TUBE ULTRAGAIN T1953

User's Manual

Version 1.2 December 2002

ENGLISH

www.behringer.com

BEHRINGER®
JUST LISTEN.

SAFETY INSTRUCTIONS

CAUTION: To reduce the risk of electric shock, do not remove the cover (or back). No user serviceable parts inside; refer servicing to qualified personnel.

WARNING: To reduce the risk of fire or electric shock, do not expose this appliance to rain or moisture.

This symbol, wherever it appears, alerts you to the presence of uninsulated dangerous voltage inside the enclosure—voltage that may be sufficient to constitute a risk of shock.

This symbol, wherever it appears, alerts you to important operating and maintenance instructions in the accompanying literature. Read the manual.

DETAILED SAFETY INSTRUCTIONS:
All the safety and operation instructions should be read before the appliance is operated.
Retain Instructions:
The safety and operating instructions should be retained for future reference.
Heed Warnings:
All warnings on the appliance and in the operating instructions should be adhered to.
Follow instructions:
All operation and user instructions should be followed.
Water and Moisture:
The appliance should not be used near water (e.g. near a bathtub, washbowl, kitchen sink, laundry tub, in a wet basement, or near a swimming pool etc.).
Ventilation:
The appliance should be situated so that its location or position does not interfere with its proper ventilation. For example, the appliance should not be situated on a bed, sofa, rug, or similar surface that may block the ventilation openings, or placed in a built-in installation, such as a bookcase or cabinet that may impede the flow of air through the ventilation openings.
Heat:
The appliance should be situated away from heat sources such as radiators, heat registers, stoves, or other appliances (including amplifiers) that produce heat.
Power Source:
The appliance should be connected to a power supply only of the type described in the operating instructions or as marked on the appliance.
Grounding or Polarization:
Precautions should be taken so that the grounding or polarization means of an appliance is not defeated.
Power-Cord Protection:
Power supply cords should be routed so that they are not likely to be walked on or pinched by items placed upon or against them, paying particular attention to cords and plugs, convenience receptacles and the point where they exit from the appliance.
Cleaning:
The appliance should be cleaned only as recommended by the manufacturer.
Non-use Periods:
The power cord of the appliance should be unplugged from the outlet when left unused for a long period of time.
Debris and Liquid Entry:
Care should be taken that debris and/or liquids do not enter the enclosure through openings.
Damage Requiring Service:
The appliance should be serviced by qualified service personnel when:
- The power supply cord or the plug has been damaged; or
- Debris or liquid has entered the appliance; or
- The appliance has been exposed to rain; or
- The appliance does not appear to operate normally or exhibits a marked change in performance; or
- The appliance has been dropped, or the enclosure damaged.

Servicing:
The user should not attempt to service the appliance beyond that which is described in the operating instructions. All other servicing should be referred to qualified service personnel.

FOREWORD

Dear Customer,

We thank you for expressing your confidence in BEHRINGER products by purchasing the BEHRINGER TUBE ULTRAGAIN. It is one of my most pleasant tasks to write this preface, as our engineering team has made it possible to enhance the traditional tube circuitry design (particularly for our VINTAGER series of products), and adapt it to meet the high sound quality and dynamics requirements of modern, pro-level audio technology. The fact that we are still fascinated by “antique” tube radios and amps as well as the fine and warm tonal character that we usually associate with them, are the reasons why vacuum tubes have kept their ground even in state-of-the-art circuit topologies used especially in professional audio technology or high-end devices. We are particularly proud that we have found an extremely effective symbiosis between solid-state and tube technologies making them affordable to anybody interested in audio technology. As always, our top-priority concern when developing this device was the demanding end user, in other words: you. It was our major goal to meet your demands. Sure, it meant a lot of hard work to develop such a product, but the fun has made it all worthwhile. The shine in the eyes of the many interested musicians at the Music Fair 1997, when they saw our VINTAGER models for the first time, was a lasting incentive driving our development efforts.

It is our philosophy to share our joy with you, because you are the most important member of the BEHRINGER family. With your highly competent suggestions for new products you’ve greatly contributed to shaping our company and making it successful. In return, we guarantee you uncompromising quality (manufactured under ISO9000 certified management system) as well as excellent technical and audio properties at an extremely favorable price. All of this will enable you to fully unfold your creativity without being hampered by budget constraints.

We are often asked how we can make it to produce such high-grade devices at such unbelievably low prices. The answer is quite simple: it’s you, our customers! Many satisfied customers means large sales volumes enabling us to get better conditions of purchase for components, etc. Isn’t it only fair to pass this benefit back to you? Because we know that your success is our success, too!

I would like to thank all people whose help on “Project TUBE ULTRAGAIN” has made it all possible. Everybody has made very personal contributions, starting from the designers of the unit via the many staff members in our company to you, the user of BEHRINGER products.

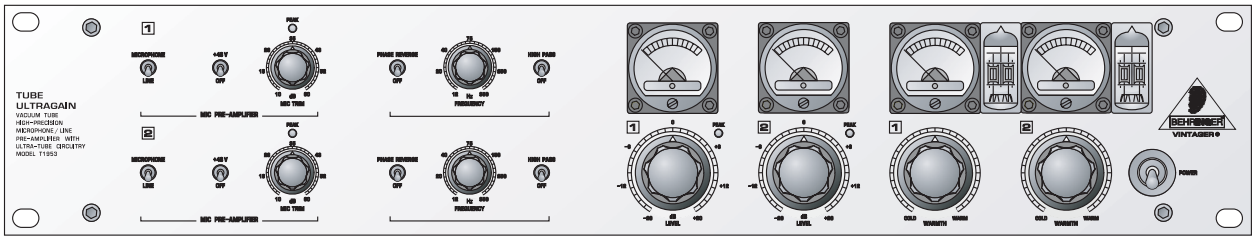
My friends, it’s been worth the trouble!

Thank you very much,

Uli Behringer

TUBE ULTRAGAIN

Tube Microphone/Line Preamplifier



▲ Ultra low-noise discrete microphone/line preamplifier with selected 12AX7 tubes

▲ ULTRA-TUBE circuitry (UTC) adds desired amount of warmth without additional noise

▲ Mic input stages are based on high quality, discrete conjugate transistor pair circuitry

▲ Ultra-wide bandwidth from 18 Hz to 30 kHz for open sound

▲ Warmth control allows precise dosage of desired tube effect

▲ Completely versatile DI-Box due to servo-balanced inputs and outputs

▲ Level converter from -10 dBV to +4 dBu

▲ Soft mute +48 V phantom power to avoid switch-on thumps

▲ Fully tunable and switchable 12 dB high-pass filter

▲ Switchable phase reverse to correct phase problems

▲ Ultra low-noise 4580 audio operational amplifiers offer outstanding sound performance

▲ Highly accurate metering with true RMS level detection

▲ Servo-balanced gold-plated XLR and 1/4" TRS inputs and outputs

▲ High-quality detented potentiometers and switches with vintage-style knobs

▲ Huge back-lit analog VU meters and stylish “retro” design

▲ BEHRINGER’s high-performance OT-1 output transformer retrofitable

▲ Manufactured under ISO9000 certified management system

TABLE OF CONTENTS

1. INTRODUCTION

With the TUBE ULTRAGAIN you have purchased an extremely musical and flexible microphone preamplifier. Our ULTRAGAIN range of devices has been a hit ever since we introduced our first model some 5 years ago. This high-end microphone preamp is based on many years of experience and findings in amplifier technology and is used throughout the world in renowned studios, sound reinforcement systems as well as in broadcast and television studios. Improving the legendary ULTRAGAIN even further was a real challenge, and we are proud of our success. The BEHRINGER TUBE ULTRAGAIN meets highest and no-compromise requirements in terms of operation, sound, specifications and workmanship.

Even at the conception of the TUBE ULTRAGAIN it was clear that we had to combine the outstanding technical specifications of our ULTRAGAIN with a warm tube sound. We are therefore proud to be able to present the TUBE ULTRAGAIN, a device featuring our newly developed UTC vacuum tube circuit combined with a no-compromise approach.

The heart of the TUBE ULTRAGAIN is an extremely low-noise microphone preamp circuit that uses discrete components to produce a highly transparent sound. In combination with our BEHRINGER tube technology, the operational amplifiers 4580 and a sophisticated circuit topology, the TUBE ULTRAGAIN yields excellent noise and distortion properties! The switchable +48 V phantom power supply allows for connecting almost any kind of microphone and suppresses power-up thumps with its “soft mute” function.

Our engineering team has made it possible to enhance the traditional tube circuitry (particularly for our TUBE ULTRAGAIN) and adapt it to meet the high sound quality and dynamics requirements of modern, pro-level audio technology. The fact that we are still fascinated by “antique” tube radios and amps as well as the fine and warm tonal character that we usually associate with them, are the reasons why vacuum tubes have kept their ground even in state-of-the-art circuit topologies used especially in professional audio technology or high-end devices. We are particularly proud that we have found a highly effective symbiosis between solid-state and tube technologies making them affordable to almost anybody in audio technology.

With the exception of 2 12AX7/ECC83 tubes, the TUBE ULTRAGAIN T1953 is based on SMD technology (Surface Mounted Device). These subminiature components known from aerospace applications ensure both extreme packing density and greater reliability.

