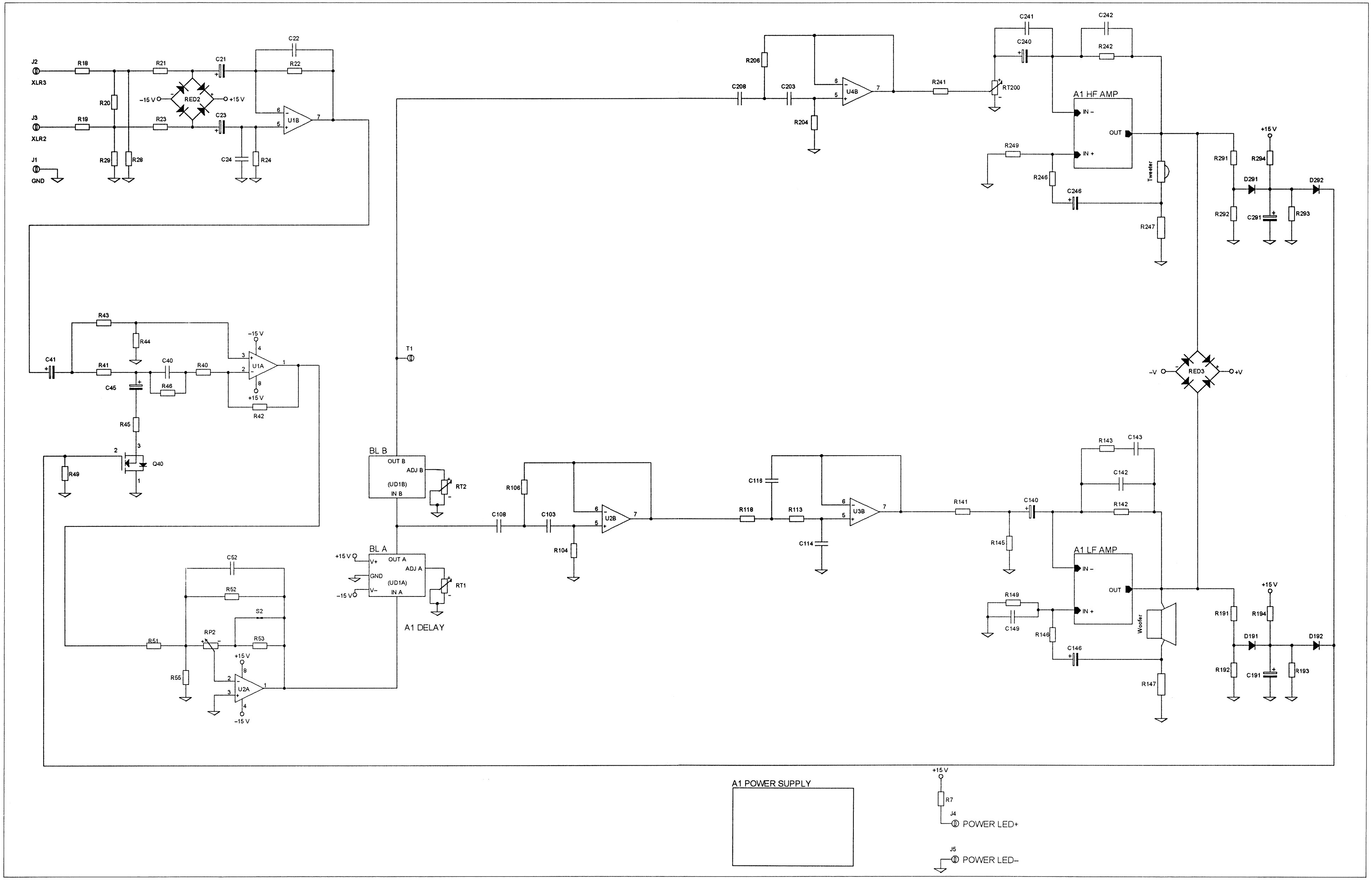
The maximum-length-sequence (MLS) test signal is a pseudo-random noise with special properties which allow analysis of response without the variability commonly associated with noise-based measurements. The analysis technique provides a high degree of immunity from interfering noise, allowing accurate measurements when the interference actually exceeds the test signal level. The MLS signal more closely resembles program material than does a sinewave and will therefore measure under conditions approximating normal use.

The MLS technique has several significant advantages over either basic impulse testing or the TDS technique. The principal advantage of MLS over impulse testing is in signal-to-noise ratio improvement. Compared to the TDS technique, MLS testing has a number of advantages. To obtain low-frequency response data, TDS must sweep very slowly. MLS has the same testing time whether evaluating only the anechoic portion (first arrival) or a longer portion of the signal for accurate bass response. With MLS, one acquisition and correlation produces an impulse response which may then be evaluated over and over to look at anechoic response, response of any selected reflection, integrated room response, etc. The TDS technique requires that the generator-to-bandpass filter frequency offset (delay time) be reset to equal the acoustical propagation delay for each acoustical path to be measured. Sweep speed is critical for the TDS technique, and an operator may easily select a speed which produces erroneous data without knowing he is making an error. Ambient acoustic noise tends to be greatest at low frequencies due to heating and air conditioning systems, traffic noise, etc. To improve signal-to-noise ratios under these typical conditions, MLS testing is normally used with pink spectral shaping (high-frequency attenuation) of the generated pseudo-random noise. A complementary filter in the analysis process produces overall flat response.

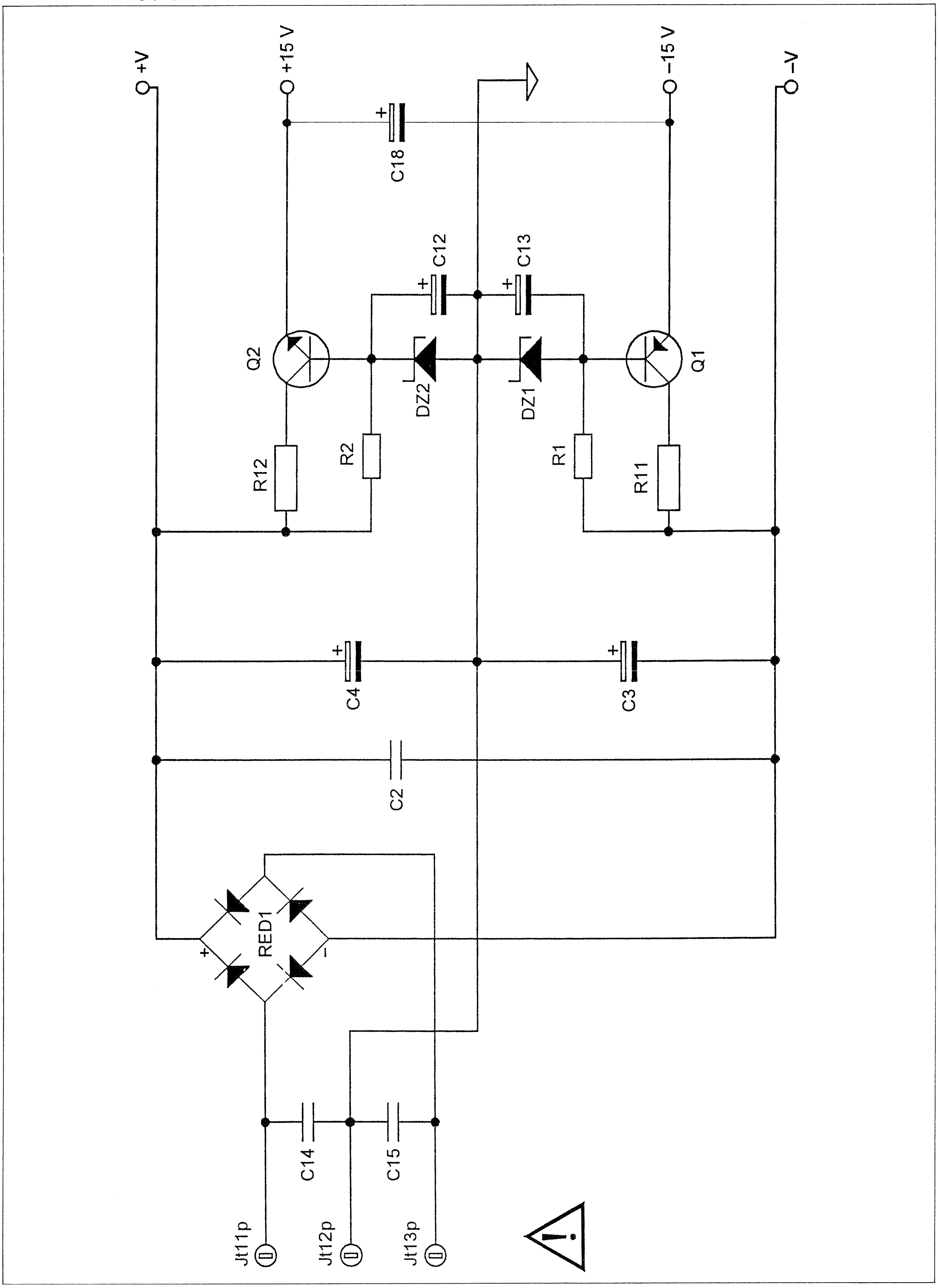
To accomplish the equivalent function in the TDS technique would require logarithmic sweeps and a variable-bandwidth filter, which is more complex and not done in available TDS instruments. Additionally, pink noise is similar in spectral distribution to voice and music, so the heating effect on individual loudspeakers of a multi-way loudspeaker system with pink MLS noise is similar to that which occurs during normal operation. The TDS technique (or any swept-sine method) concentrates all the input energy into a single loudspeaker driver at any single moment during the sweep, which can change driver characteristics during the test.

