75 W High-End Audio Amplifier with adjustable Output Impedance

75 W Power Amplifier with adjustable Output Impedance and adjustable Sensitivity for Cone Drivers and Dome Drivers

- Very High AC Supply Voltage Range
- DMOS Power Stage (Class AB)
- High Output Power >75W@2x28VAC Supply
- Muting/Standby-Function
- Very Low Distortion
- Very Low Noise
- **Adjustable Output Impedance**
- Adjustable Input Sensitivity
- Wide Common Mode Range Differential Audio Input
- Thermal Protection / Shutdown
- Clip Detector and Visualization with LED
- RoHS compliant, IPC-A-600 Class 2 and IPC-A-610 Class 2

Figure 1: Driver Module AC-PAZ75 on mounting flange

Description / Novel Features

The AC-PAZ75 is a very compact, high-end, class AB audio power amplifier (PA) with excellent linearity and low distortion, combined with a flat audio frequency response, and low noise. The PA offers a differential audio input with high suppression of common mode signals, and a sensitivity adjustment via a 10-turn potentiometer. This allows the easy combination of several PAs avoiding ground loop interferences.

The PA is extremely compact and highly integrated and it accepts AC power directly from the secondary windings of the power transformer. Thanks to the wide supply voltage range and to the high out current capability it is able to supply its full output power into 4Ω and 8Ω loads.

The AC-PAZ75 Power Amplifier offers - as novelty and different to any other power amplifiers – an electronic generated adjustable output impedance that can easily be matched via a 10-turn potentiometer to the connected dynamic loudspeaker in order to obtain the optimum low-end frequency response.

This allows the designer of an active Loudspeaker box to become independent from the Thiele/Small rules prescribing the volume of the enclosure. Usually one would use a larger volume, as calculated by TS, to get high SPL with moderate electrical input power. The output impedance is then adjusted for the desired roll-off of the SPL at low frequencies.

A dynamic driver (loudspeaker) achieves in this way a larger bandwidth, not only on the lower end of its frequency response due to the elimination of the resonance peak, but also on the upper end of its frequency response, as the effect of the stray inductivity of the voice coil is significantly decreased.

The module can be used as driver for tweeters, as well as large cone drivers, as the frequency response is absolutely flat in the full audio band.

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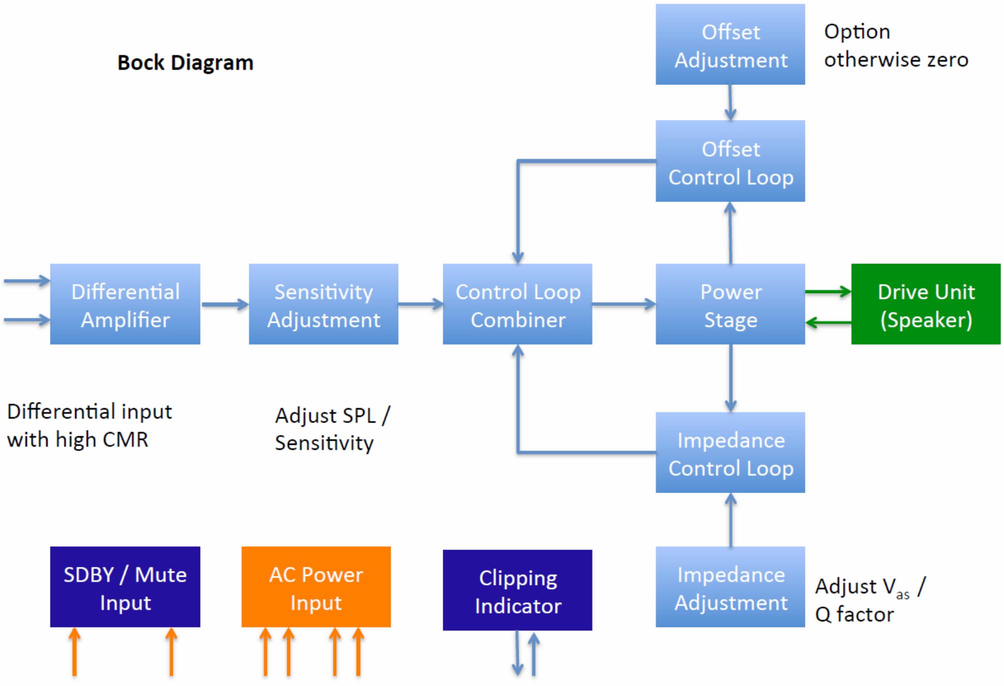