Speaking of reliability: quality assurance plays an ever important role in today’s production methods. To guarantee even greater operational reliability, our products are manufactured under one of the most stringent industrial quality assurance systems: ISO9000. This European certification is granted exclusively to companies whose manufacturing processes are in full compliance with this accurate standard.

1.1 The concept

The philosophy behind BEHRINGER products guarantees a no-compromise circuit design and employs the best choice of components. The op-amps, type 4580, used in the TUBE ULTRAGAIN are chosen for their superior signal-to-noise ratio, low distortion and linear performance. Additionally, the TUBE ULTRAGAIN uses high quality resistors and capacitors with very tight tolerances, high-grade switches as well other selected components.

The TUBE ULTRAGAIN uses 12AX7 / ECC83 tubes. These triodes are capable of handling a large dynamic range with little microphony. Add to this their relative ruggedness and above average life span and you can see why it’s one of the most popular and reliable pre-amp tubes on the market. These features also ensure you their availability for many years to come.

Balanced inputs and outputs
As standard, the BEHRINGER TUBE ULTRAGAIN is installed with electronically servo-balanced inputs and outputs. The new circuit design features automatic hum and noise reduction for balanced signals and thus allows for trouble-free operation, even at high operating levels. Externally induced mains hum etc. will be effectively suppressed. The automatic servo-function recognizes the presence of unbalanced connectors and adjusts the nominal level internally to avoid level differences between the input and output signals (correction 6 dB).

Transformer-balanced outputs (optional)
In contrast to electronic balancing, the use of transformer-balanced outputs offers the advantage of galvanic separation between units. Electrical potential differences and ground loops in audio installations do not

therefore impair the performance of the units. The transformer-balanced outputs, commonly used in radio and TV engineering, can also be fitted retrospectively upon request. The BEHRINGER transformer OT-1 is designed to the highest exacting standards and is available as an accessory.

1.2 Before you get started

Your BEHRINGER TUBE ULTRAGAIN was carefully packed in the factory and the packaging was designed to protect the unit from rough handling. Nevertheless, we recommend that you carefully examine the packaging and its contents for any signs of physical damage, which may have occurred in transit.

☞ **If the unit is damaged, please do not return it to us, but notify your dealer and the shipping company immediately, otherwise claims for damage or replacement may not be granted. Shipping claims must be made by the consignee.**

The BEHRINGER TUBE ULTRAGAIN fits into two standard 19" rack units of space (3 1/2" / 89.5 mm). Please allow at least an additional 4" depth for the connectors on the back panel.

☞ **Be sure that there is enough space around the unit for cooling and please do not place the TUBE ULTRAGAIN on high temperature devices such as power amplifiers etc. to avoid overheating.**

The mains connection of the TUBE ULTRAGAIN is made by using the supplied cable. It meets all of the international safety certification requirements. Please make sure that all units have a proper ground connection.

☞ **Before you connect your TUBE ULTRAGAIN to the mains, please make sure that your local voltage matches the voltage required by the unit!**

As a standard the audio inputs and outputs on the BEHRINGER TUBE ULTRAGAIN are fully balanced. If possible, connect the unit to other devices in a balanced configuration to allow for maximum interference immunity. The automatic servo function detects unbalanced connections and compensates the level difference automatically (6 dB correction).

1.3 Control elements

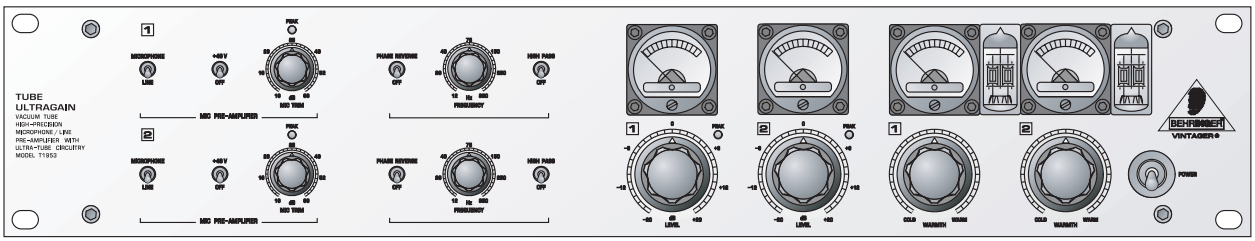


Fig. 1.1: Front panel of the TUBE ULTRAGAIN

The front panel of the BEHRINGER TUBE ULTRAGAIN consists of two identical channels with four switches, four rotary controls and 4 analog meters.

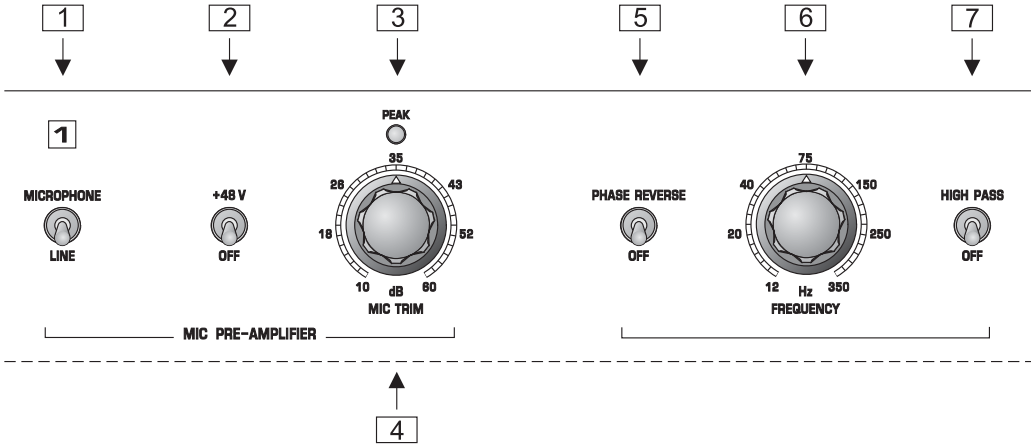


Fig. 1.2: Control elements on the front panel

1 Use the *MIC/LINE* switch to toggle between MIC and LINE modes. When the switch in up position, the unit works in MIC mode (now you can activate the +48 V switch if required; in LINE mode this function is disabled). The newly developed UTC circuitry is active in both modes.

☞ **Please note that the input phone jack is disabled in MIC mode, i.e. you must use the XLR connector to access the microphone amp.**

2 This *+48 V* switch activates the +48 V phantom power circuit that uses the signal leads to supply condenser microphones with the required operating voltage.

☞ **Please check the connected signal source for matching specifications before you switch phantom power on, so as to avoid damage to the microphone, etc.**

3 The *CLIP* LED signals that a level of at least +18 dBu is present after the microphone amp stage. With too high a level the CLIP LED warns you to reduce the gain with the MIC TRIM control, so as to avoid distortion caused by overloading. During normal operation, the LED should not light up at all.

4 The *MIC TRIM* control is enabled in MIC mode only and allows for applying gain from 10 to 60 dB to the input signal. In view of the extremely high gain levels that can be applied, you should verify that the gain control is properly set before you power up the unit. In case of doubt, set the control fully counter-clockwise, and start from there slowly raising the gain. High gain settings and the resulting levels can damage subsequent devices.

5 With the *PHASE REVERSE* switch the input signal is reversed in phase by 180°. This function is available both in MIC and LINE modes.

6 When the high pass filter is in high position, the *FREQUENCY* control defines the filter's cut-off frequency. With a setting range from 12 to 350 Hz the filter's main task is to eliminate bottom-end rumble noise, etc.

7 The *HIGH PASS* switch activates/deactivates the filter.

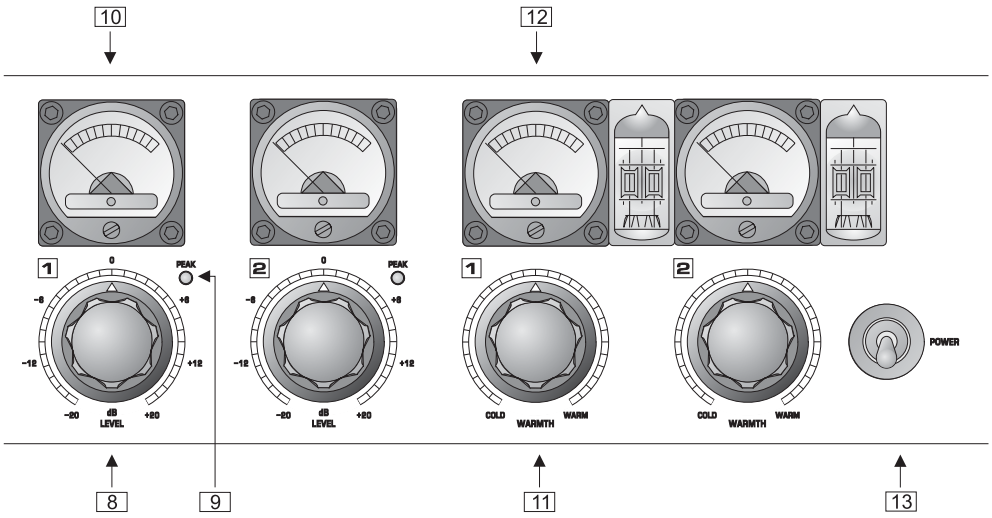


Fig. 1.3: Tube section of the TUBE ULTRAGAIN

8 Use the *LEVEL* control to set the signal gain at the input of the tube stage. The gain can be set from -20 to +20 dB, i.e. the signal can be attenuated or amplified by 20 dB. When the control is at its center position, the level is unaltered. This control is active in both MICROPHONE as well as LINE mode. Use this control to adapt the TUBE ULTRAGAIN to either home-recording level (-10 dBV) or professional level (+4 dBu). When this level is too low the tube effect becomes less audible and the signal-to-noise ratio deteriorates.