CONTENTS DIAGRAM SECTION

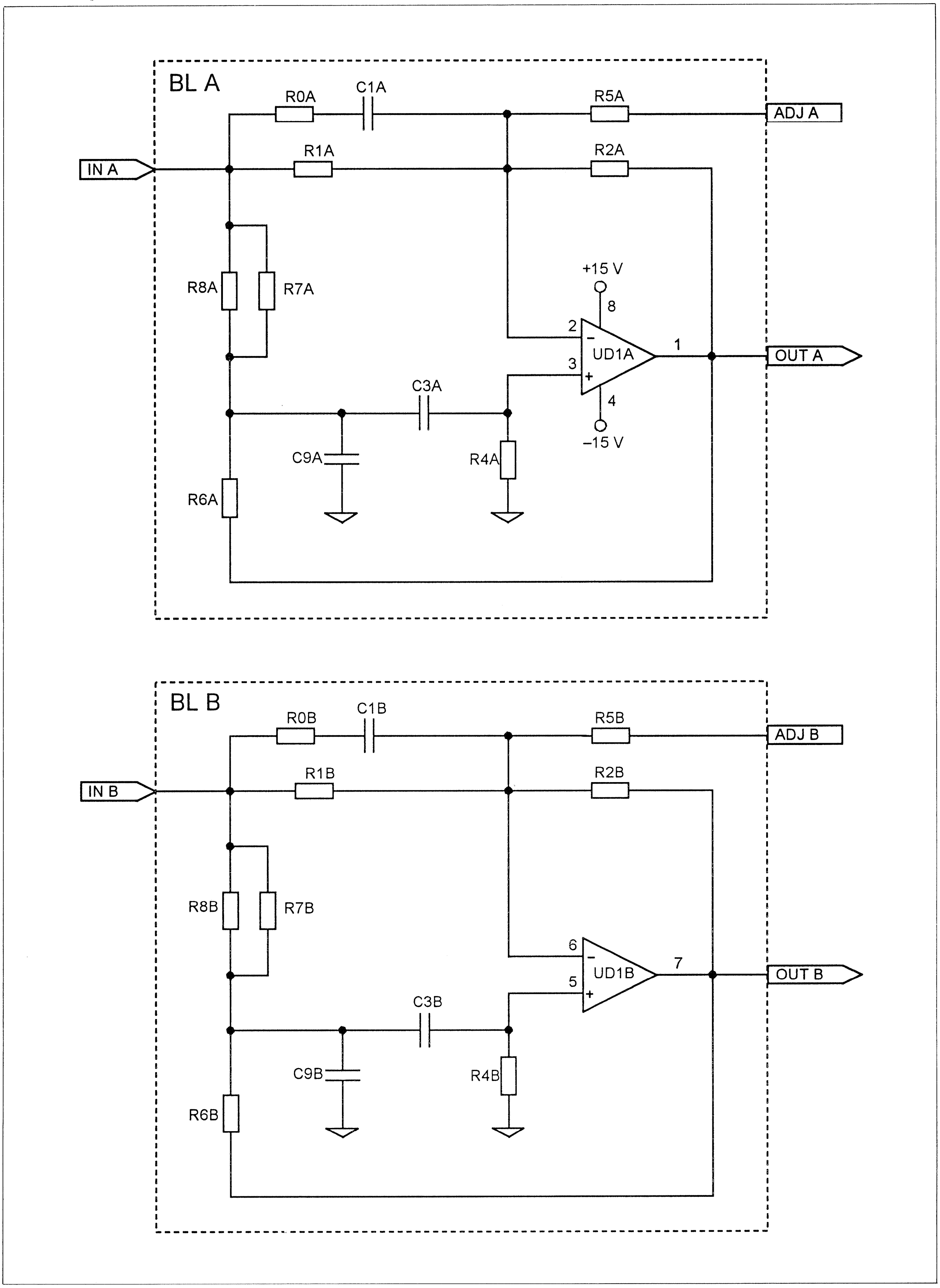
A1 Overall Diagram



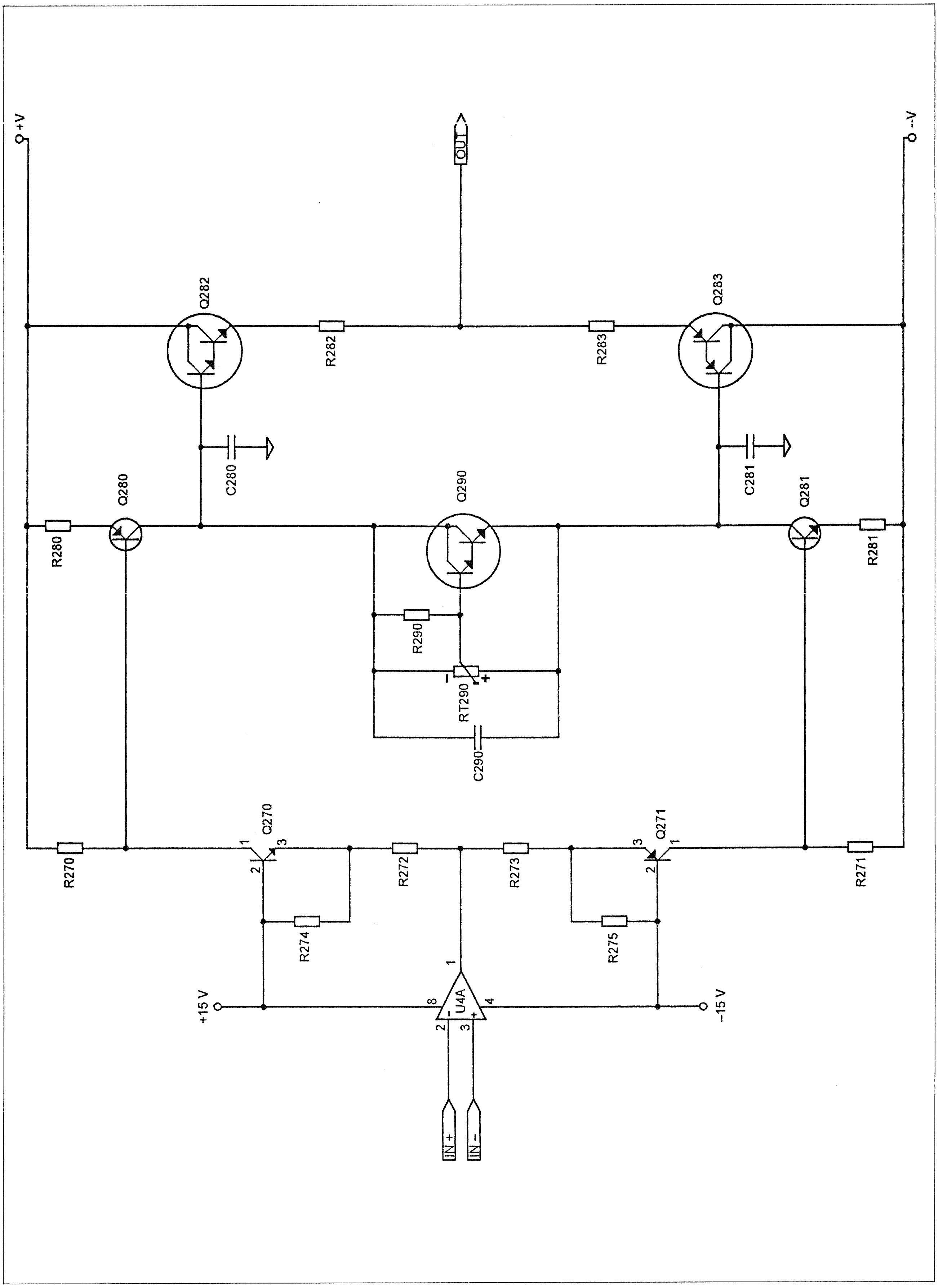
A1 Power Supply



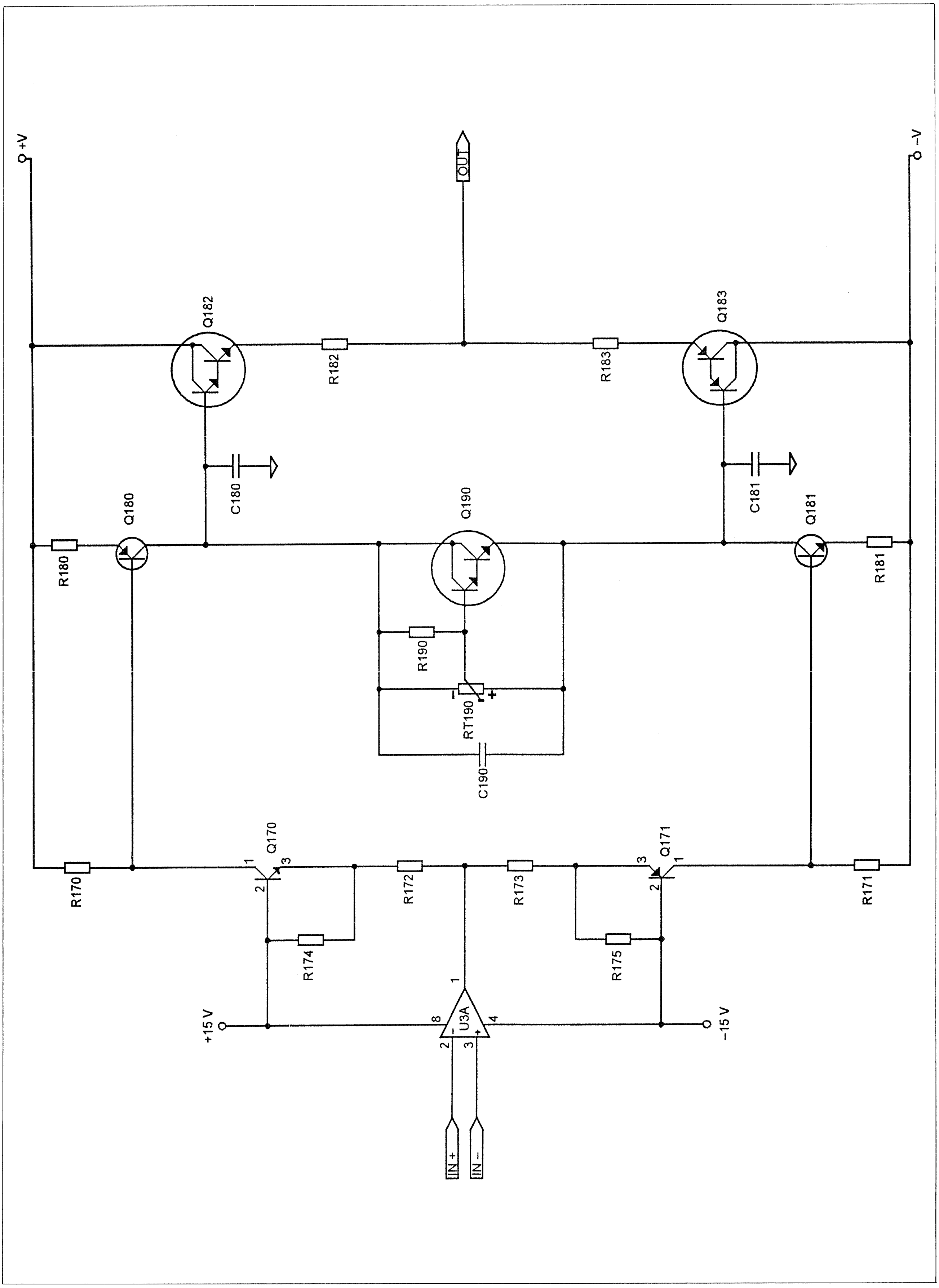
A1 Delay


BL A
R0A
C1A
R5A
ADJ A
IN A
R1A
R2A
R8A
R7A
+15 V
8
2
UD1A
1
OUT A
3
4
C3A
C9A
R4A
–15 V
R6A
BL B
R0B
C1B
R5B
ADJ B
IN B
R1B
R2B
R8B
R7B
6
UD1B
7
OUT B
5
C3B
C9B
R4B
R6B

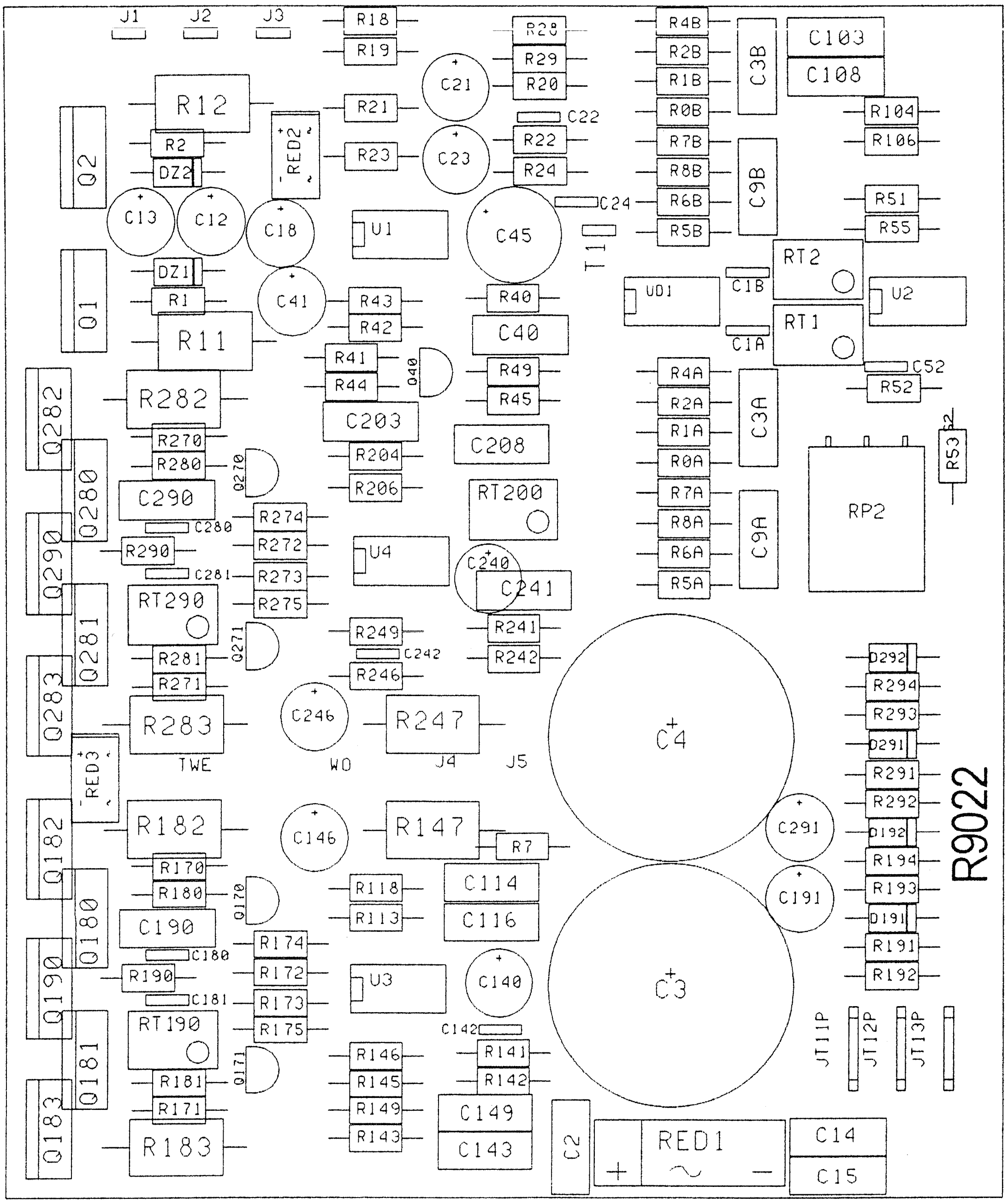
A1 HF AMP


+V
-V
OUT
Q282
Q283
R282
R283
C280
C281
Q280
Q290
Q281
R280
R281
R290
RT290
C290
Q270
Q271
R270
R272
R273
R271
R274
R275
U4A
+15 V
–15 V
IN +
IN –

A1 LF AMP


+V
OUT
–V
Q182
R182
R183
Q183
C180
C181
Q180
Q190
Q181
R180
R181
R190
RT190
C190
Q170
Q171
R170
R172
R173
R171
R174
R175
+15 V
U3A
–15 V
IN +
IN –

A1 Layout


J1
J2
J3
R18
R19
R21
R23
R28
R29
R20
R22
R24
C21
C23
C22
C24
C45
T1
R12
R2
DZ2
RED2
Q2
C13
C12
C18
U1
DZ1
R1
Q1
R11
C41
R43
R42
R41
R44
Q40
R40
C40
R49
R45
R4B
R2B
R1B
R0B
R7B
R8B
R6B
R5B
C3B
C9B
C103
C108
R104
R106
R51
R55
RT2
RT1
C1B
C1A
UD1
U2
C52
R52
R4A
R2A
R1A
R0A
R7A
R8A
R6A
R5A
C3A
C9A
RP2
R53
R282
R270
R280
Q270
Q282
Q280
C290
C280
R290
Q290
C281
RT290
Q281
Q271
R281
R271
Q283
R283
RED3
TWE
R274
R272
R273
R275
C203
R204
R206
C208
RT200
U4
C240
C241
R249
C242
R246
R241
R242
C246
R247
WO
J4
J5
C4
D292
R294
R293
D291
R291
R292
D192
R194
R193
D191
R191
R192
R9022
C291
C191
R182
R170
R180
Q170
Q182
Q180
C190
C180
R190
Q190
C181
RT190
Q181
Q171
R181
R171
Q183
R183
C146
R147
R7
R174
R172
R173
R175
R118
R113
C114
C116
U3
C140
C142
R146
R145
R149
R143
R141
R142
C149
C143
C3
JT11P
JT12P
JT13P
C2
RED1
C14
C15

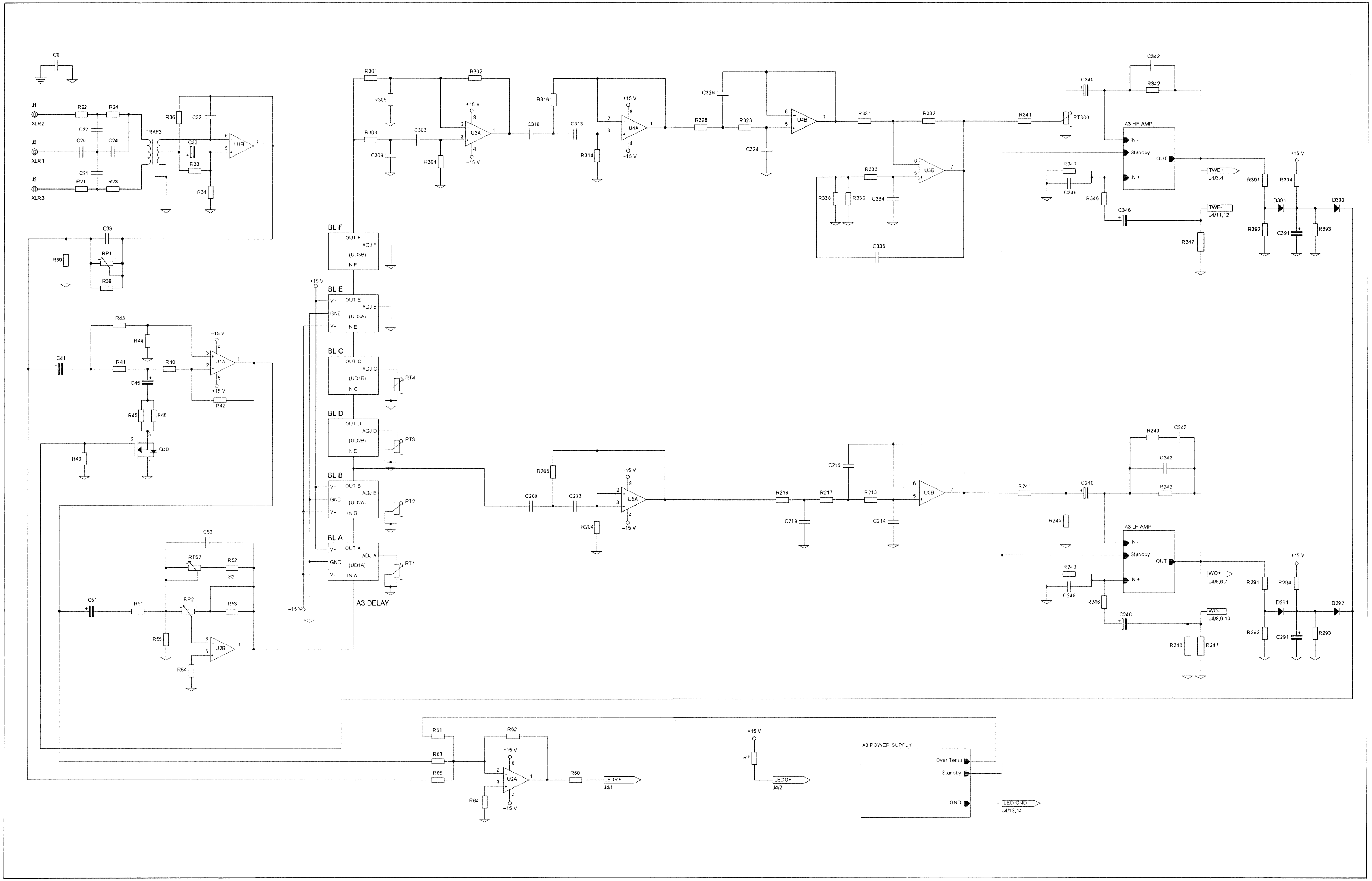
A1 Parts List

Ref.	Value
C2	Polyester, 7.5 mm, 100 nF / 100V
C3	Electrolytic, radial, 3300 µF / 50 V
C4	Electrolytic, radial, 3300 µF / 50 V
C12	Electrolytic, radial, 22 µF / 63 V
C13	Electrolytic, radial, 22 µF / 63 V
C14	Polyester, 7.5 mm, 100 nF / 100 V
C15	Polyester, 7.5 mm, 100 nF / 100 V
C18	Electrolytic, radial, 22 µF / 63 V
C21	Electrolytic, radial, 22 µF / 63 V
C22	Ceramic, 47 pF
C23	Electrolytic, radial, 22 µF / 63 V
C24	Ceramic, 47 pF
C40	Polyester, 7.5 mm, 470 nF / 100 V
C41	Electrolytic, radial, 22 µF / 63 V
C45	Electrolytic, radial, 470 µF / 25 V
C52	Ceramic, 100 pF
C103	Polyester, 7.5 mm, 220 nF / 100 V
C108	Polyester, 7.5 mm, 220 nF / 100 V
C114	Polyester, 7.5 mm, 1 nF / 630 V
C116	Polyester, 7.5 mm, 22 nF / 250 V
C140	Electrolytic, radial, 22 µF / 63 V
C142	Ceramic, 100 pF
C143	Polyester, 7.5 mm, 4.7 nF / 400 V
C146	Electrolytic, radial, 22 µF / 63 V
C180	Ceramic, 220 pF
C181	Ceramic, 220 pF
C190	Polyester, 7.5 mm, 220 nF / 100 V
C191	Electrolytic, radial, 22 µF / 63 V
C203	Polyester, 7.5 mm, 4.7 nF / 400 V
C208	Polyester, 7.5 mm, 4.7 nF / 400 V
C240	Electrolytic, radial, 22 µF / 63 V
C241	Not used
C242	Ceramic, 100 pF
C246	Not used
C280	Ceramic, 220 pF
C281	Ceramic, 220 pF
C290	Polyester, 7.5 mm, 220 nF / 100 V
C291	Electrolytic, radial, 22 µF / 63 V
CA1	Ceramic, 100 pF
CA3	Polyester, 7.5 mm, 2.2 nF / 630 V
CA9	Polyester, 7.5 mm, 2.2 nF / 630 V
CB1	Ceramic, 100 pF
CB3	Polyester, 7.5 mm, 1 nF / 630 V
CB9	Polyester, 7.5 mm, 1 nF / 630 V
D191	1N4935, fast recovery
D192	1N4935, fast recovery
D291	1N4935, fast recovery
D292	1N4935, fast recovery
DZ1	BZT03C, Z, 18 V
DZ2	BZT03C, Z, 18 V
J1	Flat pin 2.8 mm
J2	Flat pin 2.8 mm
J3	Flat pin 2.8 mm
J4,J5	LED grn + 30 cm wire
Jt11	Flat pin 4.8 mm
Jt12	Flat pin 4.8 mm
Jt13	Flat pin 4.8 mm