Figure 2: Functional Block Diagram

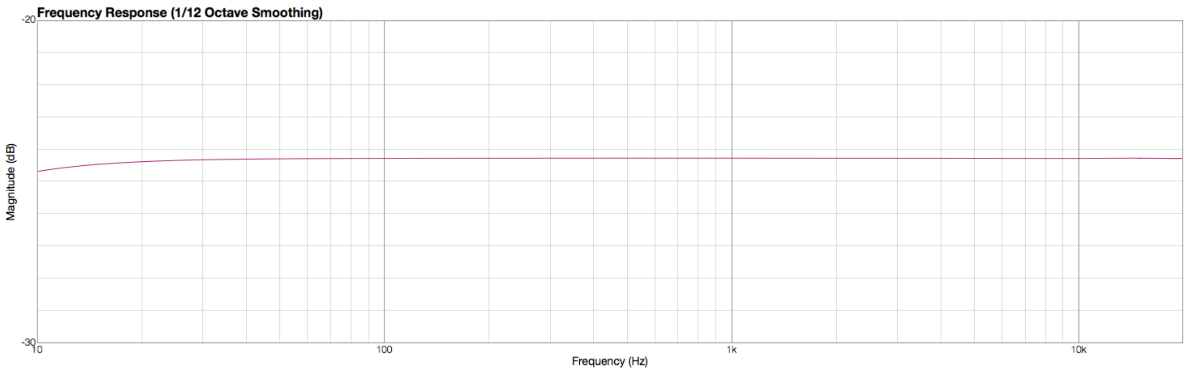

Figure 3: Frequency response in the audio band 1dB/Division

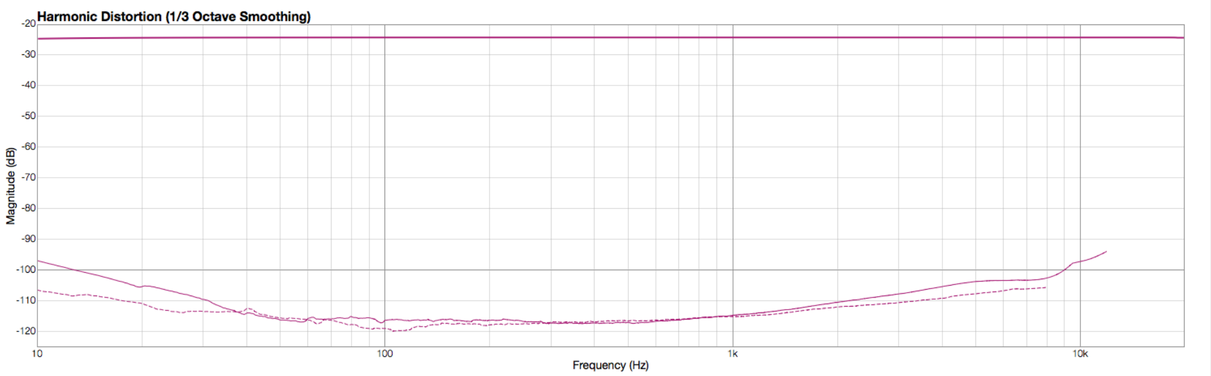

Figure 4: Harmonic Distortions k2 (solid) und k3 (dashed) 10 dB/Div

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Absolute Maximum Ratings (T_{amb} = 25°C; unless otherwise specified)

Symbol	Parameter	Min. Value	Max. Value	Unit
V_S	AC Supply Voltage (two symmetrical transformer windings)		2 x 31	Vrms
V_1	$V_{standby}$ vs. GND	-0.3	+16	V
V_2	V_{MUTE} vs. GND	-0.3	+16	V
I_0	Peak Output Current		10	A
T_{op}	Operating Ambient Temperature Range	0	+70	°C
T_{stg}, T_j	Storage and Junction Temperature	-10	+125	°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the module.