9 The *PEAK* LED above the LEVEL control warns you of overload of the unit. The LED should not light up during normal use. If the LED lights up frequently, reduce the level with the LEVEL control to avoid distortion.

10 The *VU* meter displays the output level if the TUBE ULTRAGAIN in a range from -20 to +2 dB. The 0 dB marker corresponds to the studio reference level of +4 dBu. Set the LEVEL control so that the level meter just touches the red zone. Always try to optimize the signal-to-noise ratio using this meter.

11 With the *WARMTH* control you can set the amount of harmonics that are added to the original signal. This controls the tube sound.

12 The *WARMTH* meter displays the amount of added harmonics. With this meter you can easily reach an optimum setting for the WARMTH control.

13 With the *POWER* switch the TUBE ULTRAGAIN is turned off and on. You should always make sure that the POWER switch is in the “Off” position when initially connecting the unit to the mains.

☞ **Please note that the POWER switch does not completely disconnect the device from the mains. If the device is not in use for a long period of time, please disconnect it from the mains by unplugging the power cord from the power socket.**

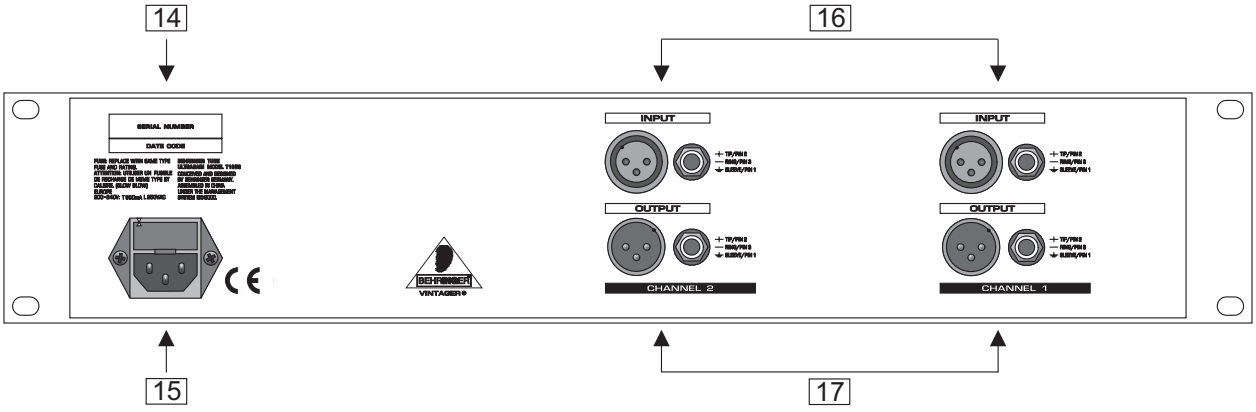


Fig 1.4: Back panel of the TUBE ULTRAGAIN

14 *SERIAL NUMBER*. Please complete and return the warranty card within 14 days of the date of purchase. Otherwise, you will lose your right to the extended warranty. Alternatively, you can register online at our website under www.behringer.com.

15 *FUSE HOLDER / VOLTAGE SELECTION*. Before connecting the T1953, confirm that the voltage display matches your local mains voltage. When replacing the fuse, you must always use the same type. In many units the fuse holder can be installed in one of two positions, allowing you to switch between 230 V and 120 V. If you wish to operate a unit outside Europe at 120 V, then a stronger fuse must be used (see chapter 6 “SPECIFICATIONS”). The mains connection is made via the IEC receptacle. An appropriate mains cable is included.

16 *AUDIO IN*. These are the audio inputs of your TUBE ULTRAGAIN, available both as balanced 1/4" TRS and XLR connectors. The XLR connector is the common mic/line input. Both the XLR and the jack connector accept unbalanced as well as balanced signals. See chapter 5 “INSTALLATION” when wiring unbalanced.

17 *AUDIO OUT*. These are the audio outputs of your TUBE ULTRAGAIN. Matching 1/4" TRS and XLR connectors are wired in parallel. The nominal level is +4 dBu. The maximum output level is +16 dBu.

2. OPERATION

Before you can use the BEHRINGER TUBE ULTRAGAIN as a preamp, we recommend that you study the various functions of the device. The high gain factors provided by the microphone preamp can produce extreme levels on the output side, which may damage subsequent devices. So, you should start with the following basic setting:

Contol element	Setting
+48 V switch	OFF
MIC TRIM control	10 dB
MICROPHONE/LINE switch	LINE
PHASE REVERSE switch	OFF
HIGH PASS switch	OFF
LEVEL control	0 dB

Tab. 2.1: Basic setup of the TUBE ULTRAGAIN

Reduce the volume level of the subsequent audio system to a minimum, and connect a microphone to the XLR input connector on the BEHRINGER TUBE ULTRAGAIN. Use either the 1/4" TRS or XLR output connectors to connect the audio system. Owing to its output-side servo-balancing circuit, the TUBE ULTRAGAIN detects whether you use a balanced or unbalanced configuration and adjusts the level internally.

Now, power up the entire equipment and press the MIC/LINE switch upwards to activate the microphone preamp. If you wish to use a condenser mic requiring +48 V phantom power, please press the +48 V switch.

☞ **Please make sure that you are using an appropriate microphone before you switch on the +48 V supply. Read the operating instructions accompanying the microphone. Some condenser mics might need another type of power supply, older dynamic microphones could be damaged by the +48 V voltage, and unbalanced microphones should never be operated in combination with a +48 V power supply.**

Configure the equipment according to the application on hand, speak into the microphone and turn the GAIN control clockwise until the 0 dB LED lights up. If your DAT recorder, mixing console or other subsequent devices have high-precision level meters, you can use these to verify the correct level setting.

The maximum output level depends on the device that follows next in the audio chain, and must therefore be set specifically. The high-precision level meter on the TUBE ULTRAGAIN indicates the current operating level. The CLIP LED lights up at a level of +18 dBu signaling that you have an additional headroom of 5 dB available, before the microphone preamp starts overloading. If distortion/overloading occurs at high volume levels, you should reduce the gain with the MIC TRIM control.

The LEVEL control
The LEVEL control sets the signal gain at the input of the tube stage. Use this control to adapt the TUBE ULTRAGAIN to either home recording level (-10 dBV) or professional level (+4 dBu). When this level is too low the tube effect becomes less audible and the signal-to-noise ratio deteriorates.

To obtain the best possible signal-to-noise ratio and subsequently the best possible sound, keep an eye on the VU level meter. If the level at the input of the tube stage is to low you will lose the tube sound and have a higher noise floor. Use the CLIP LED above the meter to ensure that the level is not set too high. This LED may light up briefly at signal peaks but should never light up constantly.

When using the TUBE ULTRAGAIN as microphone amplifier, set the LEVEL control to 0 dB for optimum signal-to-noise ratio. Adjust the sensitivity with the MIC TRIM controls. If so desired you can even overdrive the tube stages deliberately to gain a special effect. When the tubes are overdriven severely the effect resembles the overdriving of a guitar amp. This is completely different from the subtle effect of the WARMTH control. Use the controls with discretion, remember: less is more.

The PHASE REVERSE switch
The PHASE REVERSE switch reverses the audio signal's phase by 180°. Usually, you won't need this switch. However, in some cases, it might be necessary to reverse the signal phase, for example, if a microphone cable has been connected incorrectly (pins 2 and 3 interchanged), or if several microphones are used and specific circumstances with regard to room acoustics are causing problems (e.g. frequency cancellations are usually caused by phase problems). The phase reverse function will help you locate and eliminate any such problem.

The HIGH PASS switch
When you pick up acoustic signals with microphones, it is usually necessary to eliminate low-end signal portions, such as rumble or pop noise, or other interference frequencies. Often, such frequencies have very high amplitudes and do not only deteriorate the sound quality but can also damage the power amps or speakers. Your TUBE ULTRAGAIN features a tunable high pass filter with a very high slope. Activate the HIGH PASS switch and adjust the FREQUENCY control, so that any disturbing frequencies are faded out as much as possible, with the least damage done to the actual audio signals. Press/toggle the switch several times to make an A/B comparison.

The WARMTH control
The UTC circuitry forms an integral part of the BEHRINGER TUBE ULTRAGAIN. It provides the distinct tube sound. Gently turn the control clockwise to add increasing amounts of harmonics. It improves the transparency of other instruments, particularly those rich in upper harmonics. The WARMTH meters provide an instant overview of the process.