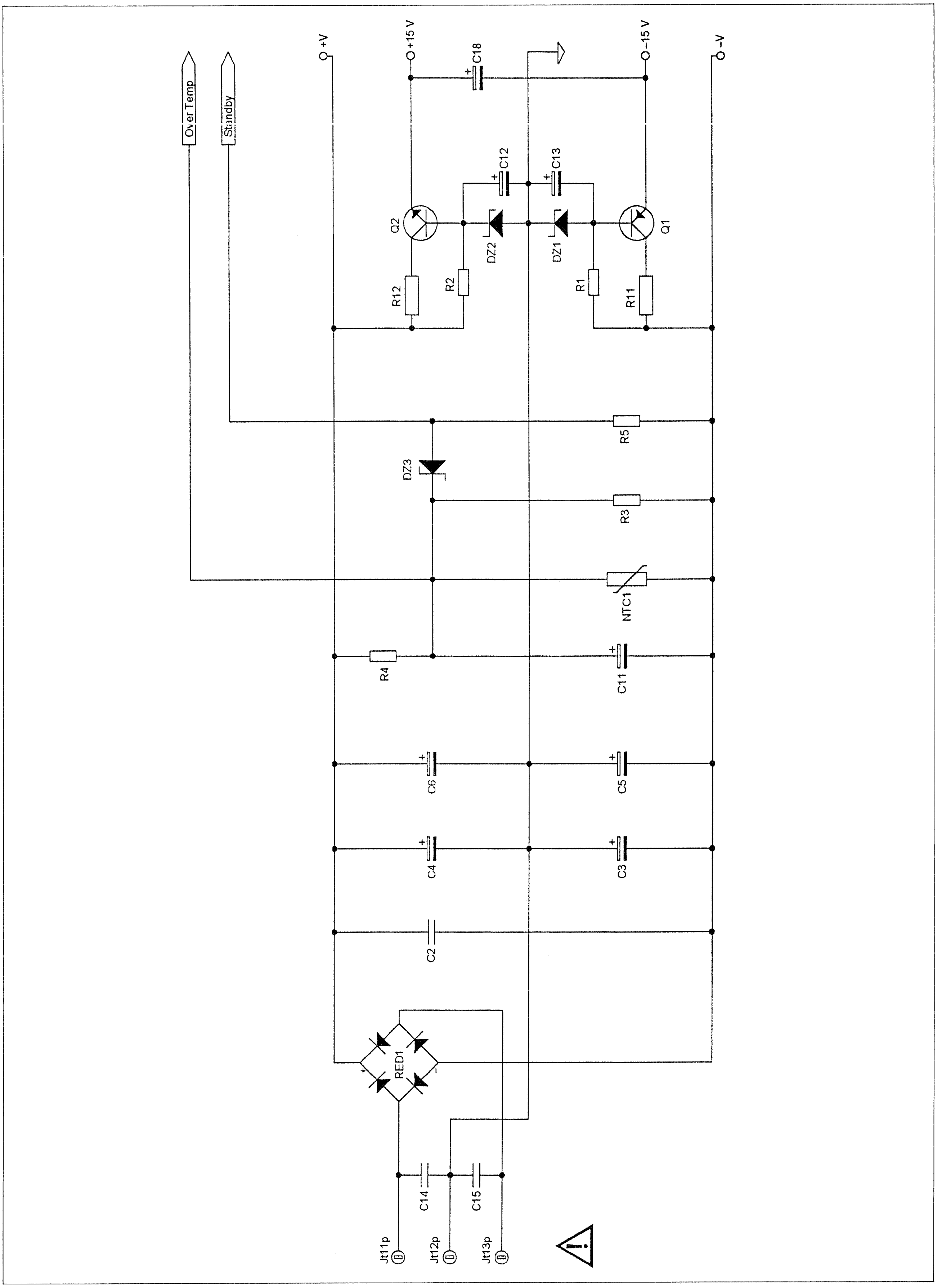
Ref.	Value
Q1	BD242C (PNP)
Q2	BD241C (NPN)
Q40	BS170 (FET)
Q170	BC546B (NPN)
Q171	BC556B (PNP)
Q180	BD242C (PNP)
Q181	BD241C (NPN)
Q182	TIP122 (NPN)
Q183	TIP127 (PNP)
Q190	TIP122 (NPN)
Q270	BC546B (NPN)
Q271	BC556B (PNP)
Q280	BD242C (PNP)
Q281	BD241C (NPN)
Q282	TIP122 (NPN)
Q283	TIP127 (PNP)
Q290	TIP122 (NPN)
R1	10k / 0.5 W
R2	10k / 0.5 W
R7	5k6 / 0.5 W
R11	560Ω / 2 W
R12	560Ω / 2 W
R18	470Ω / 0.5 W
R19	470Ω / 0.5 W
R20	4k7 / 0.5 W
R21	47k / 0.5 W
R22	100k / 0.5 W
R23	47k / 0.5 W
R24	100k / 0.5 W
R28	470k / 0.5 W
R29	470k / 0.5 W
R40	330Ω / 0.5 W
R41	47k / 0.5 W
R42	47k / 0.5 W
R43	47k / 0.5 W
R44	100Ω / 0.5 W
R45	100Ω / 0.5 W
R46	680Ω / 0.5 W
R49	100k / 0.5 W
R51	1k8 / 0.5 W
R52	10k / 0.5 W
R53	Bridge
R55	8k2 / 0.5 W
R104	47k / 0.5 W
R106	3k3 / 0.5 W
R113	5k6 / 0.5 W
R118	33k / 0.5 W
R141	15k / 0.5 W
R142	68k / 0.5 W
R143	18k / 0.5 W
R145	1k / 0.5 W
R146	33k / 0.5 W
R147	0Ω47 / 2 W
R149	1k / 0.5 W
R170	1k / 0.5 W
R171	1k / 0.5 W
R172	10k / 0.5 W
R173	10k / 0.5 W
R174	1k / 0.5 W
R175	1k / 0.5 W
R180	47Ω / 0.5 W
R181	47Ω / 0.5 W

Ref.	Value
R182	1Ω / 2 W
R183	1Ω / 2 W
R190	10k / 0.5 W
R191	33k / 0.5 W
R192	8k2 / 0.5 W
R193	22k / 0.5 W
R194	220k / 0.5 W
R204	3k9 / 0.5 W
R206	12k / 0.5 W
R241	10k / 0.5 W
R242	68k / 0.5 W
R246	Not used
R247	Wire bridge 0.8 x 50 mm
R249	2k2 / 0.5 W
R270	1k / 0.5 W
R271	1k / 0.5 W
R272	10k / 0.5 W
R273	10k / 0.5 W
R274	1k / 0.5 W
R275	1k / 0.5 W
R280	47Ω / 0.5 W
R281	47Ω / 0.5 W
R282	1Ω / 2 W
R283	1Ω / 2 W
R290	10k / 0.5 W
R291	150Ω / 0.5 W
R292	100Ω / 0.5 W
R293	10k / 0.5 W
R294	100k / 0.5 W
RA0	220k / 0.5 W
RA1	6k8 / 0.5 W
RA2	6k8 / 0.5 W
RA4	12k / 0.5 W
RA5	5k6 / 0.5 W
RA6	6k8 / 0.5 W
RA7	5k6 / 0.5 W
RA8	47k / 0.5 W
RB0	150k / 0.5 W
RB1	6k8 / 0.5 W
RB2	6k8 / 0.5 W
RB4	15k / 0.5 W
RB5	5k6 / 0.5 W
RB6	8k2 / 0.5 W
RB7	8k2 / 0.5 W
RB8	33k / 0.5 W
RED1	Rectifier B80C2300-1500
RED2	Rectifier 1A 250 V DIL4
RED3	Rectifier 1A 250 V DIL4
RP2	Potentiometer 10k, horizontal, PCB mount
RT1	Trimmer potentiometer, 2k, vertical
RT2	Trimmer potentiometer, 2k, vertical
RT190	Trimmer potentiometer, 10k, vertical
RT200	Trimmer potentiometer, 2k, vertical
RT290	Trimmer potentiometer, 10k vertical
U1	TL072CP dual opamp
U2	TL072CP dual opamp
U3	TL072CP dual opamp
U4	TL072CP dual opamp
UD1	TL072CP dual opamp