Electrical Characteristic (R_L = 8Ω; T_{amb} = 25°C; f = 1kHz; unless otherwise specified)

Symbol	Parameter	Min	Typ	Max	Unit
Vs	AC Supply Voltage Range Two identical transformer windings, or mid tapped secondary winding	21 for 4 Ohm Load		29 for 8 Ohm Load	Vrms
Iq	AC Quiescent Current (during MUTE) AC Quiescent Current (during STBY)		60 15	120 30	mA
Po	RMS Continuous Output Power d = 1%, RL = 4 Ohm Mechanical interface at 25°C	75	80		W
THD	Total harmonic distortion PO = 5 W, f = 1 kHz, 8 Ohm resistive Load		0.002		%
Audio Input					
R_{id}	Differential Input Resistance		25k		Ω
R_{i0}	Input Resistance to GND	10k		20k	Ω
V_{CM}	Input Common Mode Range		±5		V
V_{IS}	Input Sensitivity (for full output power) Adjustable via 10 turn potentiometer	200 mV		2 V	V
Standby Function					
$V_{st\ on}$	Standby ON Threshold			1.2	V
$V_{st\ off}$	Standby OFF Threshold	3.0			V
$ATT_{st\text{-}by}$	Standby Attenuation	70	90		dB
I_{LDS}	Driver Sink Current Capability	-0,7			mA
MUTE Function					
$V_{M\ on}$	Standby ON Threshold			1.2	V
$V_{M\ off}$	Standby OFF Threshold	3.0			V
ATT_{Mute}	Standby Attenuation	60	80		dB
I_{LDS}	Driver Sink Current Capability	-0,7			mA
Clip Detector					
I_{LED}	LED operating current		14		mA

Symbol	Parameter	Min	Typ	Max	Unit
Over Temperature Detection and Turn ON/OFF					
T_{OFF}	Switch OFF temperature	70	75	80	°C
T_{ONHY}	Switch ON Hysteresis		4		K

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Description and Application Information

The Power Amplifier (PA) is supplied with two equal AC voltages. Two separate windings of the AC transformer are recommended, but also a middle tapped secondary winding can be used.

2 x 21 VAC with a 4 Ohms voice coil allow typically 80 W continuous output power.

2 x 29 VAC with an 8 Ohms voice coil allow typically 80 W continuous output power.

In order to minimize the heat dissipation of the PA it is recommended to choose the AC supply voltage wrt. the load impedance. Appropriate cooling of the PA is required.

In order to protect the voice coil of tweeters, the AC supply voltage can be lowered without any degradation of the performance down to 21V AC, independent from the voice coil resistance.

The audio input signal is feed to a differential amplifier with high common mode signal rejection in order to avoid ground (GND) loops. A Connection between the driving amplifier GND and the PA GND is therefore necessary in order to establish a common GND reference.

After the sensitivity adjustment via a 10-turn potentiometer, the signal is fed to a combiner stage. There the signal of the offset control loop and the signals from the feedback loops are combined.

The PA is DC coupled; however, the offset control loop is constantly active with a very long integration time constant (seconds) to ensure that the current through the voice coil is zero on average.

In case it is foreseen to adjust the rest position of the voice coil, an optional 10-turn potentiometer can be added to generate a defined current of either polarity through the voice coil. This can be used to minimize even non-linearity of the dynamic driver. Criterion is minimum k_2 of the sound pressure level.

The impedance adjustment weighs several feedback loops in order to realize an electronically generated positive output impedance of the PA. That is adjusted via a 10-turn potentiometer in such way, that the quality factor of the low-end resonance of the drive unit is set to the desired value - usually in the range between Q = 0.7 … 0.9. Criterion is the desired frequency roll-off of the sound pressure level at low frequencies.

In this way the designer becomes independent from the Thiele/Small criterion for the volume of the enclosure.

The driver (loudspeaker) must be connected with both leads (active and return) to the PA in order to allow appropriate working of the control loops.

Novelty / Advantage:

The Q-factor of the connected dynamic driver (cone driver or dome driver) can be adjusted electronically in the range between its mechanical Q-factor and the electronic Q-factor given in the data sheet. This allows adjusting the low frequency sound pressure frequency response by the designer to his preferred value - independent from the volume of the enclosure of the drive unit. This is pioneering, allowing freedom for the enclosure design and an extended bandwidth of the driver (loudspeaker) due to a lower frequency roll-off of its response.