3. APPLICATIONS

This section describes some typical applications of the BEHRINGER TUBE ULTRAGAIN. Starting from the following basic settings you can use it to solve the majority of audio problems.

Please take your time to study the application examples, so as to be able to fully exploit the TUBE ULTRAGAIN and its variety of features.

Basically, the TUBE ULTRAGAIN can be used in five areas of application:

1. Using the TUBE ULTRAGAIN as a high-quality microphone preamp.
2. Using the TUBE ULTRAGAIN to convert home recording to studio levels, and vice versa.
3. Using the TUBE ULTRAGAIN to balance unbalanced signals (DI-box).
4. Using the TUBE ULTRAGAIN to enhance the sound of the program material by adding "tube warmth".

3.1 The TUBE ULTRAGAIN as a microphone preamp

Hook up a microphone and set the basics setting as described in chapter 2. Turn the WARMTH control fully counterclockwise and you have a very pure and neutral mic preamp with excellent noise and distortion figures. Turn the WARMTH control clockwise to increase the tube sound with the UTC tube stage.

3.2 The TUBE ULTRAGAIN as a level converter

Semi-professional devices in hi-fi and home recording environments are usually operated with a nominal level of -10 dBV (0.316 V), while the level used in studios is 0 dBu (0.775 V) or +4 dBu (1.23 V). So, when you connect devices of both types to each other, you should do this via some kind of level translator.

The BEHRINGER TUBE ULTRAGAIN is excellently suited for this application. In LINE mode, the LEVEL control allows you to raise or lower the input signal level by as much as 20 dB. The functions PHASE REVERSE and HIGH PASS are also enabled in this mode.

3.3 The TUBE ULTRAGAIN as a direct injection box

When electrical signals delivered by instruments such as guitars, keyboards, etc. are transported over long unbalanced lines, the transmission quality may be affected by hum or other interference signals induced in the cable. This problem is usually encountered in studio or stage environments, where long cable lengths and magnetic fields of great magnitude may produce interference.

So-called direct injection (DI)-boxes are used to counter this effect: the DI-box converts the unbalanced signal coming from the instrument into a balanced signal that is sent over the line. Interference induced in balanced cables is then eliminated by a subsequent balanced input stage.

Using the TUBE ULTRAGAIN for this kind of application is easy. Simply connect the line output of your keyboard to the 1/4" TRS input on the TUBE ULTRAGAIN. Then use the TUBE ULTRAGAIN's balanced output to send the signal to a stage box or other transmission chain. You can use both the XLR and jack connectors of the TUBE ULTRAGAIN. Set the unit to LINE mode, with any additional functions switched off (an exception being the LEVEL control which can be used to adjust levels, if necessary).

3.4 The TUBE ULTRAGAIN as tube interface

In your daily studio work, the TUBE ULTRAGAIN can be used for a variety of applications that provide subtle sound enhancement. For example, it gives percussion instruments more "punch", or improves the transparency of other instruments, particularly those rich in upper harmonics. The source material is enriched in sound volume and brilliance. Enhanced "depth" makes it easier to locate individual instruments. Vocal sounds gain in presence and volume, without masking other instruments. Thus, voices become a more integral part of the overall mix. Synthetic sounds, especially MIDI guitar sounds become more real and natural than without the TUBE ULTRAGAIN. So, with the TUBE ULTRAGAIN you can adopt a more active approach during the mixdown process and work out subtleties, while focusing particularly on the musical aspects of your recordings.

When the TUBE ULTRAGAIN is used as a microphone preamp or as line driver, this effect can be obtained at the recording stage. But tracks that are already laid can benefit from processing by the TUBE ULTRAGAIN. Make sure that the unit is switched to line, and that the PHASE REVERSE and HIGH PASS switches are not engaged. You can insert the TUBE ULTRAGAIN in the channel or subgroup inserts of your console. The TUBE ULTRAGAIN can also easily be used on the entire mix, when inserted in the main mix bus or as a serial devices between the desk and for instance a DAT recorder the whole mix can benefit from the warm tube sound.

4. TECHNICAL BACKGROUND

The steady development of modern sound reinforcement systems has made it possible to produce almost any level of loudness. Yet, the increase in loudness goes in line with a need for optimized audio quality. Today, audiences expect to hear a powerful and transparent sound. To fully understand how the BEHRINGER TUBE ULTRAGAIN works you will need to know the meaning of a decibel and how audio dynamics work.

With the TUBE ULTRAGAIN, as with any other type dynamics processor the amount of boost/attenuation applied is expressed in decibels (dB). What's a decibel? The abbreviation dB is not a unit (although often used as one), but describes a logarithmic proportion. The entire dynamic range of human hearing (from the threshold of audibility to a jet-airplane, see fig. 4.1) starts with about 0.00002 Pa (threshold of audibility) and goes up to 130 Pa (threshold of pain). This also means that 0 dB is not silence, minus infinity dB will mean absolute silence.

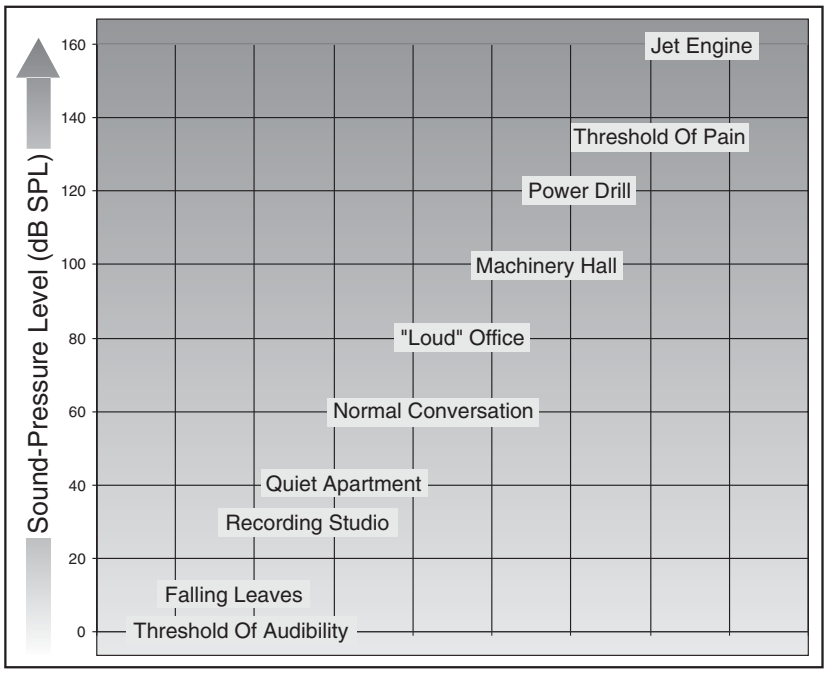


Fig. 4.1: Dynamic range of human hearing

The range of sound pressure levels or the dynamic range of human hearing encompasses a factor of 10,000,000. This enormous range of values is difficult to handle and additionally does not represent the subjective perception of sound, since human hearing tends to use a logarithmic curve. When an increase in loudness by the factor two is perceived as one step, four times the loudness level equals two steps. So, the decibel is a unit of measurement that describes a level in relation to a reference quantity. To make clear which reference quantity is meant, the abbreviation SPL (sound pressure level) is sometimes used together with dB. Starting with a value of 0 dB SPL (= $2*10^{-5}$ Pa) for the threshold of audibility, any dB values can be calculated by means of the following formula:

$$L = 20 \cdot \log \frac{p_2}{p_1}$$

L = e.g. the absolute sound pressure level in dB SPL
p_1 = e.g. a reference sound pressure of 0.00002 Pa
p_2 = the sound pressure (in Pa) produced by the sound source to be calculated
log = decimal logarithm.

As can be seen, human hearing has a very wide dynamic range of about 130 dB, which surpasses the range of a DAT or CD player with an approximate range of 96 dB. From a physical point of view, a 3 dB boost corresponds to an increase in power by the factor 2. However, the human ear perceives a signal to be twice as loud as before only if it is boosted by about 10 dB.

4.1 Audio dynamics

As demonstrated, it is possible to manufacture analog audio equipment with a dynamic range of up to 130 dB. In contrast to analog techniques, the dynamic range of digital equipment is approximately 25 dB less. With conventional record and tape recorder technology, as well as broadcasting, this value is further reduced. Generally, dynamic restrictions are due to noisy storage in transmission media and also the maximum headroom of these systems.

4.1.1 Noise as a physical phenomenon

All electrical components produce a certain level of inherent noise. Current flowing through a conductor leads to uncontrolled random electron movements. For statistical reasons, this produces frequencies within the whole audio spectrum. If these currents are highly amplified, the result will be perceived as noise. Since all frequencies are equally affected, we term this white noise. It is fairly obvious that electronics cannot function

without components. Even if special low-noise components are used, a certain degree of basic noise cannot be avoided.

This effect is similar when replaying a tape. The non-directional magnetic particles passing the replay head can also cause uncontrolled currents and voltages. The resulting sound of the various frequencies is heard as noise. Even the best possible tape biasing can “only” provide signal-to-noise ratios of about 70 dB, which is not acceptable today since the demands of listeners have increased. Due to the laws of physics, improving the design of the magnetic carrier is impossible using conventional means.