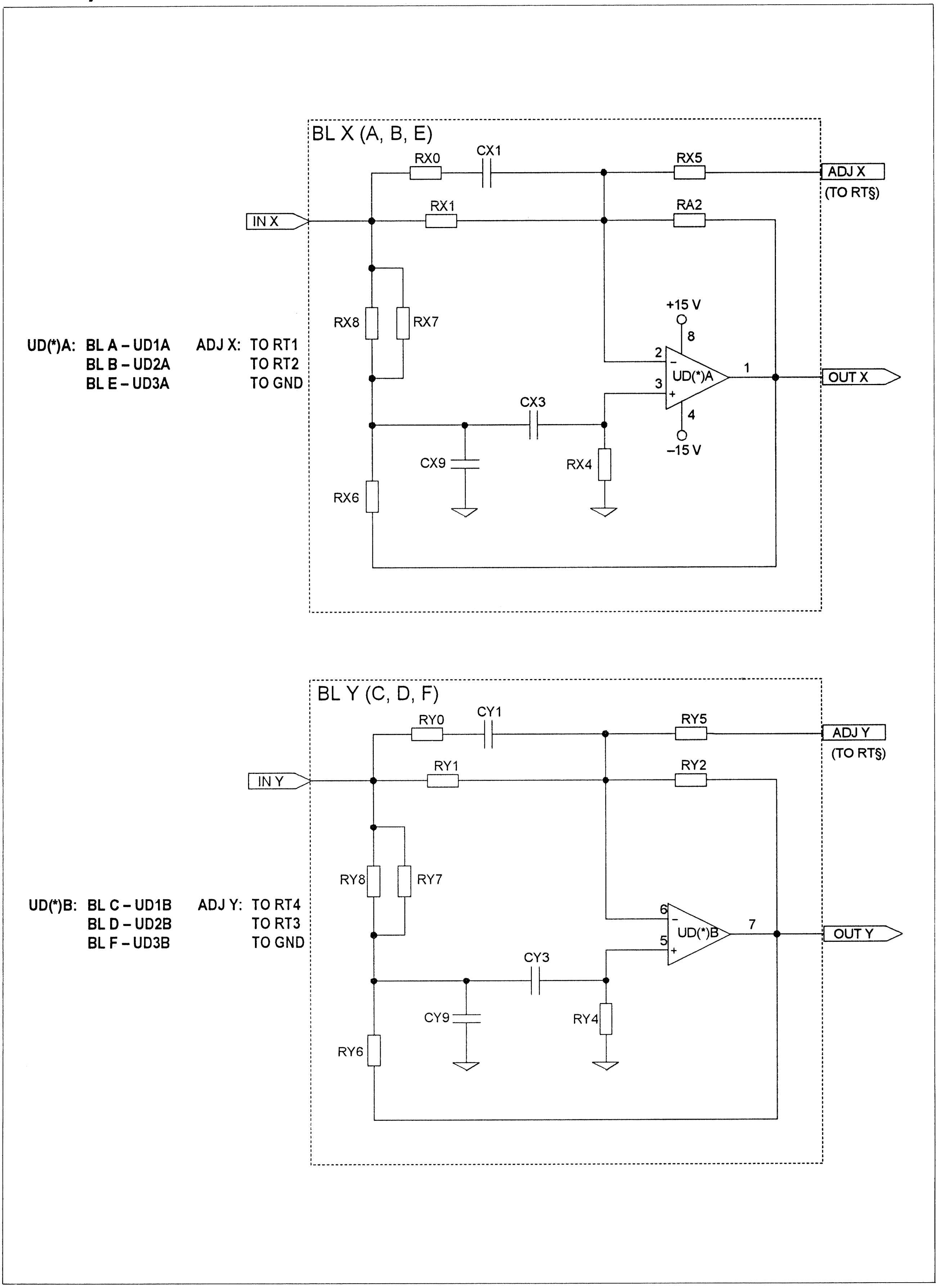
A3 Overall Diagram



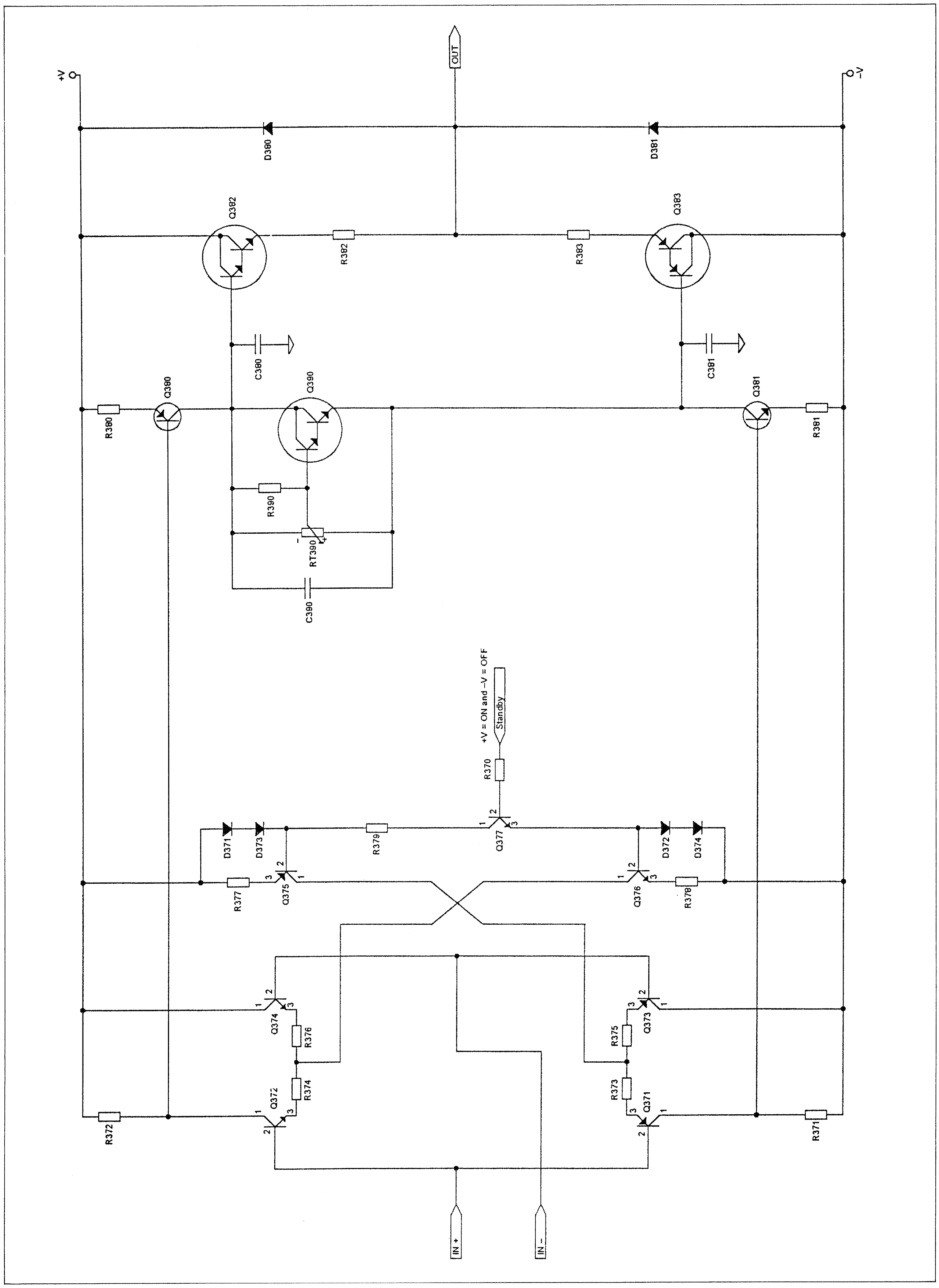
A3 Power Supply



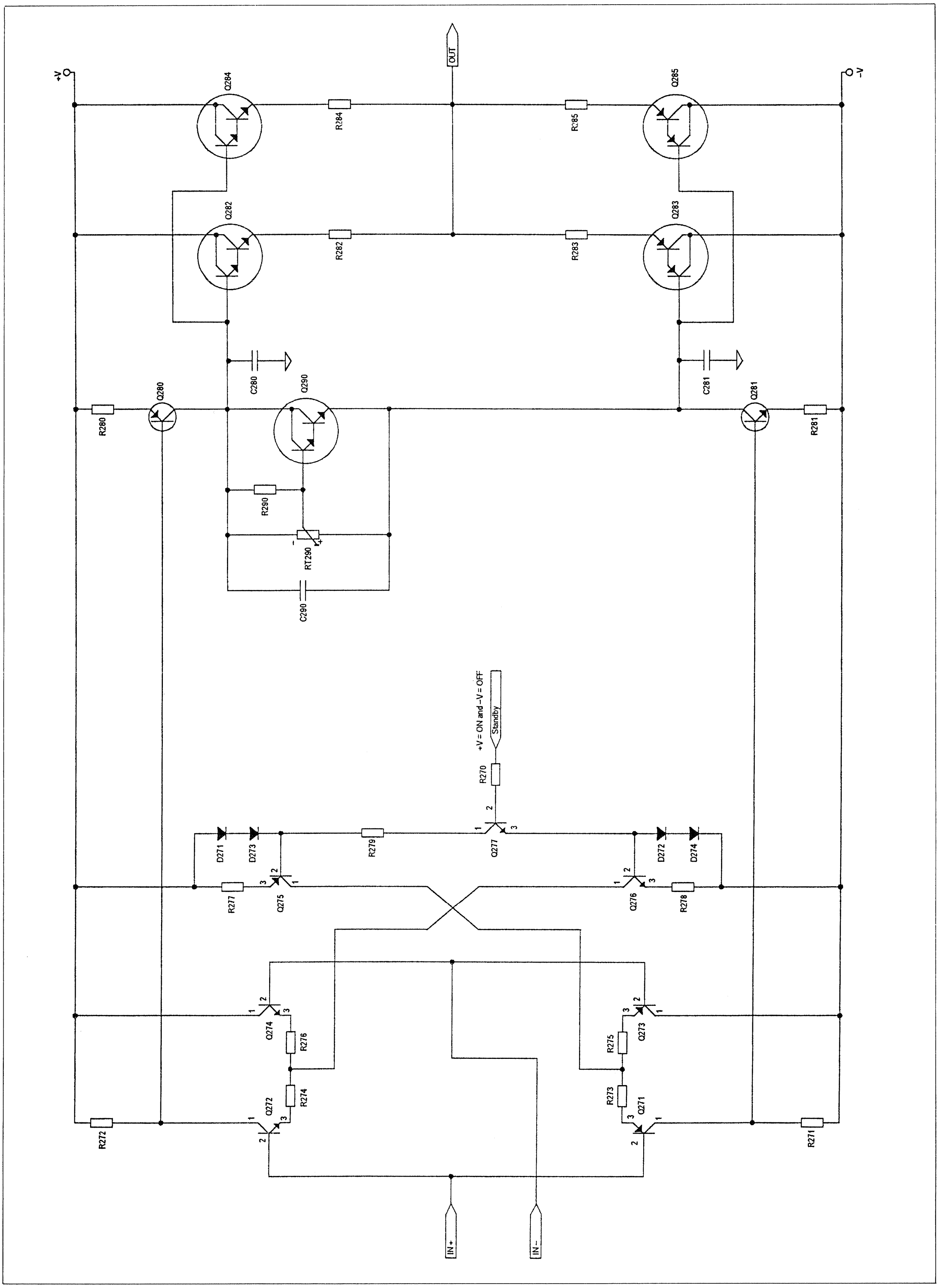
A3 Delay


BL X (A, B, E)
RX0
CX1
RX5
ADJ X
(TO RT§)
IN X
RX1
RA2
RX8
RX7
+15 V
8
UD(*)A: BL A – UD1A
BL B – UD2A
BL E – UD3A
ADJ X: TO RT1
TO RT2
TO GND
2
3
UD(*)A
1
OUT X
4
–15 V
CX3
CX9
RX4
RX6
BL Y (C, D, F)
RY0
CY1
RY5
ADJ Y
(TO RT§)
IN Y
RY1
RY2
RY8
RY7
UD(*)B: BL C – UD1B
BL D – UD2B
BL F – UD3B
ADJ Y: TO RT4
TO RT3
TO GND
6
5
UD(*)B
7
OUT Y
CY3
CY9
RY4
RY6

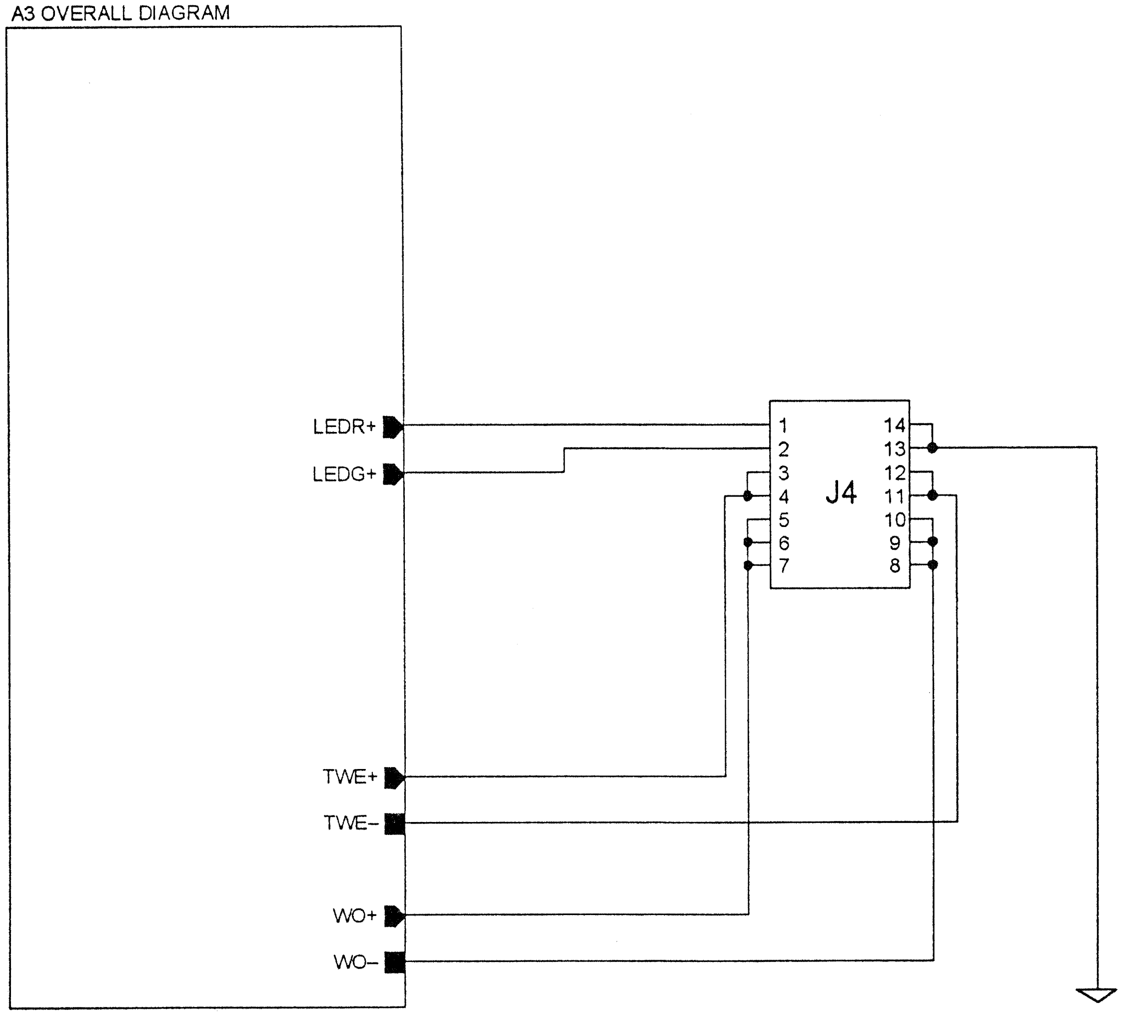
A3 HF AMP


OUT
+V
-V
D380
D381
Q382
Q383
R382
R383
C380
C381
Q380
Q390
Q381
R380
R381
R390
RT390
C390
+V = ON and -V = OFF
Standby
R370
Q377
R379
D371
D373
D372
D374
R377
Q375
Q376
R378
Q374
R376
Q373
R375
Q372
R374
R373
Q371
R372
R371
IN +
IN -

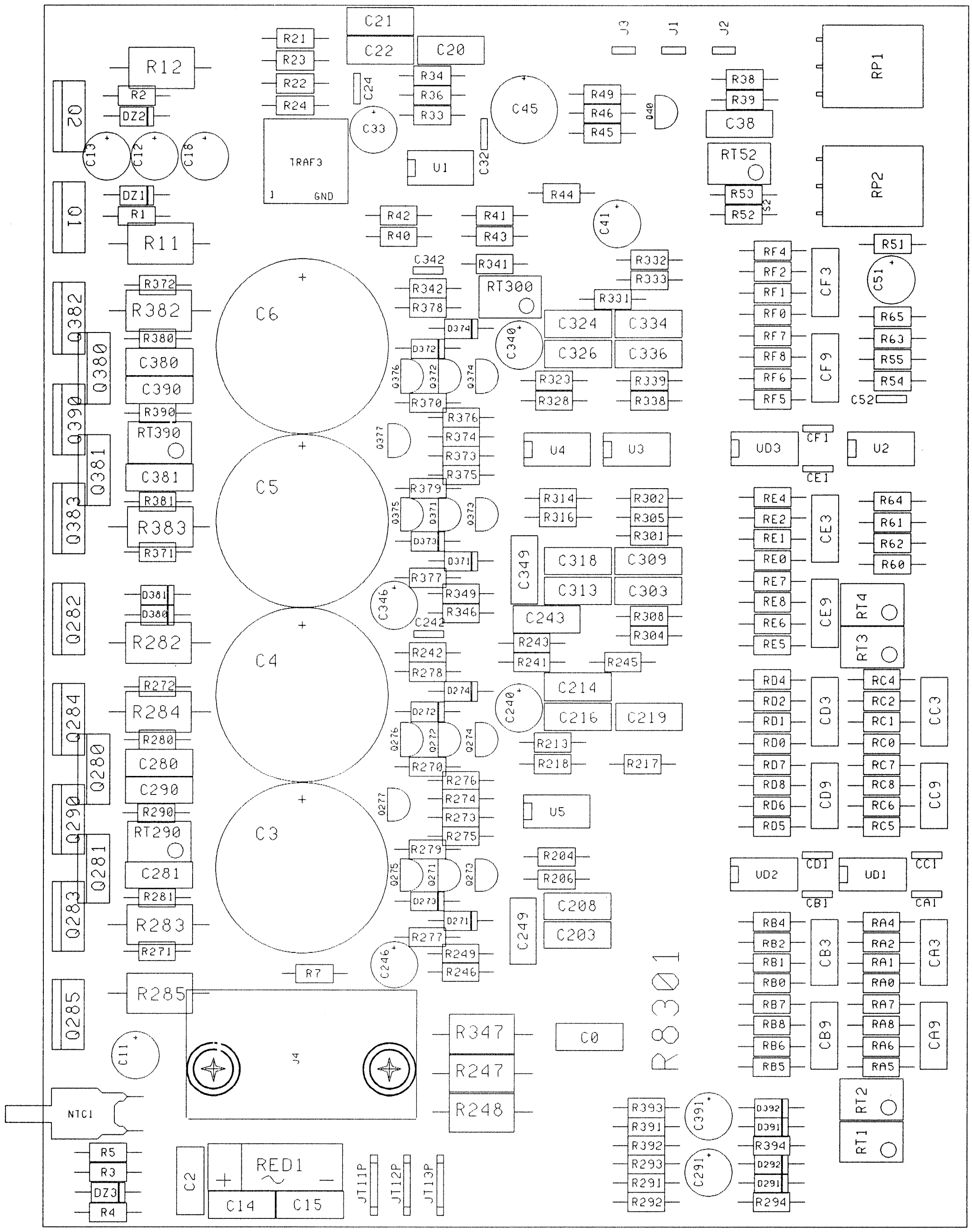
A3 LF AMP


OUT
+V
-V
Q284
Q285
Q282
Q283
R284
R285
R282
R283
C280
C281
Q280
Q281
Q290
R280
R281
R290
RT290
C290
+V = ON and -V = OFF
Standby
R270
Q277
R279
D271
D273
D272
D274
Q275
Q276
R277
R278
Q274
Q273
R276
R275
Q272
Q271
R274
R273
R272
R271
IN+
IN-

A3 Multipin Connector



A3 Layout


C21
C22
C20
R21
R23
R22
R24
R12
R2
DZ2
Q2
C13
C12
C18
TRAF3
GND
C24
C33
R34
R36
R33
C45
U1
C32
R49
R46
R45
Q40
J3
J1
J2
R38
R39
C38
RT52
R53
R52
RP1
RP2
DZ1
R1
Q1
R11
R44
C41
R42
R40
R41
R43
C342
R341
R332
R333
RT300
R331
R342
R378
C6
C5
C4
C3
R372
R382
Q382
R380
C380
Q380
C390
R390
Q390
RT390
Q381
C381
R381
R383
Q383
R371
D374
D372
Q376
Q372
Q374
C340
C324
C334
C326
C336
R323
R328
R339
R338
R370
R376
R374
R373
R375
Q377
U4
U3
UD3
U2
CF1
CE1
R379
Q375
Q371
Q373
D373
D371
R377
R349
R346
C346
C242
C349
R314
R316
R302
R305
R301
C318
C309
C313
C303
C243
R308
R304
R243
R241
R245
D381
D380
Q282
R282
R242
R278
D274
D272
C240
C214
C216
C219
R213
R218
R217
R272
R284
Q284
R280
C280
Q280
C290
Q290
R290
RT290
Q281
C281
R281
R283
Q283
R271
R270
R276
R274
R273
R275
Q277
Q276
Q272
Q274
U5
R279
Q275
Q271
Q273
D273
D271
R277
R249
R246
C246
C249
R204
R206
C208
C203
R7
R285
Q285
C11
J4
R347
R247
R248
C0
R8301
NTC1
R5
R3
DZ3
R4
C2
RED1
C14
C15
J111P
J112P
J113P
R393
R391
R392
R293
R291
R292
C391
C291
D392
D391
R394
D292
D291
R294
RF4
RF2
RF1
RF0
RF7
RF8
RF6
RF5
CF3
CF9
R51
C51
R65
R63
R55
R54
C52
RE4
RE2
RE1
RE0
RE7
RE8
RE6
RE5
CE3
CE9
R64
R61
R62
R60
RT4
RT3
RD4
RD2
RD1
RD0
RD7
RD8
RD6
RD5
CD3
CD9
RC4
RC2
RC1
RC0
RC7
RC8
RC6
RC5
CC3
CC9
UD2
CD1
CB1
UD1
CC1
CA1
RB4
RB2
RB1
RB0
RB7
RB8
RB6
RB5
CB3
CB9
RA4
RA2
RA1
RA0
RA7
RA8
RA6
RA5
CA3
CA9
RT2
RT1