One would usually choose system Q-factors between
0.7 (close to Bessel) and
0.9 (slight low frequency boost)

Customer Adjustments:

1. Potentiometer for the output impedance

2. Potentiometer for the sensitivity of the amplifier input (SPL-level adjustment)

3. Optional: Potentiometer for the adjustment of the voice coil rest position for minimizing the harmonic component k_2.

Background Information

Usually, high quality dynamic drivers are driven by an amplifier with close to zero output impedance. This results in a heavy over-damping of the driver's low-frequency resonance - especially true for bass drive modules. In order to bring the quality factor Q of the low-frequency resonance to an adequate level (Q = 0.7 … 0.9), the enclosure needs to be made small enough to raise the Q factor to the desired level. This, however, shifts the low-end roll-off of the driver to higher frequencies and limits therefore the usable bandwidth.

The novel AC-PAZ75 power amplifier avoids this limitation. It allows adjusting the low frequency response of the connected driver electronically.

The chosen enclosure volume (larger than TS suggests) and the driver's parameters solely define the low-end frequency response of the dynamic driver.

The (initially over-damped) quality factor of the low-end resonance can be independently raised via the impedance control of the PA to the desired level.

In this way the low-end roll-off and its quality factor become independent from each other allowing an extended frequency range of the driver in its enclosure.

Mechanical Layout (PCB)

The complete circuit is realized on a multi-layer PCB with the dimensions of 65mm x 92mm. The PCB provides two mounting holes. The power amplifier IC4 must be thermal connected to a cooling element but mounted electrical isolated. Mounting equipment for Package Multiwatt15V should be used.

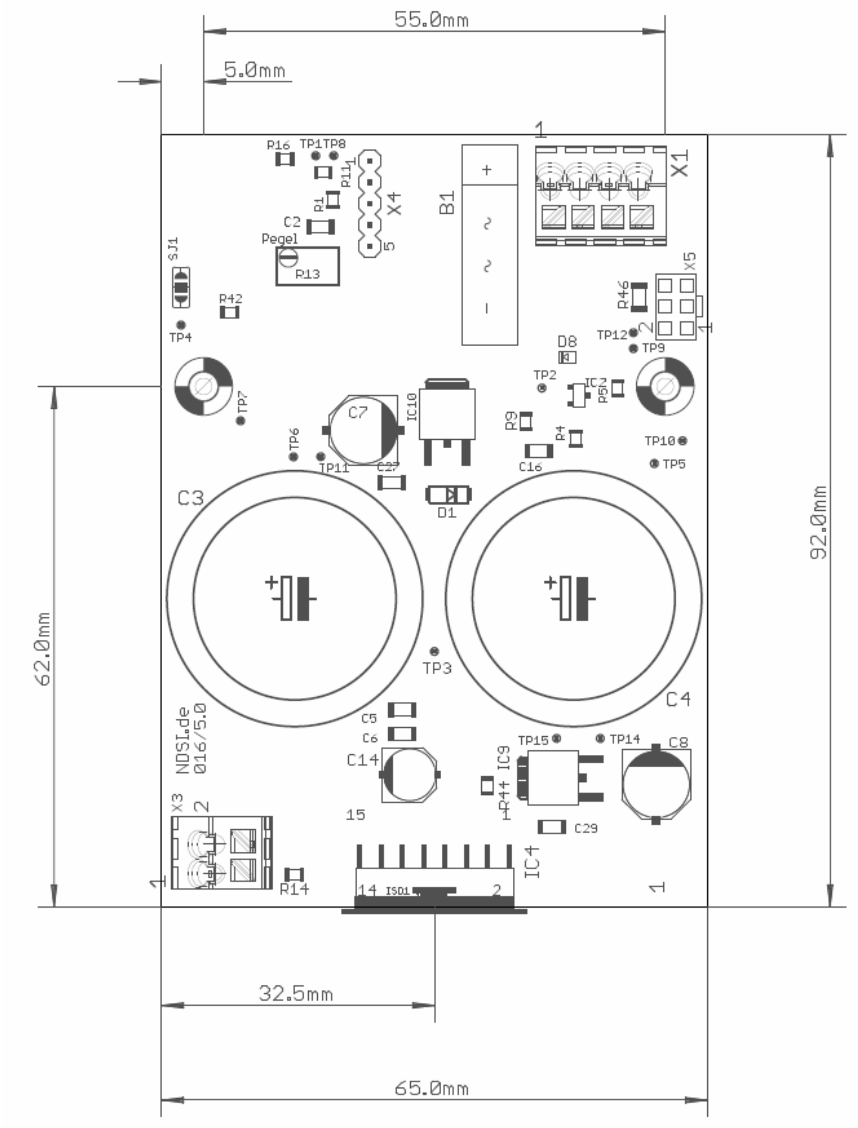

Figure 5: Mechanical Layout of the PCB w/o mounting flange

A possible mounting flange solution with cooling is shown in Figure 6. Depending on the module configuration the height of the module is typically 63mm including mounting flange.