4.1.2 What are audio dynamics?

The human ear can detect the most wide ranging amplitude changes—from the slightest whisper to the deafening roar of a jet-plane. If one tried to record or reproduce this wide spectrum of sound with the help of amplifiers, cassette recorders, records or even digital recorders (CD, DAT etc.), one would immediately be restricted by the physical limitations of electronic and acoustic sound reproduction technology.

The usable dynamic range of electroacoustic equipment is limited as much at the low end as at the high end. The thermal noise of the electrons in the components results in an audible basic noise floor and thus represents the bottom limit of the transmission range. The upper limit is determined by the levels of the internal operating voltages; if they are exceeded, audible signal distortion is the result. Although in theory, the usable dynamic range sits between these two limits, it is considerably smaller in practice, since a certain reserve must be maintained to avoid distortion of the audio signal if sudden level peaks occur. Technically speaking, we refer to this reserve as “headroom”—usually this is about 10 - 20 dB. A reduction of the operating level would allow for greater headroom, i.e. the risk of signal distortion due to level peaks would be reduced. However, at the same time, the basic noise floor of the program material would be increased considerably.

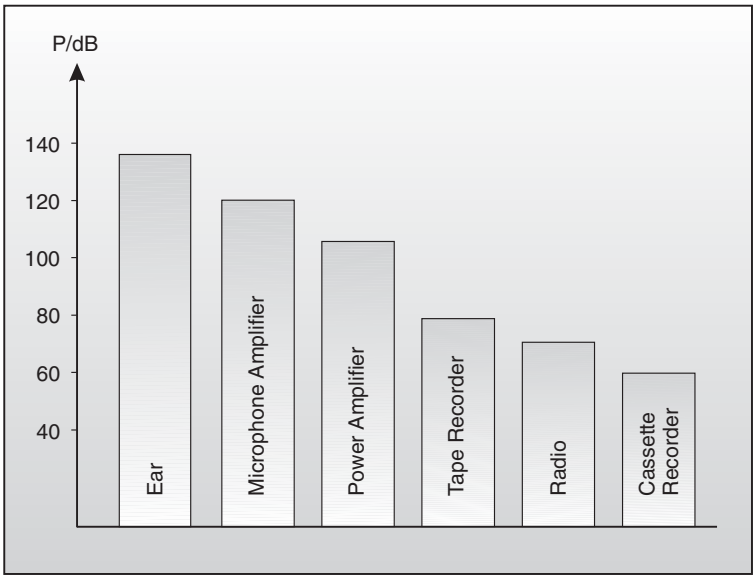


Fig. 4.2: The dynamic range capabilities of various devices

It is therefore useful to keep the operating level as high as possible without risking signal distortion in order to achieve optimum transmission quality.

It is possible to further improve the transmission quality by constantly monitoring the program material with the aid of a volume fader, which manually levels the material. During low passages the gain is increased, during loud passages the gain is reduced. Of course it is fairly obvious that this kind of manual control is rather restrictive; it is difficult to detect signal peaks and it is almost impossible to level them out. Manual control is simply not fast enough to be satisfactory.

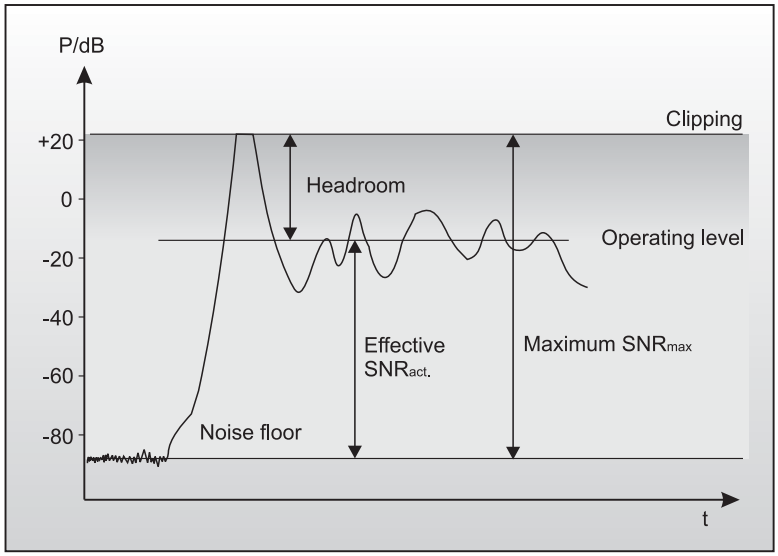


Fig. 4.3: The interactive relationship between operating level and headroom

The need therefore arises for a fast acting automatic gain control system which will constantly monitor the signals and which will always adjust the gain to maximize the signal-to-noise ratio without incurring signal distortion. This device is called a compressor or limiter.

4.2 The tubes used in the TUBE ULTRAGAIN

A closer look at developments and trends in audio technology shows that tubes are currently enjoying a renaissance, in a time when even amateur musicians are free to use digital effects processors and recording media, and ever more affordable digital mixing consoles are becoming a natural part of the equipment of many semi-professional studios. The manufacturers try with ever new algorithms to get the most out of DSP's (Digital Signal Processors), the heart of any digital system.

Still, many audio engineers, particularly old hands often prefer using both old and new tube-equipped devices. As they want to use their warm sound character for their productions, they are ready to accept that these "goodies" produce a higher noise floor than modern, transistor-based devices. As a consequence, you can find a variety of tube-based microphones, equalizers, preamps and compressors in today's recording and mastering environments. The combination of semiconductor and tube technologies gives you the additional possibility of using the best of both worlds, while being able to make up for their specific drawbacks.

4.3 Tube history

Due to many patent litigations, it is difficult to determine exactly when the tube was "born". First developments in tube technology were reported between 1904 and 1906. It was a research task of that time to find a suitable method for receiving and rectifying high frequencies. On April 12, 1905, a certain Mr. Fleming was granted a patent for his "hot-cathode valve" which was based on Edison's incandescent lamp. This valve was used as a rectifier for high-frequency signals. Robert van Lieben was the first to discover (probably by chance) that the anode current can be controlled by means of a perforated metal plate (grid), one of the milestones in the development of amplification tubes. In 1912, Robert van Lieben finally developed the first tube for the amplification of low-frequency signals. Initially, the biggest problem was to produce sufficient volume levels, which is why resonance step-ups (though impairing the frequency response) were used to maximize the attainable volume. Later, the objective was to optimize the electroacoustic transducers of amplifiers in such a way that a broad frequency band could be transmitted with the least distortion possible. However, a tube-specific problem is its non-linear amplification curve, i.e. it modifies the sound character of the source material. Despite all efforts to ensure a largely linear frequency response, it had to be accepted that tube devices produce a "bad" sound. Additionally, the noise floor generated by the tubes limited the usable dynamics of connected storage media (magnetic tape machines). Thus, a one-to-one reproduction of the audio signal's dynamics (expressed as the difference between the highest and lowest loudness levels of the program material) proved impossible. To top it all, tube devices required the use of high-quality and often costly transducers and sophisticated voltage supplies.

With the introduction of semiconductor technologies in the field of audio amplification it soon became clear that the tube would have to give way to the transistor, as this device featured an enormously enhanced signal-to-noise ratio, less complex power supply and improved frequency response. Plus, semiconductor-based circuits can be realized much more easily—for less money. Two decades later, the introduction of binary signal processing meant the beginning of a new era of recording media that provided plenty of dynamic response and allowed for loss-free copying of audio signals. As digital media were enhanced, however, many people began to miss the warmth, power and liveliness they knew from analog recordings. This is why purists still today consider digital recordings as “sterile” in sound.

4.4 Design and functional principle of tubes

Tubes can be roughly classified according to the number of electrodes they use. There are tubes with two, three or five electrodes usually referred to as diodes, triodes or pentodes.

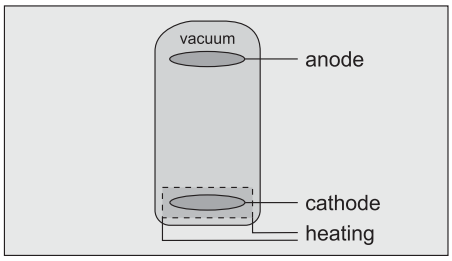


Fig. 4.4: Diode

The diode contains two electrodes in a vacuum glass bulb that have electrical connection to the outside. The vacuum allows for a free movement of electrons. When one of the electrodes is heated up (= thus becoming a cathode), it begins to emit electrons. When a positive dc voltage is applied to the other electrode (= anode), the negative electrons start to wander from the cathode to the anode. With reverse polarity between cathode and anode, a current flow is not possible because the unheated anode emits more or less no electrons. This design was used, for example, as a rectifier in the power supplies of amplifiers. The magnitude and velocity of the flow of electrons depend on the cathode’s temperature, the material it consists of, and the magnitude of the anode voltage. When the electrons hit the anode they produce heat that is dissipated by using large anode plates.