A3 Parts List

Ref.	Value
C0	not used
C2	Polyester, 7.5 mm, 220 nF / 100 V
C3	Electrolytic, radial, 3300 µF / 50 V
C4	Electrolytic, radial, 3300 µF / 50 V
C5	Electrolytic, radial, 3300 µF / 50 V
C6	Electrolytic, radial, 3300 µF / 50 V
C11	Electrolytic, radial, 22 µF / 63 V
C12	Electrolytic, radial, 22 µF / 63 V
C13	Electrolytic, radial, 22 µF / 63 V
C14	Polyester, 7.5 mm, 100 nF / 100 V
C15	Polyester, 7.5 mm, 100 nF / 100 V
C18	Electrolytic, radial, 22 µF / 63 V
C20	Polyester, 7.5 mm, 1 nF / 630 V
C21	Polyester, 7.5 mm, 1 nF / 630 V
C22	Polyester, 7.5 mm, 1 nF / 630 V
C24	not used
C32	Ceramic, 220 pF
C33	Electrolytic, radial, 22 µF / 63 V
C38	Polyester, 7.5 mm, 220 nF / 100 V
C41	Electrolytic, radial, 22 µF / 63 V
C45	Electrolytic, radial, 470 µF / 25 V
C51	Electrolytic, radial, 22 µF / 63 V
C52	Ceramic, 220 pF
C203	Polyester, 7.5 mm, 220 nF / 100 V
C208	Polyester, 7.5 mm, 220 nF / 100 V
C214	Polyester, 7.5 mm, 2.2 nF / 630 V
C216	Polyester, 7.5 mm, 10 nF / 250 V
C219	Polyester, 7.5 mm, 22 nF / 250 V
C240	Electrolytic, radial, 22 µF / 63 V
C242	Ceramic, 100 pF
C243	Polyester, 7.5 mm, 47 nF / 100 V
C246	Electrolytic, radial, 22 µF / 63 V
C249	not used
C280	Polyester, 7.5 mm, 1 nF / 630 V
C281	Polyester, 7.5 mm, 1 nF / 630 V
C290	Polyester, 7.5 mm, 220 nF / 100 V
C291	Electrolytic, radial, 22 µF / 63 V
C303	Polyester, 7.5 mm, 4.7 nF / 400 V
C309	Polyester, 7.5 mm, 4.7 nF / 400 V
C313	Polyester, 7.5 mm, 4.7 nF / 400 V
C318	Polyester, 7.5 mm, 4.7 nF / 400 V
C324	Polyester, 7.5 mm, 1 nF / 630 V
C326	Polyester, 7.5 mm, 22 nF / 250 V
C334	Polyester, 7.5 mm, 4.7 nF / 400 V
C336	Polyester, 7.5 mm, 4.7 nF / 400 V
C340	Electrolytic, radial, 22 µF / 63 V
C342	Ceramic, 100 pF
C346	Electrolytic, radial, 22 µF / 63 V
C349	not used
C380	Polyester, 7.5 mm, 1 nF / 630 V
C381	Polyester, 7.5 mm, 1 nF / 630 V
C390	Polyester, 7.5 mm, 220 nF / 100 V
C391	Electrolytic, radial, 22 µF / 63 V
CA1	Ceramic, 100 pF
CA3	Polyester, 7.5 mm, 3.3 nF / 400 V
CA9	Polyester, 7.5 mm, 3.3 nF / 400 V
CB1	Ceramic, 100 pF
CB3	Polyester, 7.5 mm, 3.3 nF / 400 V
CB9	Polyester, 7.5 mm, 3.3 nF / 400 V
CC1	Ceramic, 100 pF
CC3	Polyester, 7.5 mm, 1 nF / 630 V
CC9	Polyester, 7.5 mm, 1 nF / 630 V
CD1	Ceramic, 100 pF
CD3	Polyester, 7.5 mm, 2.2 nF / 630 V
CD9	Polyester, 7.5 mm, 2.2 nF / 630 V

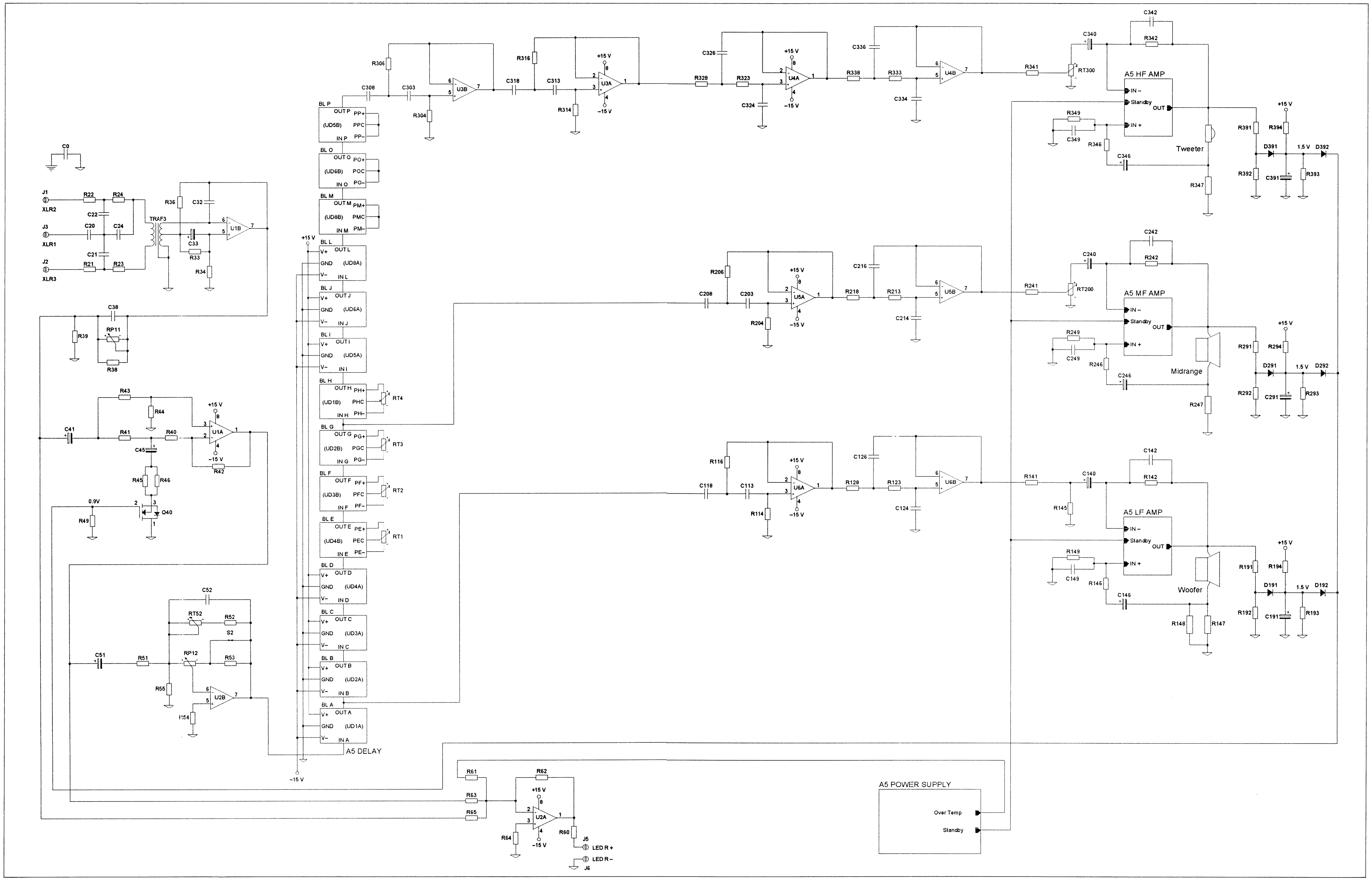
Ref.	Value
CE1	Ceramic, 100 pF
CE3	Polyester, 7.5 mm, 2.2 nF / 630 V
CE9	Polyester, 7.5 mm, 2.2 nF / 630 V
CF1	Ceramic, 100 pF
CF3	Polyester, 7.5 mm, 1 nF / 630 V
CF9	Polyester, 7.5 mm, 1 nF / 630 V
D271	1N4935, fast recovery
D272	1N4935, fast recovery
D273	1N4935, fast recovery
D274	1N4935, fast recovery
D291	1N4935, fast recovery
D292	1N4935, fast recovery
D371	1N4935, fast recovery
D372	1N4935, fast recovery
D373	1N4935, fast recovery
D374	1N4935, fast recovery
D380	not used
D381	not used
D391	1N4935, fast recovery
D392	1N4935, fast recovery
DZ1	BZT03C, Z, 18 V
DZ2	BZT03C, Z, 18 V
DZ3	BZX85C, Z, 27 V
J1	Flat pin, 2.8 mm
J2	Flat pin, 2.8 mm
J3	Flat pin, 2.8 mm
J4	Connector 36 pin, m, right
Jt11	Flat pin, 4.8 mm
Jt12	Flat pin, 4.8 mm
Jt13	Flat pin, 4.8 mm
NTC1	150k, thread M3
Q1	TIP127 (PNP)
Q2	TIP122 (NPN)
Q40	BS170 (FET)
Q271	BC556B (PNP)
Q272	BC546B (NPN)
Q273	BC556B (PNP)
Q274	BC546B (NPN)
Q275	BC556B (PNP)
Q276	BC546B (NPN)
Q277	BC546B (NPN)
Q280	BD242C (PNP)
Q281	BD241C (NPN)
Q282	TIP122 (NPN)
Q283	TIP127 (PNP)
Q284	TIP122 (NPN)
Q285	TIP127 (PNP)
Q290	TIP122 (NPN)
Q371	BC556B (PNP)
Q372	BC546B (NPN)
Q373	BC556B (PNP)
Q374	BC546B (NPN)
Q375	BC556B (PNP)
Q376	BC546B (NPN)
Q377	BC546B (NPN)
Q380	BD242C (PNP)
Q381	BD241C (NPN)
Q382	TIP122 (NPN)
Q383	TIP127 (PNP)
Q390	TIP122 (NPN)

Ref.	Value
R1	10k / 0.5 W
R2	10k / 0.5 W
R3	100k / 0.5 W
R4	30k / 0.5 W
R5	100k / 0.5 W
R7	5k6 / 0.5 W
R11	560Ω / 2 W
R12	560Ω / 2 W
R21	1k / 0.5 W
R22	1k / 0.5 W
R23	1k / 0.5 W
R24	1k / 0.5 W
R33	4k7 / 0.5 W
R34	4k7 / 0.5 W
R36	2k2 / 0.5 W
R38	not used
R39	10k / 0.5 W
R40	220Ω / 0.5 W
R41	33k / 0.5 W
R42	33k / 0.5 W
R43	33k / 0.5 W
R44	47Ω / 0.5 W
R45	47Ω / 0.5 W
R46	1k / 0.5 W
R49	100k / 0.5 W
R51	2k2 / 0.5 W
R52	4k7 / 0.5 W
R53	not used
R54	1k / 0.5 W
R55	4k7 / 0.5 W
R60	4k7 / 0.5 W
R61	220k / 0.5 W
R62	47k / 0.5 W
R63	10k / 0.5 W
R64	10k / 0.5 W
R65	10k / 0.5 W
R204	82k / 0.5 W
R206	3k3 / 0.5 W
R213	15k / 0.5 W
R217	22k / 0.5 W
R218	2k2 / 0.5 W
R241	4k7 / 0.5 W
R242	18k / 0.5 W
R243	15k / 0.5 W
R245	1k / 0.5 W
R246	1k / 0.5 W2
R247	0Ω47 / 2 W
R248	0Ω47 / 2 W
R249	1k / 0.5 W5
R270	220k / 0.5 W
R271	1k / 0.5 W
R272	1k / 0.5 W
R273	47Ω / 0.5 W
R274	47Ω / 0.5 W
R275	47Ω / 0.5 W
R276	47Ω / 0.5 W
R277	330Ω / 0.5 W
R278	330Ω / 0.5 W
R279	22k / 0.5 W
R280	100Ω / 0.5 W
R281	100Ω / 0.5 W
R282	1Ω / 2 W
R283	1Ω / 2 W
R284	1Ω / 2 W
R285	1Ω / 2 W
R290	10k / 0.5 W
R291	10k / 0.5 W
R292	1k / 0.5 W2
R293	10k / 0.5 W
R294	100k / 0.5 W
R301	10k / 0.5 W
R302	10k / 0.5 W