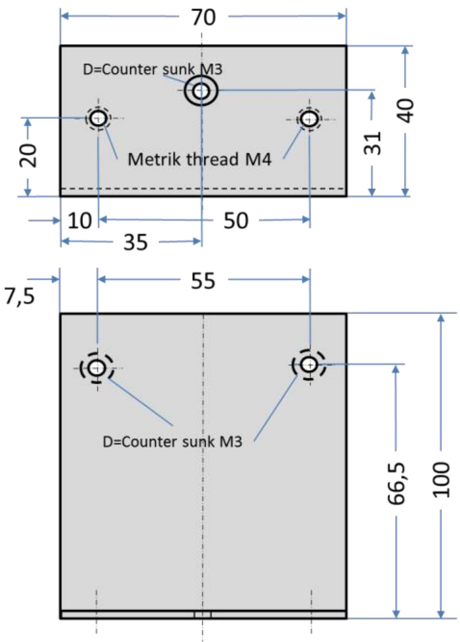

Figure 6: Mounting Flange (Ver. 1)

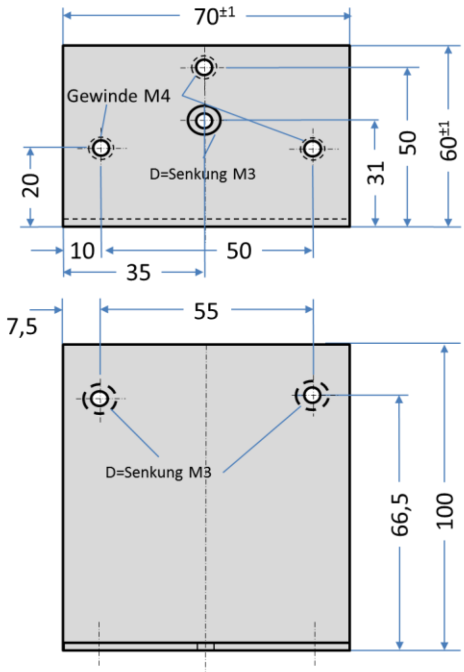

Figure 7: Mounting Flange (Ver. 2)

The mounting flange provides on the small side (upper picture) two metrical threads M4.

Both sides have flat surfaces; there are no protruding elements.

With serial number TBD the module will be equipped with an improved mounting flange.

This flange provides an enlarged small side (60mm instead 40mm) and one additional metrical thread M4.

Mechanical Characteristic (PCB including mounting flange)

Symbol	Parameter		Min	Typ	Max	Unit
X	Module Dimension X			70		mm
Y	Module Dimension Y			100		mm
H	Module Hight H	Capacitors 4.7mF	59	60	61	mm
		Capacitors 10mF	60	63	65	
W	Module Weight	Capacitors 4.7mF		205	225	g
		Capacitors 10mF		220	240	
T	Mounting Flange Material Thickness			4		mm
M	Flange Material		AlMgSi0,5/EN AW-6060			

The mounting flange is electrically isolated from the amplifier.

WARNINGS

- Any external power supply used with this module shall comply with relevant regulations and standards applicable in the country of intended use.
- This product should be operated in a well-ventilated environment, and if used inside a case, the case should not be covered or should provide enough room for proper ventilation/cooling. Alternative the module could be mounted on a stable, flat, conductive surface for additional cooling purpose.
- The connection of incompatible devices to the module may affect compliance, result in damage to the unit, and invalidate the warranty.
- All peripherals used with this product should comply with relevant standards for the country of use and be marked accordingly to ensure that safety and performance requirements are met. These articles include but are not limited to power supply, amplifiers, programming adapters and other external elements.
- The cables and connectors of all peripherals used with this product must have adequate insulation so that relevant safety requirements are met.