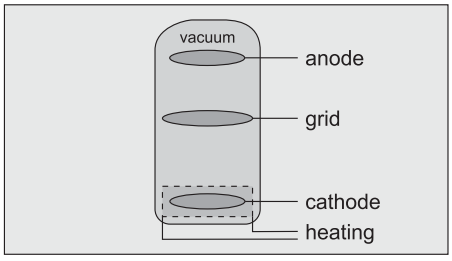


Fig. 4.5: Triode

The triode has an additional metal grid between anode and cathode. By applying a negative voltage, this grid can be used to control the internal resistance of the tube, and hence the anode current. When the grid bias voltage (voltage between cathode and grid) becomes negative, the current flowing to the anode is reduced because the negatively charged grid repels the arriving electrons. As a consequence, there are less electrons to reach the anode. When the bias voltage is raised towards zero, the flow of electrons accelerates. When it finally becomes zero or even positive, the grid current begins to flow which considerably reduces the current flowing to the anode and can possibly destroy the tube. Triodes are most commonly used in preamps, often in pairs arranged in one tube (twin triode).

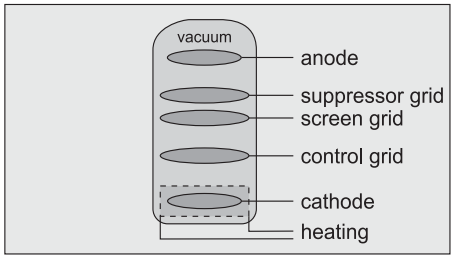


Fig. 4.6: Pentode

In a triode the capacitance between grid and anode is a problem with regard to high frequencies and large amplification factors. For this reason, the pentode has a positively charged screen grid between the control grid and the anode. However, the positive charge of the screen grid attracts electrons emitted from the anode plate when it is hit by arriving electrons. To prevent this electron emission, a decelerating or suppressor grid is placed between anode and screen grid. As it is negatively charged it blocks the electrons, so that they cannot reach the screen grid. Pentodes are most commonly used in power stages.

4.5 Properties of tubes

In general, the saturation (overdriving) of both transistor and tube-based circuits results in various types of distortion. These phenomena are quite complex in the real world, but for the sake of a straightforward mathematical description we are going to classify them as linear and non-linear distortion. Linear distortion is produced by frequency-dependent amplification or attenuation processes such as occurs in all kinds of filters and equalizers. Linear-distortion signals have the same frequency portions both on the input and output sides, but with different phase positions and amplitudes. Non-linear distortions have additional harmonics and distortion components that were not contained in the original input signal.

For example, when the plainest of all oscillations, a sine wave with a fixed frequency f, is overdriven, new oscillations with frequencies of 2*f, 3*f, etc. (integral multiples of the original frequency) are produced. These new frequencies are referred to as upper harmonics grouped as odd and even harmonics. Unlike the transistor, saturated tubes mostly produce even harmonics which are perceived by the human ear as more pleasant in sound than odd harmonics. Another important aspect lies in the fact that tubes produce distortion more gradually than transistors, which is why we speak of the “saturation” of a tube stage. When you overdrive a transistor you get a sudden square deformation of the sine signal applied at the input, which produces an extreme harmonic spectrum at the output.

Non-linear distortions are measured with a distortion factor that consists of the total harmonic distortion [k] and partial harmonic distortions [kn]. The latter are defined as the ratio between the voltage of a single harmonic and the voltage of the distorted overall signal. Thus, the content of even harmonics is expressed as k2, k4, ... and that of odd harmonics as k1, k3, ...

$$k_n = \frac{U_n}{U_{ges}}$$

Formula for calculating partial harmonic distortion

The total harmonic distortion is the root of all squared distortion factors of the second and third degrees. Since the higher harmonics have only little impact on the measured results, they can be neglected.

$$k = \sqrt{k_2^2 + k_3^2}$$

Formula for calculating total harmonic distortion

In tube circuits the distortion factor k2 is used to describe an effect which the human ear classifies as “pleasant”. Also the frequency bands in which distortion occurs play an important role because the human ear differentiates very clearly in the frequency range of human speech.

4.6 The best of both worlds

Despite many efforts neither manufacturers nor developers have succeeded so far in simulating these positive properties of the tube by means of other devices. Additionally, the natural capabilities of the tube to act as a soft limiter can only be mimicked with highly sophisticated circuitry. Today's studio technology requirements are therefore met by a combination of both high-grade semiconductor and tube technologies. In this context, tubes no longer serve their original purpose as amplifiers, but are used for the detailed shaping of sound.

4.7 UTC circuit

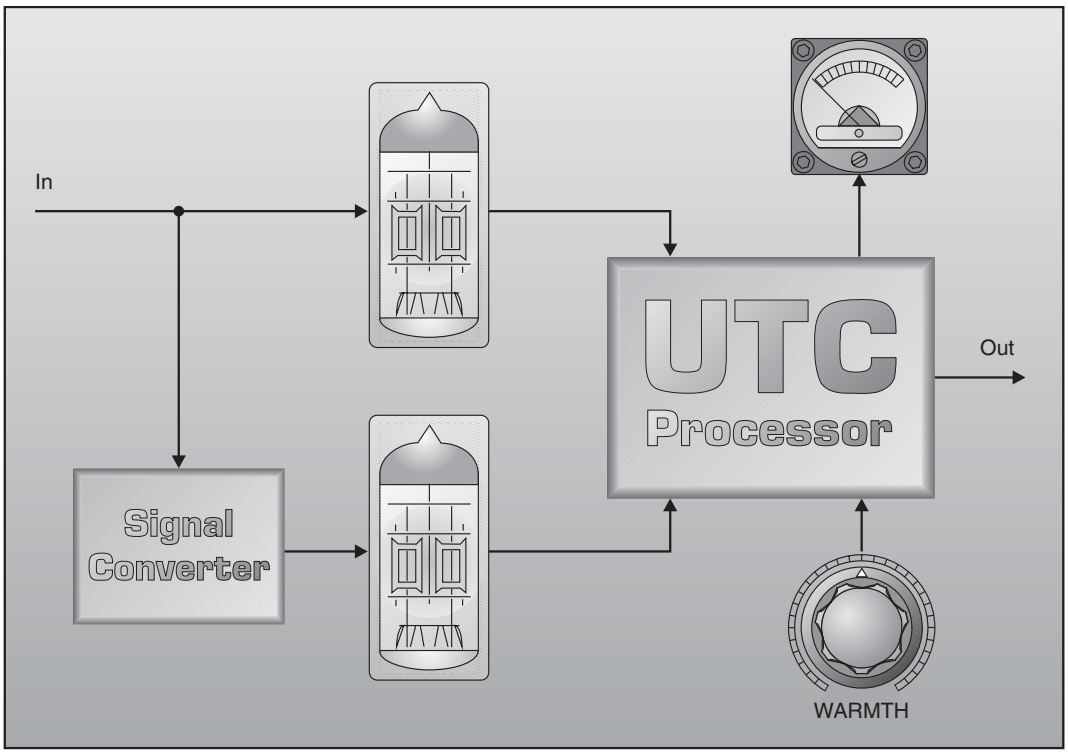


Fig. 4.7: UTC circuit

The TUBE ULTRAGAIN splits up the audio signal applied at the input and processes it differently for both signal paths. Each of the two tube halves amplifies the original signal and the signal modified in its phase spectrum (twin triode). Additional harmonics are produced by slightly overdriving the tube stage. When the two signals are processed by the UTC circuit, the interference noise found in conventional tube circuits can be largely eliminated, and the actual tube effect be added gradually. The more you turn the Warmth control to the right, the more tube sound will be added to the original signal.

4.8 Studio applications

In a recording studio tubes do not perform the same task as they do in an overdriven guitar amp, where the considerably higher saturation of the tube(s) leads to a full and often deliberate modification of the input signal (in many cases combined with a heavy increase in noise floor levels). In the studio more subtle effects are needed. Here, tube circuits add life to the signal's tonal character and increase its power to make itself heard. Often, tubes also increase the signal's perceived loudness (in relation to the unprocessed signal), i.e. the perceived loudness goes up although the volume level remains the same. This is because the dynamic range of the applied audio signal is limited by the tube circuit, while the amplitude of the signal with the lowest loudness is raised. Thus, increasing tube saturation produces a slight compression effect over the entire dynamic range.

A similar effect can be perceived when analog tape is saturated. This saturation effect also compresses the recorded audio material and produces additional harmonics.

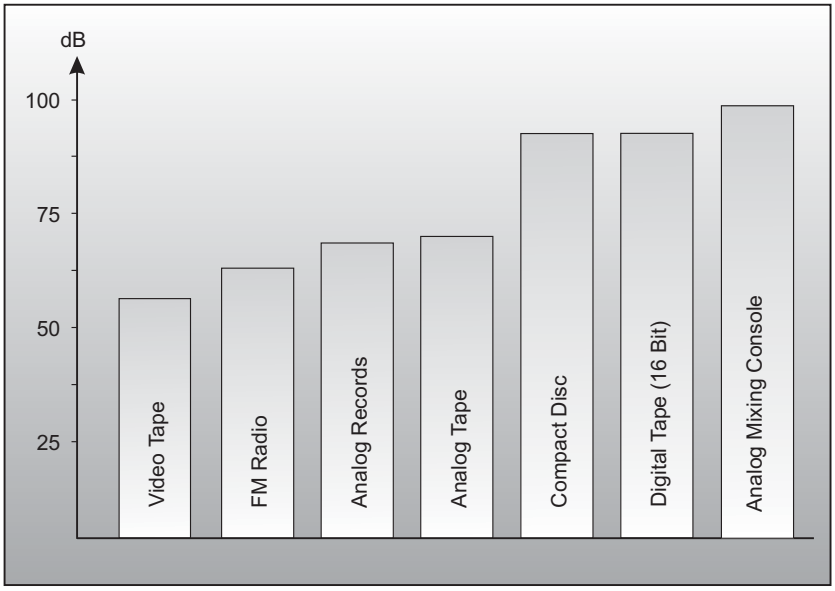


Fig. 4.8: Dynamic range of various media

4.9 Phantom power

Condenser microphones need a specific supply voltage polarizing the condenser diaphragm. This voltage can be furnished from an internal battery, or an external power supply that is either connected directly to the microphone or supplies the voltage through the microphone cable. In practice, this technique is usually referred to as +48 V or phantom power supply, and uses the microphone cable to carry both the audio signal and the supply voltage required for the microphone.