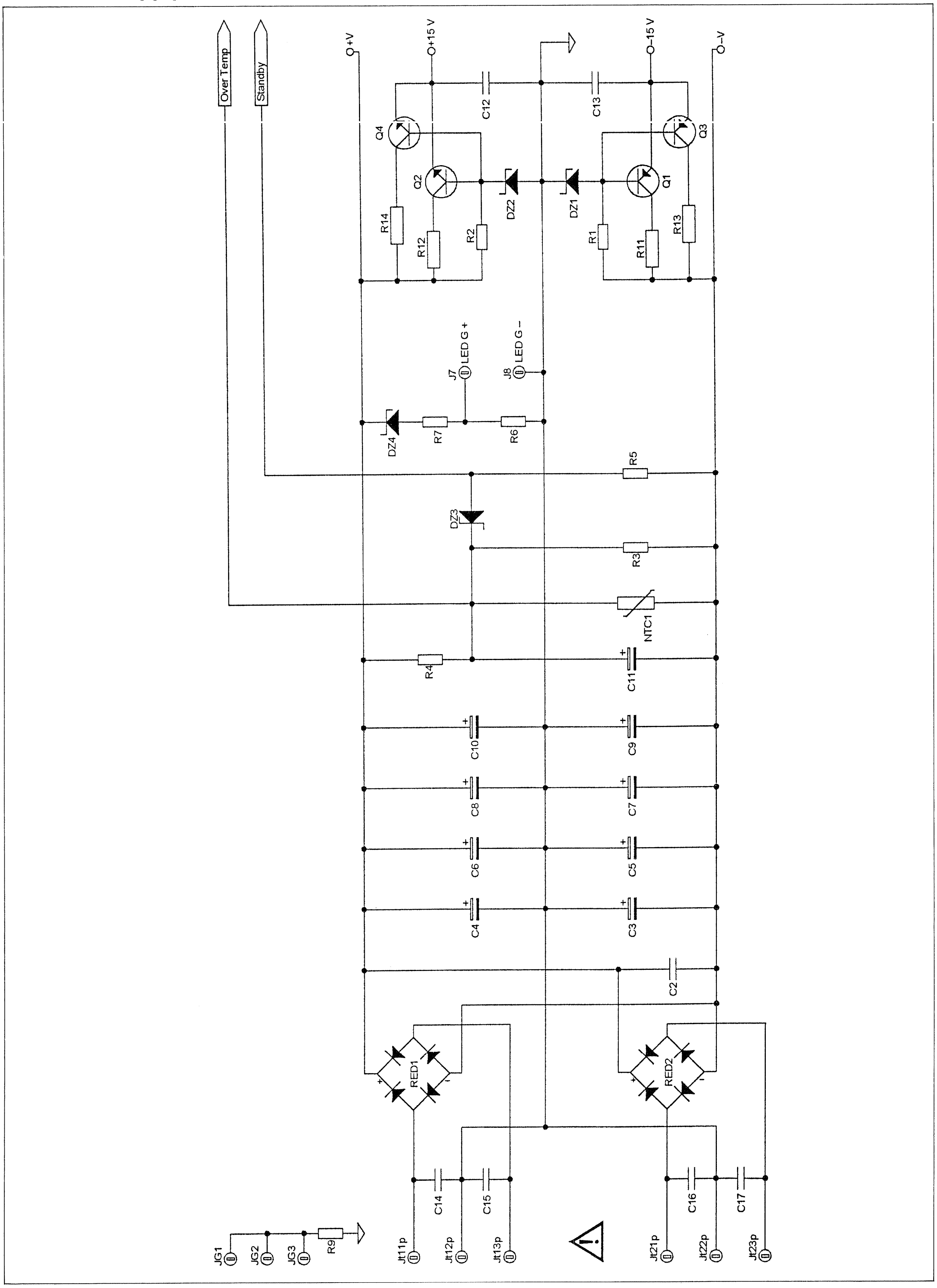
A3 Parts List

Ref.	Value	Ref.	Value
R304	10k / 0.5 W	RE0	220k / 0.5 W
R305	18k / 0.5 W	RE1	6K8 / 0.5 W
R308	10k / 0.5 W	RE2	6K8 / 0.5 W
R314	56K / 0.5 W	RE4	10k / 0.5 W
R316	2k7 / 0.5 W	RE5	5k6 / 0.5 W
R323	1k / 0.5 W5	RE6	6K8 / 0.5 W
R328	1k / 0.5 W5	RE7	5k6 / 0.5 W
R331	10k / 0.5 W	RE8	47k / 0.5 W
R332	10k / 0.5 W		
R333	8k2 / 0.5 W	RF0	150k / 0.5 W
R338	5k6 / 0.5 W	RF1	6K8 / 0.5 W
R339	not used	RF2	6K8 / 0.5 W
R341	8k2 / 0.5 W	RF4	15k / 0.5 W
R342	22k / 0.5 W	RF5	5k6 / 0.5 W
R346	10k / 0.5 W	RF6	10k / 0.5 W
R347	0Ω47 / 2 W	RF7	10k / 0.5 W
R349	1k / 0.5 W5	RF8	33k / 0.5 W
R370	220k / 0.5 W		
R371	1k / 0.5 W	RP1	Potentiometer 10k, horizontal, PCB mount
R372	1k / 0.5 W	RP2	Potentiometer 10k, horizontal, PCB mount
R373	47Ω / 0.5 W		
R374	47Ω / 0.5 W	RT1	Trimmer potentiometer, 2k, vertical
R375	47Ω / 0.5 W	RT2	Trimmer potentiometer, 2k, vertical
R376	47Ω / 0.5 W	RT3	Trimmer potentiometer, 2k, vertical
R377	330Ω / 0.5 W	RT4	Trimmer potentiometer, 2k, vertical
R378	330Ω / 0.5 W	RT52	Trimmer potentiometer, 10k, vertical
R379	22k / 0.5 W	RT290	Trimmer potentiometer, 10k vertical
R380	100Ω / 0.5 W	RT300	Trimmer potentiometer, 2k, vertical
R381	100Ω / 0.5 W	RT390	Trimmer potentiometer, 10k, vertical
R382	1Ω / 2 W		
R383	1Ω / 2 W	RED1	Rectifier B 80C2300-1500
R390	10k / 0.5 W		
R391	220Ω / 0.5 W	TRA3	Line input transformer Studer (..426.00)
R392	100Ω / 0.5 W		
R393	10k / 0.5 W	U1	TL072CP dual opamp
R394	100k / 0.5 W	U2	TL072CP dual opamp
		U3	TL072CP dual opamp
RA0	470k / 0.5 W	U4	TL072CP dual opamp
RA1	6K8 / 0.5 W	U5	TL072CP dual opamp
RA2	6K8 / 0.5 W		
RA4	15k / 0.5 W	UD1	TL072CP dual opamp
RA5	4k7 / 0.5 W	UD2	TL072CP dual opamp
RA6	12k / 0.5 W	UD3	TL072CP dual opamp
RA7	8k2 / 0.5 W		
RA8	100k / 0.5 W		
RB0	220k / 0.5 W		
RB1	6K8 / 0.5 W		
RB2	6K8 / 0.5 W		
RB4	10k / 0.5 W		
RB5	4k7 / 0.5 W		
RB6	6K8 / 0.5 W		
RB7	4k7 / 0.5 W		
RB8	not used		
RC0	150k / 0.5 W		
RC1	6K8 / 0.5 W		
RC2	6K8 / 0.5 W		
RC4	15k / 0.5 W		
RC5	4k7 / 0.5 W		
RC6	10k / 0.5 W		
RC7	10k / 0.5 W		
RC8	33k / 0.5 W		
RD0	220k / 0.5 W		
RD1	6K8 / 0.5 W		
RD2	6K8 / 0.5 W		
RD4	10k / 0.5 W		
RD5	4k7 / 0.5 W		
RD6	6K8 / 0.5 W		
RD7	5k6 / 0.5 W		
RD8	47k / 0.5 W		

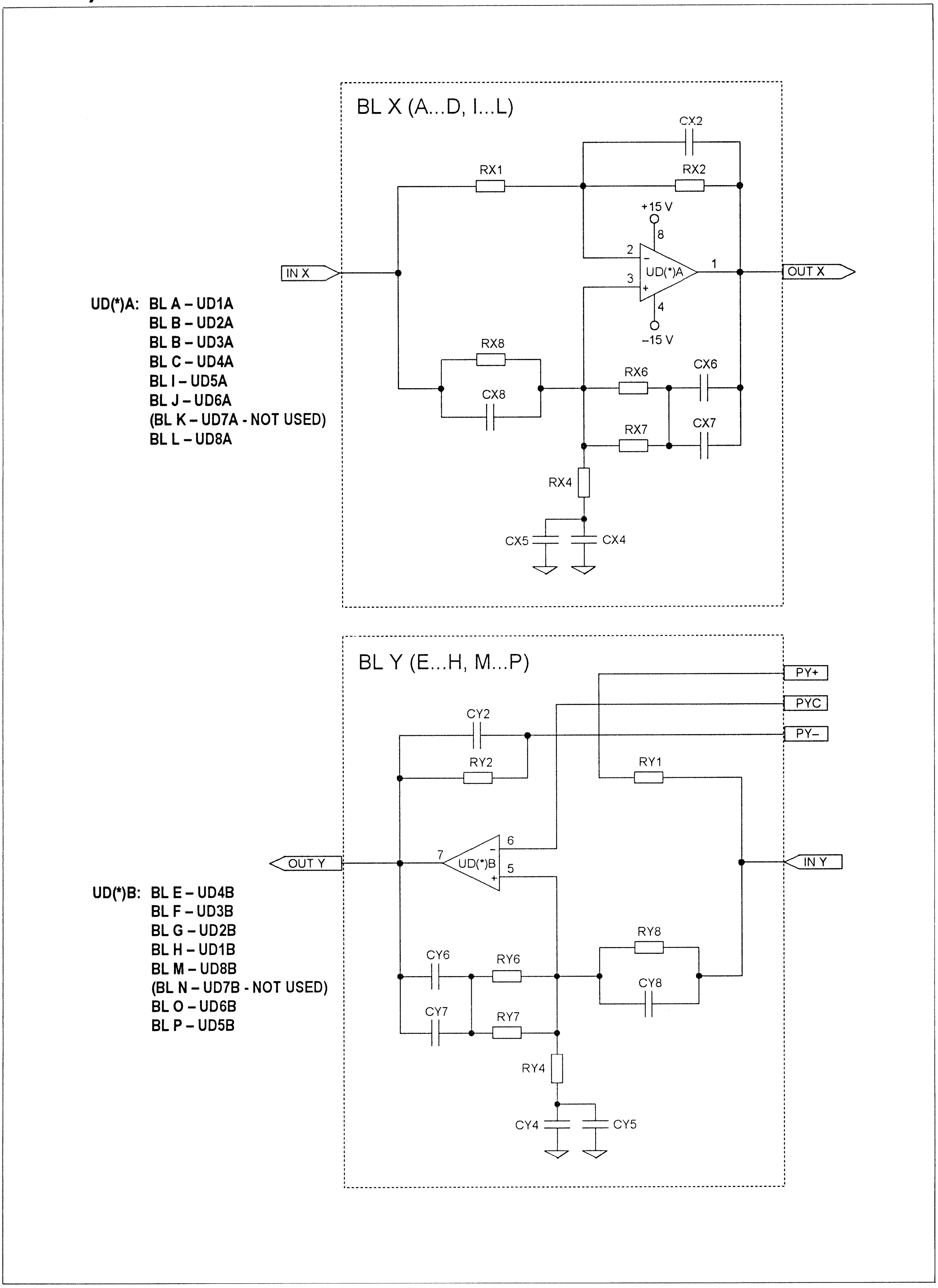
A5 Overall Diagram



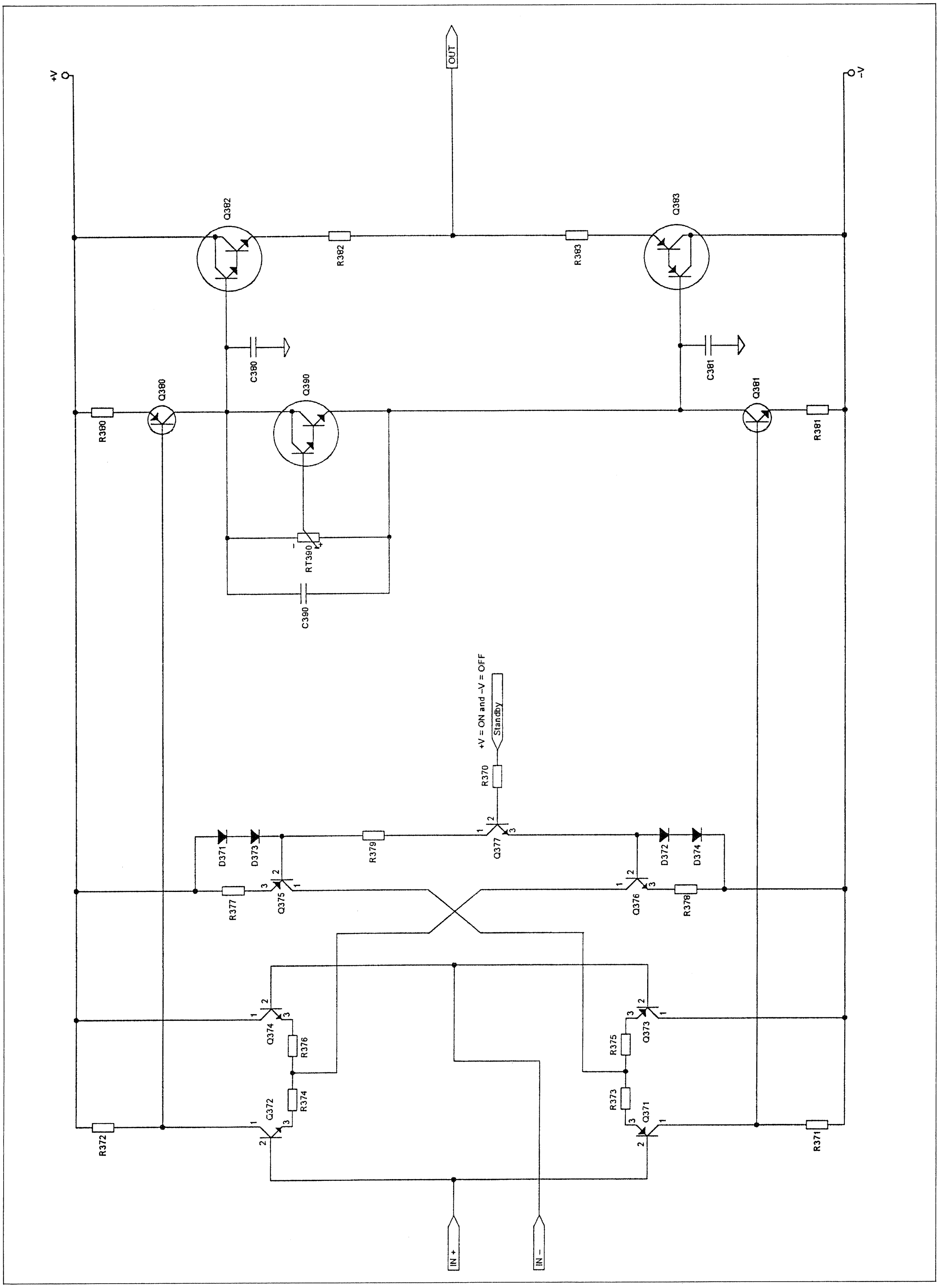
A5 Power Supply



A5 Delay

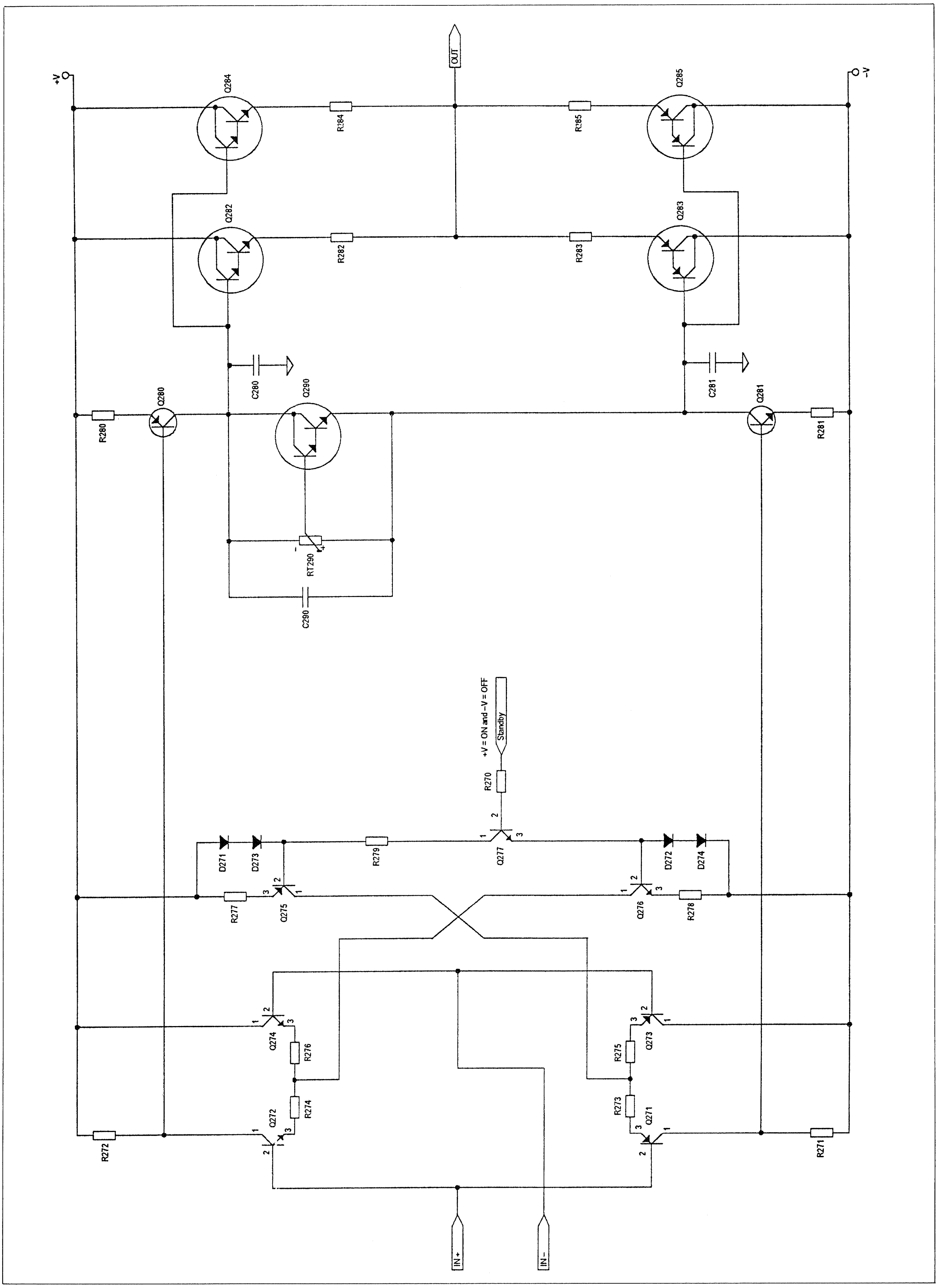

BL X (A...D, I...L)
CX2
RX1
RX2
+15 V
8
2
1
UD(*)A
3
4
IN X
OUT X
–15 V
RX8
CX6
RX6
CX8
RX7
CX7
RX4
CX5
CX4
UD(*)A: BL A – UD1A
BL B – UD2A
BL B – UD3A
BL C – UD4A
BL I – UD5A
BL J – UD6A
(BL K – UD7A - NOT USED)
BL L – UD8A
BL Y (E...H, M...P)
PY+
PYC
CY2
PY–
RY2
RY1
6
7
UD(*)B
5
OUT Y
IN Y
UD(*)B: BL E – UD4B
BL F – UD3B
BL G – UD2B
BL H – UD1B
BL M – UD8B
(BL N – UD7B - NOT USED)
BL O – UD6B
BL P – UD5B
RY8
CY6
RY6
CY8
CY7
RY7
RY4
CY4
CY5