Please read this chapter thoroughly: phantom power can damage the microphone, if used improperly.

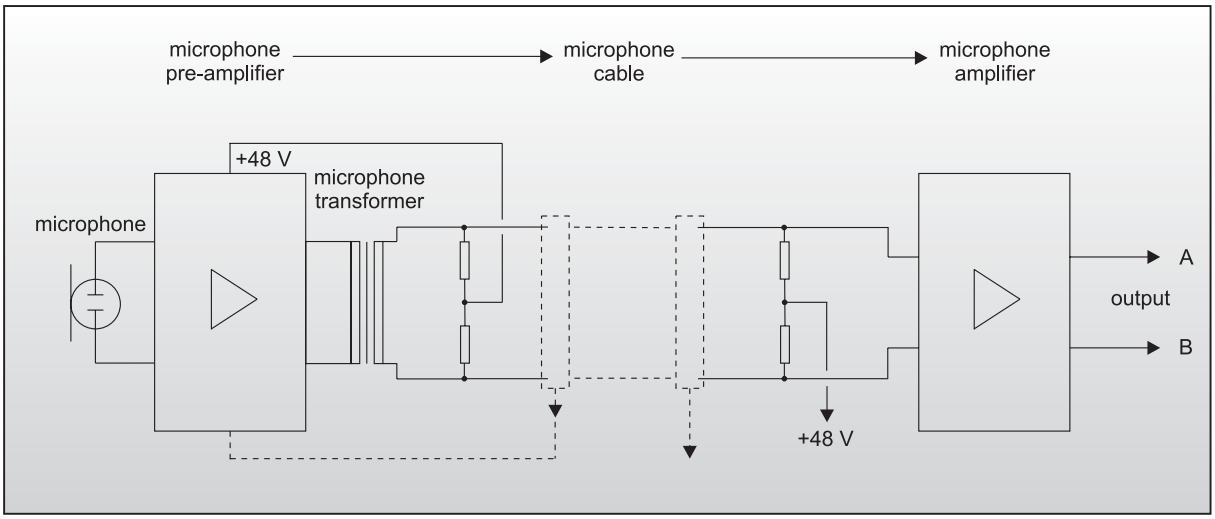


Fig. 4.9: Functional diagram of phantom power supply

We speak of phantom power when a microphone cable is used to carry several signals, with a DC voltage “layered” on the actual audio signal. The typical phantom DC voltage is +48 V, which is applied both to the positive (pin 2) and negative inputs (pin 3) of the XLR connector, using current-limiting resistors. As the phantom voltage is split up in a balanced configuration among the signal leads, there is no need to apply it directly to the microphone transducer or the microphone itself, where it could damage the transducer and/or capsule. In an unbalanced configuration, DC voltage would be applied directly, which would inevitably lead to disturbing noise or could even damage the electronics.

To eliminate this risk, the BEHRINGER TUBE ULTRAGAIN automatically disables the unbalanced jack in MIC mode. Microphones can thus only be connected to the XLR connector.

Never switch on the +48 V supply when you use unbalanced microphones, as this could cause electrical damage.

Some people hold that the sound of dynamic microphones is affected when the +48 V supply is on, or that ribbon microphones cannot be operated from an input equipped with +48 V phantom power. None of these statements is true. As a matter of fact, problems of this kind are caused by one of the following reasons:

1. When the output transformer of the microphone suffers from a short circuit or leakage current at any point, disturbing noise, clicks or hum can occur. In this case, you should have the microphone repaired.

2. When you connect a microphone while the +48 V supply is switched on, it cannot be guaranteed that both signal leads of the XLR connectors establish the electrical contact precisely at the same point of time. Therefore, detrimental current could flow because the connection is temporarily unbalanced. We recommend that you switch off the +48 V supply before you attempt to connect a microphone.

☞ **Please make sure that you are using an appropriate microphone before you switch on the +48 V supply. Read the operating instructions accompanying the microphone. Some condenser mics might need another type of power supply, older dynamic microphones could be damaged by the +48 V voltage, and unbalanced microphones should never be operated in combination with a +48 V power supply.**

5. INSTALLATION

5.1 Rack mounting

The BEHRINGER TUBE ULTRAGAIN fits into two standard 19" rack units of space (3 1/2" / 89.5 mm). Please allow at least an additional 4" / 10 cm depth for the connectors on the back panel. Be sure that there is enough air space around the unit for cooling and please do not place the TUBE ULTRAGAIN on high temperature devices such as power amplifiers etc. to avoid overheating.

5.2 Mains connection

The mains connection of the TUBE ULTRAGAIN is made by using a mains cable and a standard IEC receptacle. It meets all of the international safety certification requirements.

☞ **Please make sure that all units have a proper ground connection. For your own safety, it is advisable not to remove the ground connection within the units or at the supply, or fail to make this connection at all.**

Before you switch on the unit, check that it is configured to match your AC mains voltage requirements. If it does not comply, then it is necessary to switch the operating voltage to the correct supply requirements BEFORE turning on the unit, otherwise the unit could be severely damaged. You will find this combined fuse holder/voltage selector at the back, adjacent to the IEC receptacle. **IMPORTANT: This does not apply for general export models which are built for one operating voltage only.**

The AC voltage selection is defined by the position of the fuse holder. If you intend to change the operating voltage, remove the fuse holder and twist it by 180 degrees before you reinsert it. Matching the two markers monitors the selected voltage.

☞ **If the unit is switched to another operating voltage, the fuse rating must be changed. See the technical specifications in the appendix.**

A safety fuse protects the unit from serious defects. If the fuse blows, this is a warning sign and always indicates that the circuit is overloaded. The fault must always be repaired before the fuse is replaced. If the safety fuse is faulty and needs replacing after the unit is repaired, please make sure that you replace it only with the identical type and rating. NEVER use fuses of different ratings or cover faulty fuses with aluminium foil. This can cause fire and electric shocks and will endanger your life and the lives of others.

5.3 Audio connections

As standard, the BEHRINGER TUBE ULTRAGAIN is installed with electronically servo-balanced inputs and outputs. This circuit design features automatic hum and noise reduction for balanced signals and thus allows for trouble-free operation, even at high operating levels. Externally induced mains hum etc. will be effectively suppressed. The automatic servo-function recognizes the presence of unbalanced connectors and adjusts the nominal level internally to avoid level differences between the input and output signals (correction 6 dB).

☞ **Please ensure that only qualified persons install and operate the TUBE ULTRAGAIN. During installation and operation the user must have sufficient electrical contact to earth. Electrostatic charges might affect the operation of the TUBE ULTRAGAIN!**

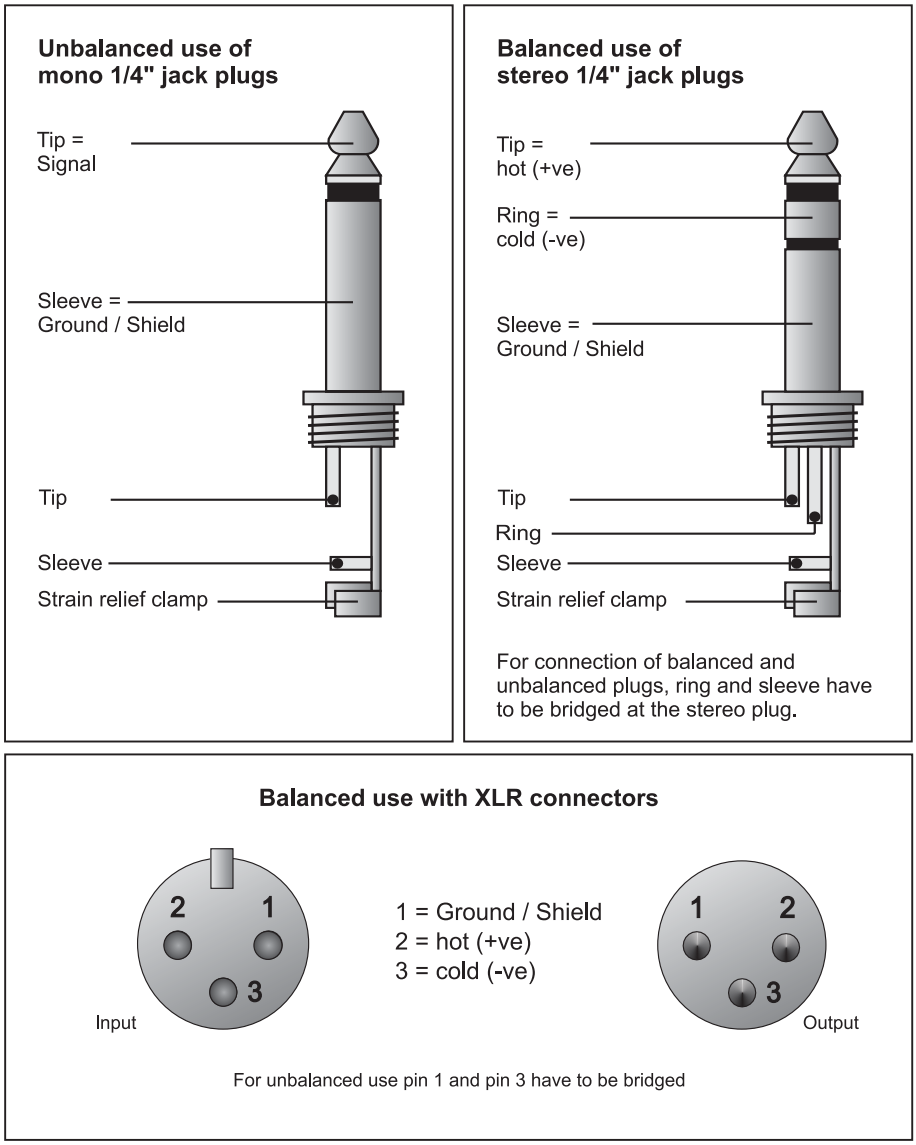


Fig. 5.1: Different plug types

5.4 Transformer-balanced output (option)

In contrast to electronic balancing, the use of transformer-balanced outputs offers the advantage of galvanic separation between units. Electrical potential differences and ground loops in audio installations do not therefore impair the performance of the units. The transformer-balanced outputs, commonly used in radio and TV engineering, can also be fitted retrospectively upon request. The BEHRINGER transformer OT-1 is designed to the highest exacting standards and is available as an accessory.

6. SPECIFICATIONS

Microphone inputs

Connections	XLR
Type	transformerless, DC-decoupled input
Impedance	3 kOhm balanced
Max. input level	+10 dBu balanced and unbalanced
CMRR	typical 40 dB, >55 dB @ 1 kHz

Line inputs

Connections	XLR and 1/4" TRS
Type	transformerless, DC-decoupled input stage
Impedance	50 kOhm balanced, 25 kOhm unbalanced
Max. input level	+23 dBu balanced and unbalanced
CMRR	typical 40 dB, >55 dB @ 1 kHz

Audio outputs

Connections	XLR and 1/4" TRS
Type	electronic, servo-balanced output stage
Impedance	60 Ohm balanced, 30 Ohm unbalanced
Max. output level	+21 dBu balanced and unbalanced

System specifications

Bandwidth	18 Hz to 30 kHz, +/- 3 dB
Signal-to-noise ratio	>108 dBu, unweighted, 22 Hz to 22 kHz

Controls

Mic trim	variable (+10 to +60 dB)
Frequency (High Pass)	variable (12 to 350 Hz)
Level	variable (-20 dB to +20 dB)
Warmth	variable (cold to warm)

Function switches

+48 V	engages the phantom power
Mic/Line	switches from line to microphone preamp
Phase reverse	phase reversal (180°)
High Pass	engages the high pass filter

Options

Output transformer	BEHRINGER OT-1 retrofittable

Power supply

Mains voltages	USA/Canada	120 V~, 60 Hz
	U.K./Australia	240 V~, 50 Hz
	Europe	230 V~, 50 Hz
	General Export Model	100 - 120 V~, 200 - 240 V~, 50 - 60 Hz
Power consumption	max. 30 Watts	
Fuse	100 - 120 V~: **T 1 A H**	
	200 - 240 V~: **T 500 mA H**	
Mains connection	standard IEC receptacle	

Physical

Dimension (H x W x D)	3 1/2" (89.5 mm) x 19" (482.6 mm) x 8 1/2" (217 mm)
Net weight	approx. 8 kg
Shipping weight	approx. 10 kg

BEHRINGER is constantly striving to maintain the highest professional standards. As a result of these efforts, modifications may be made from time to time to existing products without prior notice. Specifications and appearance may differ from those listed or shown.

7. WARRANTY

§ 1 WARRANTY CARD/ONLINE REGISTRATION

To be protected by the extended warranty, the buyer must complete and return the enclosed warranty card within 14 days of the date of purchase to BEHRINGER Spezielle Studiotechnik GmbH, in accordance with the conditions stipulated in § 3. Failure to return the card in due time (date as per postmark) will void any extended warranty claims. Based on the conditions herein, the buyer may also choose to use the online registration option via the Internet (www.behringer.com or www.behringer.de).

§ 2 WARRANTY

1. BEHRINGER (BEHRINGER Spezielle Studiotechnik GmbH including all BEHRINGER subsidiaries listed on the enclosed page, except BEHRINGER Japan) warrants the mechanical and electronic components of this product to be free of defects in material and workmanship for a period of one (1) year* from the original date of purchase, in accordance with the warranty regulations described below. If the product shows any defects within the specified warranty period that are not excluded from this warranty as described under § 3 and 4, BEHRINGER shall, at its discretion, either replace or repair the product using suitable new or reconditioned parts. In the case that other parts are used which constitute an improvement, BEHRINGER may, at its discretion, charge the customer for the additional cost of these parts.

2. If the warranty claim proves to be justified, the product will be returned to the user freight prepaid.

3. Warranty claims other than those indicated above are expressly excluded.

§ 3 RETURN AUTHORIZATION NUMBER

1. To obtain warranty service, the buyer (or his authorized dealer) must call BEHRINGER (see enclosed list) during normal business hours **BEFORE** returning the product. All inquiries must be accompanied by a description of the problem. BEHRINGER will then issue a return authorization number.

2. Subsequently, the product must be returned in its original shipping carton, together with the return authorization number to the address indicated by BEHRINGER.

3. Shipments without freight prepaid will not be accepted.

§ 4 WARRANTY REGULATIONS

1. Warranty services will be furnished only if the product is accompanied by a copy of the original retail dealer's invoice. Any product deemed eligible for repair or replacement by BEHRINGER under the terms of this warranty will be repaired or replaced within 30 days of receipt of the product at BEHRINGER.

2. If the product needs to be modified or adapted in order to comply with applicable technical or safety standards on a national or local level, in any country which is not the country for which the product was originally developed and manufactured, this modification/adaptation shall not be considered a defect in materials or workmanship. The warranty does not cover any such modification/adaptation, irrespective of whether it was carried out properly or not. Under the terms of this warranty, BEHRINGER shall not be held responsible for any cost resulting from such a modification/adaptation.

3. Free inspections and maintenance/repair work are expressly excluded from this warranty, in particular, if caused by improper handling of the product by the user. This also applies to defects caused by normal wear and tear, in particular, of faders, potentiometers, keys/buttons and similar parts.

4. Damages/defects caused by the following conditions are not covered by this warranty:

- ▲ improper handling, neglect or failure to operate the unit in compliance with the instructions given in BEHRINGER user or service manuals.
- ▲ connection or operation of the unit in any way that does not comply with the technical or safety regulations applicable in the country where the product is used.
- ▲ damages/defects caused by force majeure or any other condition that is beyond the control of BEHRINGER.

5. Any repair or opening of the unit carried out by unauthorized personnel (user included) will void the warranty.

6. If an inspection of the product by BEHRINGER shows that the defect in question is not covered by the warranty, the inspection costs are payable by the customer.

7. Products which do not meet the terms of this warranty will be repaired exclusively at the buyer's expense. BEHRINGER will inform the buyer of any such circumstance. If the buyer fails to submit a written repair order within 6 weeks after notification, BEHRINGER will return the unit C.O.D. with a separate invoice for freight and packing. Such costs will also be invoiced separately when the buyer has sent in a written repair order.

§ 5 WARRANTY TRANSFERABILITY

This warranty is extended exclusively to the original buyer (customer of retail dealer) and is not transferable to anyone who may subsequently purchase this product. No other person (retail dealer, etc.) shall be entitled to give any warranty promise on behalf of BEHRINGER.

§ 6 CLAIM FOR DAMAGES

Failure of BEHRINGER to provide proper warranty service shall not entitle the buyer to claim (consequential) damages. In no event shall the liability of BEHRINGER exceed the invoiced value of the product.

§ 7 OTHER WARRANTY RIGHTS AND NATIONAL LAW

1. This warranty does not exclude or limit the buyer's statutory rights provided by national law, in particular, any such rights against the seller that arise from a legally effective purchase contract.

2. The warranty regulations mentioned herein are applicable unless they constitute an infringement of national warranty law.

* Customers in the European Union please contact BEHRINGER Germany Support for further details.

BEHRINGER Spezielle Studiotechnik GmbH, Hanns-Martin-Schleyer-Str. 36-38, 47877 Willich-Münchheide II, Germany
Tel. +49 (0) 21 54 / 92 06-0, Fax +49 (0) 21 54 / 92 06-30