A5 HF AMP

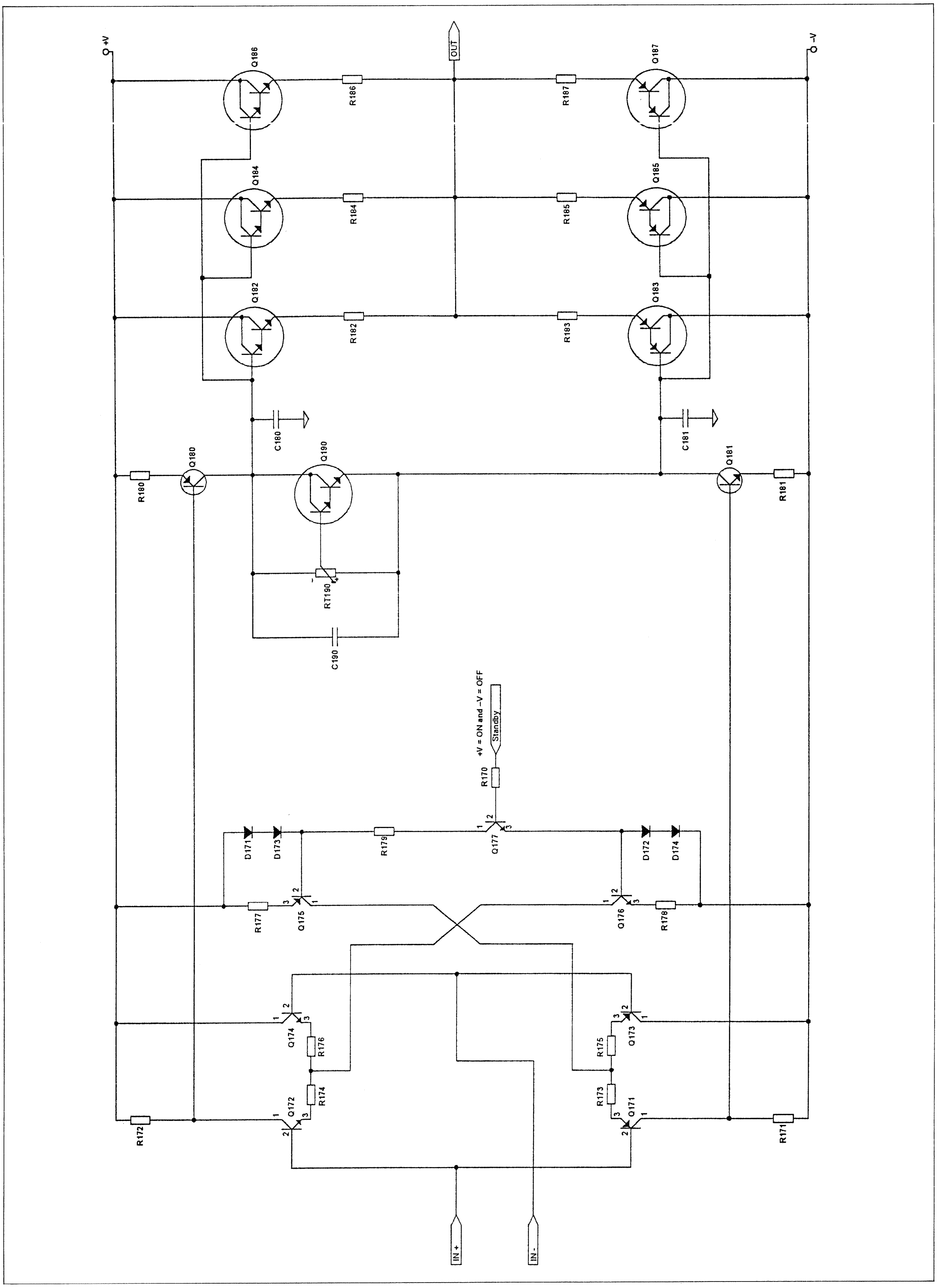


+V
-V
OUT
Q382
Q383
R382
R383
C380
C381
Q380
Q390
Q381
R380
R381
RT390
C390
+V = ON and -V = OFF
Standby
R370
Q377
R379
D371
D373
D372
D374
Q375
Q376
R377
R378
Q374
Q373
R376
R375
Q372
Q371
R374
R373
R372
R371
IN +
IN -

A5 MF AMP

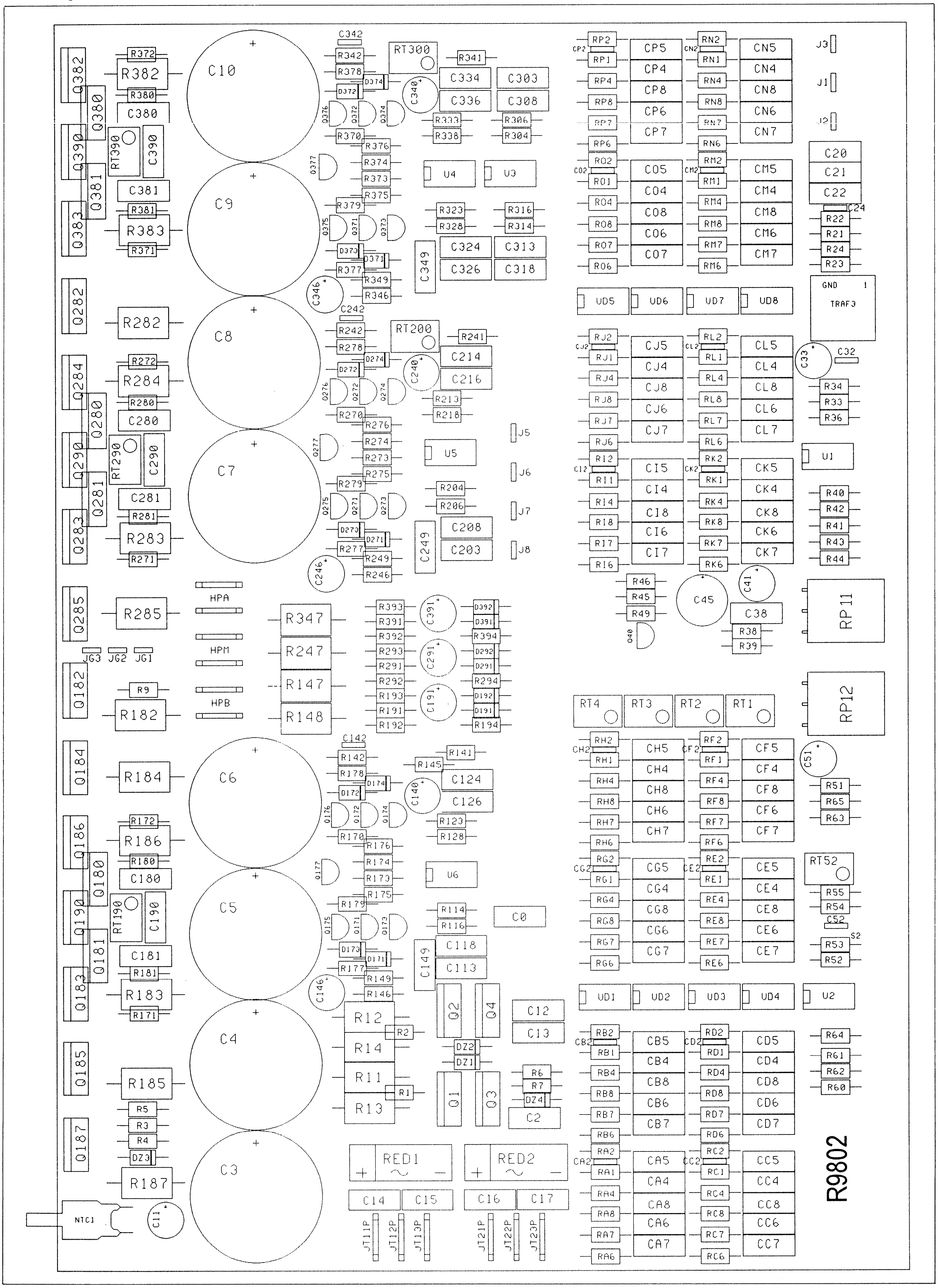

OUT
+V
-V
Q284
R284
R285
Q285
Q282
R282
R283
Q283
C280
Q290
C281
R280
Q280
Q281
R281
RT290
C290
+V = ON and -V = OFF
Standby
R270
Q277
D271
D273
R279
D272
D274
R277
Q275
Q276
R278
Q274
R276
Q273
R275
R274
Q272
R273
Q271
R272
R271
IN+
IN-

A5 LF AMP



+V
-V
OUT
Q186
Q187
Q184
Q185
Q182
Q183
R186
R187
R184
R185
R182
R183
C180
C181
Q180
Q181
Q190
R180
R181
RT190
C190
+V = ON and -V = OFF
Standby
R170
Q177
R179
D171
D173
D172
D174
R177
Q175
Q176
R178
Q174
Q173
R176
R175
R174
R173
Q172
Q171
R172
R171
IN +
IN -

A5 Layout


C342
RT300
R341
C334
C303
C336
C308
R372
R382
R380
C380
RT390
C390
C381
R381
R383
R371
Q382
Q380
Q390
Q381
Q383
C10
C9
R342
R378
D374
D372
C340
R303
R338
R306
R304
R370
R376
R374
R373
R375
R379
U4
U3
R323
R328
R316
R314
C324
C326
C313
C318
C349
D373
D371
R377
R349
R346
C346
Q282
R282
C8
C242
R242
R278
RT200
R241
C214
C216
D274
D272
C240
R213
R218
R272
R284
R280
C280
RT290
C290
C281
R281
R283
R271
Q284
Q280
Q290
Q281
Q283
C7
R270
R276
R274
R273
R275
R279
U5
J5
J6
J7
J8
R204
R206
C208
C203
C249
D273
D271
R277
R249
R246
C246
Q285
R285
HPA
HPM
HPB
JG3
JG2
JG1
R347
R247
R147
R148
R393
R391
R392
R293
R291
R292
R193
R191
R192
C391
C291
C191
D392
D391
R394
D292
D291
R294
D192
D191
R194
Q182
R9
R182
Q184
R184
C6
C142
R142
R178
D174
D172
R145
R141
C124
C126
C140
R123
R128
R170
R176
R174
R173
R175
R179
U6
R114
R116
C0
C118
C113
C149
R177
R149
R146
C146
Q186
R172
R186
R180
C180
RT190
C190
C181
R181
R183
R171
Q180
Q190
Q181
Q183
C5
C4
C3
R12
R2
R14
R11
R1
R13
Q2
Q4
Q1
Q3
C12
C13
DZ2
DZ1
R6
R7
DZ4
C2
Q185
R185
R5
R3
R4
DZ3
Q187
R187
NTC1
C11
RED1
RED2
C14
C15
C16
C17
JT11P
JT12P
JT13P
JT21P
JT22P
JT23P
RP2
RP1
RP4
RP8
RP7
RP6
CP5
CP4
CP8
CP6
CP7
RN2
RN1
RN4
RN8
RN7
RN6
CN5
CN4
CN8
CN6
CN7
J3
J1
J2
RO2
RO1
RO4
RO8
RO7
RO6
CO5
CO4
CO8
CO6
CO7
RM2
RM1
RM4
RM8
RM7
RM6
CM5
CM4
CM8
CM6
CM7
C20
C21
C22
C24
R22
R21
R24
R23
GND
TRAF3
UD5
UD6
UD7
UD8
C33
C32
R34
R33
R36
U1
R40
R42
R41
R43
R44
R46
R45
R49
C45
C41
C38
R38
R39
RP11
RP12
RT4
RT3
RT2
RT1
C51
R51
R65
R63
RT52
R55
R54
C52
R53
R52
UD1
UD2
UD3
UD4
U2
R64
R61
R62
R60
R9802

A5 Parts List

Ref.	Value
C0	not used
C2	Polyester, 7.5 mm, 220 nF / 100V
C3	Electrolytic, radial, 3300 µF / 50V
C4	Electrolytic, radial, 3300 µF / 50V
C5	Electrolytic, radial, 3300 µF / 50V
C6	Electrolytic, radial, 3300 µF / 50V
C7	Electrolytic, radial, 3300 µF / 50V
C8	Electrolytic, radial, 3300 µF / 50V
C9	Electrolytic, radial, 3300 µF / 50V
C10	Electrolytic, radial, 3300 µF / 50V
C11	Electrolytic, radial, 22 µF / 63V
C12	Polyester, 7.5 mm, 220 nF / 100V
C13	Polyester, 7.5 mm, 220 nF / 100V
C14	Polyester, 7.5 mm, 100 nF / 100V
C15	Polyester, 7.5 mm, 100 nF / 100V
C16	Polyester, 7.5 mm, 100 nF / 100V
C17	Polyester, 7.5 mm, 100 nF / 100V
C20	Polyester, 7.5 mm, 1 nF / 630V
C21	Polyester, 7.5 mm, 1 nF / 630V
C22	Polyester, 7.5 mm, 1 nF / 630V
C24	not used
C32	Ceramic, 220 pF
C33	Electrolytic, radial, 22 µF / 63V
C38	Polyester, 7.5 mm, 220 nF / 100V
C41	Electrolytic, radial, 22 µF / 63V
C45	Electrolytic, radial, 470 µF / 25V
C51	Electrolytic, radial, 22 µF / 63V
C52	Ceramic, 220 pF
C113	Polyester, 7.5 mm, 220 nF / 100 V
C118	Polyester, 7.5 mm, 220 nF / 100 V
C124	Polyester, 7.5 mm, 100 nF / 100 V
C126	Polyester, 7.5 mm, 47 nF / 100 V
C140	Electrolytic, radial, 22 µF / 63 V
C142	Ceramic, 100 pF
C146	Electrolytic, radial, 22 µF / 63 V
C149	not used
C180	Polyester, 7.5 mm, 1 nF / 630 V
C181	Polyester, 7.5 mm, 1 nF / 630 V
C190	Polyester, 7.5 mm, 220 nF / 100 V
C191	Electrolytic, radial, 22 µF / 63 V
C203	Polyester, 7.5 mm, 100 nF / 100 V
C208	Polyester, 7.5 mm, 100 nF / 100 V
C214	Polyester, 7.5 mm, 2.2 nF / 630 V
C216	Polyester, 7.5 mm, 22 nF / 250 V
C240	Electrolytic, radial, 22 µF / 63 V
C242	Ceramic, 100 pF
C246	Electrolytic, radial, 22 µF / 63 V
C249	not used
C280	Polyester, 7.5 mm, 1 nF / 630 V
C281	Polyester, 7.5 mm, 1 nF / 630 V
C290	Polyester, 7.5 mm, 220 nF / 100 V
C291	Electrolytic, radial, 22 µF / 63 V
C303	Polyester, 7.5 mm, 10 nF / 250 V
C308	Polyester, 7.5 mm, 10 nF / 250 V
C313	Polyester, 7.5 mm, 10 nF / 250 V
C318	Polyester, 7.5 mm, 10 nF / 250 V
C324	Polyester, 7.5 mm, 1 nF / 630 V
C326	Polyester, 7.5 mm, 10 nF / 250 V
C334	Polyester, 7.5 mm, 1 nF / 630 V
C336	Polyester, 7.5 mm, 4.7 nF / 400 V
C340	Electrolytic, radial, 22 µF / 63 V
C342	Ceramic, 100 pF
C346	Electrolytic, radial, 22 µF / 63 V
C349	not used
C380	Polyester, 7.5 mm, 1 nF / 630 V
C381	Polyester, 7.5 mm, 1 nF / 630 V
C390	Polyester, 7.5 mm, 220 nF / 100 V
C391	Electrolytic, radial, 22 µF / 63 V

Ref.	Value
CA2	Ceramic, 100 pF
CA4	not used
CA5	Polyester, 7.5 mm, 10 nF / 250 V
CA6	Polyester, 7.5 mm, 10 nF / 250 V
CA7	Polyester, 7.5 mm, 10 nF / 250 V
CA8	Polyester, 7.5 mm, 10 nF / 250 V
CB2	Ceramic, 100 pF
CB4	not used
CB5	Polyester, 7.5 mm, 1 nF / 630 V
CB6	Polyester, 7.5 mm, 2.2 nF / 630 V
CB7	Polyester, 7.5 mm, 2.2 nF / 630 V
CB8	Polyester, 7.5 mm, 2.2 nF / 630 V
CC2	Ceramic, 100 pF
CC4	not used
CC5	Polyester, 7.5 mm, 2.2 nF / 630 V
CC6	Polyester, 7.5 mm, 4.7 nF / 400 V
CC7	Polyester, 7.5 mm, 4.7 nF / 400 V
CC8	Polyester, 7.5 mm, 4.7 nF / 400 V
CD2	Ceramic, 100 pF
CD4	not used
CD5	Polyester, 7.5 mm, 1 nF / 630 V
CD6	Polyester, 7.5 mm, 2.2 nF / 630 V
CD7	Polyester, 7.5 mm, 2.2 nF / 630 V
CD8	Polyester, 7.5 mm, 2.2 nF / 630 V
CE2	Ceramic, 100 pF
CE4	not used
CE5	Polyester, 7.5 mm, 2.2 nF / 630 V
CE6	Polyester, 7.5 mm, 4.7 nF / 400 V
CE7	Polyester, 7.5 mm, 4.7 nF / 400 V
CE8	Polyester, 7.5 mm, 4.7 nF / 400 V
CF2	Ceramic, 100 pF
CF4	not used
CF5	Polyester, 7.5 mm, 2.2 nF / 630 V
CF6	Polyester, 7.5 mm, 4.7 nF / 400 V
CF7	Polyester, 7.5 mm, 4.7 nF / 400 V
CF8	Polyester, 7.5 mm, 4.7 nF / 400 V
CG2	Ceramic, 100 pF
CG4	not used
CG5	Polyester, 7.5 mm, 1 nF / 630 V
CG6	Polyester, 7.5 mm, 2.2 nF / 630 V
CG7	Polyester, 7.5 mm, 2.2 nF / 630 V
CG8	Polyester, 7.5 mm, 2.2 nF / 630 V
CH2	Ceramic, 100 pF
CH4	not used
CH5	Polyester, 7.5 mm, 1 nF / 630 V
CH6	Polyester, 7.5 mm, 2.2 nF / 630 V
CH7	Polyester, 7.5 mm, 2.2 nF / 630 V
CH8	Polyester, 7.5 mm, 2.2 nF / 630 V
CI2	Ceramic, 100 pF
CI4	not used
CI5	Polyester, 7.5 mm, 1 nF / 630 V
CI6	Polyester, 7.5 mm, 1 nF / 630 V
CI7	Polyester, 7.5 mm, 1 nF / 630 V
CI8	Polyester, 7.5 mm, 1 nF / 630 V
CJ2	Ceramic, 100 pF
CJ4	not used
CJ5	Polyester, 7.5 mm, 1 nF / 630 V
CJ6	Polyester, 7.5 mm, 2.2 nF / 630 V
CJ7	Polyester, 7.5 mm, 2.2 nF / 630 V
CJ8	Polyester, 7.5 mm, 2.2 nF / 630 V

Ref.	Value
CK2	not used
CK4	not used
CK5	not used
CK6	not used
CK7	not used
CK8	not used
CL2	Ceramic, 100 pF
CL4	not used
CL5	Polyester, 7.5 mm, 1 nF / 630 V
CL6	Polyester, 7.5 mm, 2.2 nF / 630 V
CL7	Polyester, 7.5 mm, 2.2 nF / 630 V
CL8	Polyester, 7.5 mm, 2.2 nF / 630 V
CM2	Ceramic, 100 pF
CM4	not used
CM5	Polyester, 7.5 mm, 1 nF / 630 V
CM6	Polyester, 7.5 mm, 2.2 nF / 630 V
CM7	Polyester, 7.5 mm, 2.2 nF / 630 V
CM8	Polyester, 7.5 mm, 2.2 nF / 630 V
CN2	not used
CN4	not used
CN5	not used
CN6	not used
CN7	not used
CN8	not used
CO2	Ceramic, 100 pF
CO4	not used
CO5	Polyester, 7.5 mm, 1 nF / 630 V
CO6	Polyester, 7.5 mm, 2.2 nF / 630 V
CO7	Polyester, 7.5 mm, 2.2 nF / 630 V
CO8	Polyester, 7.5 mm, 2.2 nF / 630 V
CP2	Ceramic, 100 pF
CP4	not used
CP5	Polyester, 7.5 mm, 1 nF / 630 V
CP6	Polyester, 7.5 mm, 2.2 nF / 630 V
CP7	Polyester, 7.5 mm, 2.2 nF / 630 V
CP8	Polyester, 7.5 mm, 2.2 nF / 630 V
D171	1N4935, fast recovery
D172	1N4935, fast recovery
D173	1N4935, fast recovery
D174	1N4935, fast recovery
D191	1N4935, fast recovery
D192	1N4935, fast recovery
D271	1N4935, fast recovery
D272	1N4935, fast recovery
D273	1N4935, fast recovery
D274	1N4935, fast recovery
D291	1N4935, fast recovery
D292	1N4935, fast recovery
D371	1N4935, fast recovery
D372	1N4935, fast recovery
D373	1N4935, fast recovery
D374	1N4935, fast recovery
D391	1N4935, fast recovery
D392	1N4935, fast recovery
DZ1	BZT03C, Z, 18 V
DZ2	BZT03C, Z, 18 V
DZ3	BZX85C, Z, 27 V
DZ4	BZX85C, Z, 27 V

A5 Parts List

Ref.	Value
J1	Flat pin, 2.8 mm
J2	Flat pin, 2.8 mm
J3	Flat pin, 2.8 mm
J5	Flat pin, 2.8 mm
J6	Flat pin, 2.8 mm
J7	Flat pin, 2.8 mm
J8	Flat pin, 2.8 mm
JG1	Flat pin, 2.8 mm
JG2	Flat pin, 2.8 mm
JG3	Flat pin, 2.8 mm
Jt11	Flat pin, 4.8 mm
Jt12	Flat pin, 4.8 mm
Jt13	Flat pin, 4.8 mm
Jt21	Flat pin, 4.8 mm
Jt22	Flat pin, 4.8 mm
Jt23	Flat pin, 4.8 mm
NTC1	150k, thread M3
Q1	TIP127 (PNP)
Q2	TIP122 (NPN)
Q3	TIP127 (PNP)
Q4	TIP122 (NPN)
Q40	BS170 (FET)
Q171	BC556B (PNP)
Q172	BC546B (NPN)
Q173	BC556B (PNP)
Q174	BC546B (NPN)
Q175	BC556B (PNP)
Q176	BC546B (NPN)
Q177	BC546B (NPN)
Q180	BD242C (PNP)
Q181	BD241C (NPN)
Q182	TIP122 (NPN)
Q183	TIP127 (PNP)
Q184	TIP122 (NPN)
Q185	TIP127 (PNP)
Q186	TIP122 (NPN)
Q187	TIP127 (PNP)
Q190	TIP122 (NPN)
Q271	BC556B (PNP)
Q272	BC546B (NPN)
Q273	BC556B (PNP)
Q274	BC546B (NPN)
Q275	BC556B (PNP)
Q276	BC546B (NPN)
Q277	BC546B (NPN)
Q280	BD242C (PNP)
Q281	BD241C (NPN)
Q282	TIP122 (NPN)
Q283	TIP127 (PNP)
Q284	TIP122 (NPN)
Q285	TIP127 (PNP)
Q290	TIP122 (NPN)
Q371	BC556B (PNP)
Q372	BC546B (NPN)
Q373	BC556B (PNP)
Q374	BC546B (NPN)
Q375	BC556B (PNP)
Q376	BC546B (NPN)
Q377	BC546B (NPN)
Q380	BD242C (PNP)
Q381	BD241C (NPN)
Q382	TIP122 (NPN)
Q383	TIP127 (PNP)
Q390	TIP122 (NPN)

Ref.	Value
R1	10k / 0.5 W
R2	10k / 0.5 W
R3	not used
R4	47k / 0.5 W
R5	100k / 0.5 W
R6	not used
R7	5k6 / 0.5 W
R9	1k / 0.5 W
R11	560Ω / 2 W
R12	560Ω / 2 W
R13	560Ω / 2 W
R14	560Ω / 2 W
R21	1k / 0.5 W
R22	1k / 0.5 W
R23	1k / 0.5 W
R24	1k / 0.5 W
R33	2k2 / 0.5 W
R34	10k / 0.5 W
R36	2k2 / 0.5 W
R38	not used
R39	10k / 0.5 W
R40	220Ω / 0.5 W
R41	33k / 0.5 W
R42	33k / 0.5 W
R43	33k / 0.5 W
R44	47Ω / 0.5 W
R45	47Ω / 0.5 W
R46	1k / 0.5 W
R49	100k / 0.5 W
R51	2k2 / 0.5 W
R52	4k7 / 0.5 W
R53	not used
R54	1k / 0.5 W
R55	4k7 / 0.5 W
R60	4k7 / 0.5 W
R61	100k / 0.5 W
R62	47k / 0.5 W
R63	10k / 0.5 W
R64	10k / 0.5 W
R65	10k / 0.5 W
R114	56k / 0.5 W
R116	5k6 / 0.5 W
R123	8k2 / 0.5 W
R128	8k2 / 0.5 W
R141	3k9 / 0.5 W
R142	22k / 0.5 W
R145	1k / 0.5 W
R146	12k / 0.5 W
R147	0Ω47 / 2 W
R148	0Ω47 / 2 W
R149	3k3 / 0.5 W
R170	220k / 0.5 W
R171	1k / 0.5 W
R172	1k / 0.5 W
R173	47Ω / 0.5 W
R174	47Ω / 0.5 W
R175	47Ω / 0.5 W
R176	47Ω / 0.5 W
R177	330Ω / 0.5 W
R178	330Ω / 0.5 W
R179	22k / 0.5 W
R180	100Ω / 0.5 W
R181	100Ω / 0.5 W
R182	1Ω / 2 W
R183	1Ω / 2 W
R184	1Ω / 2 W
R185	1Ω / 2 W
R186	1Ω / 2 W
R187	1Ω / 2 W
R191	10k / 0.5 W

Ref.	Value
R192	1k / 0.5 W2
R193	10k / 0.5 W
R194	100k / 0.5 W
R204	4k7 / 0.5 W
R206	3k9 / 0.5 W
R213	12k / 0.5 W
R218	10k / 0.5 W
R241	4k7 / 0.5 W
R242	22k / 0.5 W
R246	33k / 0.5 W
R247	0Ω47 / 2 W
R249	3k3 / 0.5 W
R270	220k / 0.5 W
R271	1k / 0.5 W
R272	1k / 0.5 W
R273	47Ω / 0.5 W
R274	47Ω / 0.5 W
R275	47Ω / 0.5 W
R276	47Ω / 0.5 W
R277	330Ω / 0.5 W
R278	330Ω / 0.5 W
R279	22k / 0.5 W
R280	100Ω / 0.5 W
R281	100Ω / 0.5 W
R282	1Ω / 2 W
R283	1Ω / 2 W
R284	1Ω / 2 W
R285	1Ω / 2 W
R291	1k / 0.5 W8
R292	220Ω / 0.5 W
R293	10k / 0.5 W
R294	100k / 0.5 W
R304	5k6 / 0.5 W
R306	3k3 / 0.5 W
R314	12k / 0.5 W
R316	4k7 / 0.5 W
R323	1k / 0.5 W8
R328	1k / 0.5 W8
R333	1k / 0.5 W8
R338	1k / 0.5 W8
R341	6k8 / 0.5 W
R342	22k / 0.5 W
R346	22k / 0.5 W
R347	0Ω47 / 2 W
R349	3k3 / 0.5 W
R370	220k / 0.5 W
R371	1k / 0.5 W
R372	1k / 0.5 W
R373	47Ω / 0.5 W
R374	47Ω / 0.5 W
R375	47Ω / 0.5 W
R376	47Ω / 0.5 W
R377	330Ω / 0.5 W
R378	330Ω / 0.5 W
R379	22k / 0.5 W
R380	100Ω / 0.5 W
R381	100Ω / 0.5 W
R382	1Ω / 2 W
R383	1Ω / 2 W
R391	330Ω / 0.5 W
R392	100Ω / 0.5 W
R393	10k / 0.5 W
R394	100k / 0.5 W
RA1	4k7 / 0.5 W
RA2	4k7 / 0.5 W
RA4	4k7 / 0.5 W
RA6	3k9 / 0.5 W
RA7	5k6 / 0.5 W
RA8	4k7 / 0.5 W

A5 Parts List

Ref.	Value	Ref.	Value
RB1	4k7 / 0.5 W	RL1	4k7 / 0.5 W
RB2	4k7 / 0.5 W	RL2	4k7 / 0.5 W
RB4	12k / 0.5 W	RL4	8k2 / 0.5 W
RB6	5k6 / 0.5 W	RL6	2k2 / 0.5 W
RB7	5k6 / 0.5 W	RL7	15k / 0.5 W
RB8	5k6 / 0.5 W	RL8	3k9 / 0.5 W
RC1	4k7 / 0.5 W	RM1	4k7 / 0.5 W
RC2	4k7 / 0.5 W	RM2	4k7 / 0.5 W
RC4	8k2 / 0.5 W	RM4	8k2 / 0.5 W
RC6	3k9 / 0.5 W	RM6	2k2 / 0.5 W
RC7	3k9 / 0.5 W	RM7	15k / 0.5 W
RC8	3k9 / 0.5 W	RM8	3k9 / 0.5 W
RD1	4k7 / 0.5 W	RN1	not used
RD2	4k7 / 0.5 W	RN2	not used
RD4	12k / 0.5 W	RN4	not used
RD6	5k6 / 0.5 W	RN6	not used
RD7	5k6 / 0.5 W	RN7	not used
RD8	5k6 / 0.5 W	RN8	not used
RE1	4k7 / 0.5 W	RO1	4k7 / 0.5 W
RE2	4k7 / 0.5 W	RO2	4k7 / 0.5 W
RE4	12k / 0.5 W	RO4	8k2 / 0.5 W
RE6	5k6 / 0.5 W	RO6	2k2 / 0.5 W
RE7	5k6 / 0.5 W	RO7	15k / 0.5 W
RE8	5k6 / 0.5 W	RO8	3k9 / 0.5 W
RF1	4k7 / 0.5 W	RP1	4k7 / 0.5 W
RF2	4k7 / 0.5 W	RP2	4k7 / 0.5 W
RF4	8k2 / 0.5 W	RP4	8k2 / 0.5 W
RF6	12k / 0.5 W	RP6	2k2 / 0.5 W
RF7	2k2 / 0.5 W	RP7	15k / 0.5 W
RF8	3k9 / 0.5 W	RP8	3k9 / 0.5 W
RG1	4k7 / 0.5 W	RP11	Potentiometer 10k, horizontal, PCB mount
RG2	4k7 / 0.5 W	RP12	Potentiometer 10k, horizontal, PCB mount
RG4	12k / 0.5 W		
RG6	not used	RT1	Trimmer potentiometer, 1k, vertical
RG7	2k7 / 0.5 W	RT2	Trimmer potentiometer, 1k, vertical
RG8	5k6 / 0.5 W	RT3	Trimmer potentiometer, 1k, vertical
		RT4	Trimmer potentiometer, 1k, vertical
RH1	4k7 / 0.5 W	RT52	Trimmer potentiometer, 10k, vertical
RH2	4k7 / 0.5 W	RT190	Trimmer potentiometer, 10k, vertical
RH4	6k8 / 0.5 W	RT200	Trimmer potentiometer, 1k, vertical
RH6	3k3 / 0.5 W	RT290	Trimmer potentiometer, 10k, vertical
RH7	3k3 / 0.5 W	RT300	Trimmer potentiometer, 1k, vertical
RH8	3k3 / 0.5 W	RT390	Trimmer potentiometer, 10k, vertical
RI1	4k7 / 0.5 W	RED1	Rectifier B 80C2300-1500
RI2	4k7 / 0.5 W	RED2	Rectifier B 80C2300-1500
RI4	8k2 / 0.5 W		
RI6	8k2 / 0.5 W	TRA3	Line input transformer Studer (..426.00)
RI7	8k2 / 0.5 W		
RI8	8k2 / 0.5 W	U1	TL072CP dual opamp
RJ1	4k7 / 0.5 W	U2	TL072CP dual opamp
RJ2	4k7 / 0.5 W	U3	TL072CP dual opamp
RJ4	8k2 / 0.5 W	U4	TL072CP dual opamp
RJ6	2k2 / 0.5 W	U5	TL072CP dual opamp
RJ7	15k / 0.5 W	U6	TL072CP dual opamp
RJ8	3k9 / 0.5 W		
		UD1	TL072CP dual opamp
RK1	not used	UD2	TL072CP dual opamp
RK2	not used	UD3	TL072CP dual opamp
RK4	not used	UD4	TL072CP dual opamp
RK6	not used	UD5	TL072CP dual opamp
RK7	not used	UD6	TL072CP dual opamp
RK8	not used	UD7	not used
		UD8	TL072CP dual opamp