SAFETY INSTRUCTIONS

To avoid malfunction or damage to this product, please observe the following:

- Handle only in an environment which is protected against Electro Static Discharge (ESD) to avoid possible damage of the sensitive parts.
- Do not expose to water or moisture, or place on a conductive surface whilst in operation.
- Do not expose to heat from any source; this module is designed for reliable operation at normal ambient temperatures.
- Take care whilst handling to avoid mechanical or electrical damage to the printed circuit board and connectors.
- Whilst it is powered, avoid handling the printed circuit board, or only handle it by the mounting flange to minimize the risk of electrostatic discharge damage.

Electrical Interfaces

Connector Types and Interface Description

Connector	Parameter/Signal	Typ	Wire Size
X1	AC Power Supply	WAGO 250-204	0,75 – 1,5mm² AWG 18-15
X3	Speaker Output	WAGO-250-202	0,75 – 1,5mm² AWG 18-15
X4	Audio In, MUTE and Standby	Pin Header 1x5 RM 2,54mm [1])	-

Interface: AC Power Supply and Connector Pinout (X1)

X1 Pin	Parameter/Signal		
L1	AC Input A		
L2	Return A internally connected to L3		
L3	Return B internally connected to L2		
L4	AC Input B		

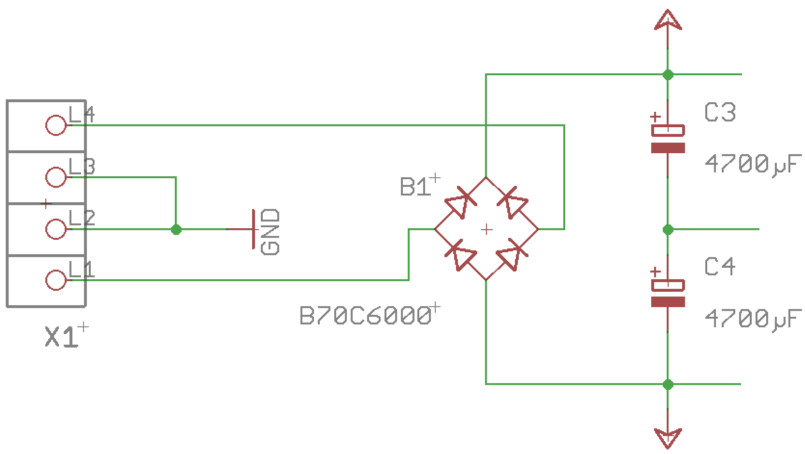

Figure 8: AC Input Circuit Diagram

[1]) Recommended connector type: Molex 22-01-2057, crimp terminals 2759 or 4809

Interface: Speaker Output Connector Pinout (X3)

X3 Pin	Parameter/Signal	
L1	Speaker Positive Output	**L2 must not be connected to Ground**
L2	Speaker Return	

Interface: Audio In and Control Connector Pinout (X4)

X4 Pin	Parameter/Signal	Remark
1	MUTE	Connect to external STBY and/or MUTE driver if required (see chapter below for more details)
2	Standby (STBY)	
3	GND	Provides the ground reference. To be routed e.g. to system star ground
4	NF (Audio) Input negative	Differential audio input
5	NF (Audio) Input positive	

Standby (STBY) and MUTE

The PA offers two independent in/outputs for Standby and Muting. Both functions are active low when used as inputs. They can serve as outputs in order to synchronize other AC-PAZ75.

An external driver for STBY and MUTE must be open Collector or open Drain for proper function.

The circuit dedicated to the switching on and off of the amplifier has been carefully optimized to avoid any kind of uncontrolled audible transient at the output during settling of the internal control loops.

If not used, both control inputs may be left open. In that case the PA will be active about 5 (TBC) seconds after power on. It will use an internally controlled power down sequence as soon as external power is switched off.

If connected in parallel with further PAs, a time wise synchronized activation / deactivation of all PAs is ensured.

In case of an external control of STBY and/or MUTE the following steps during the ON/OFF sequence are recommended:

Power ON-Sequence:

1. Supply AC power to the PA – settling of internal control loops
2. Deactivation of STBY → Quiescent current stabilizes to its nominal value
3. Deactivation of MUTE → Signal is present at the output

Power OFF-Sequence:

4. Activation of MUTE
5. Activation of STBY
6. Switch off of the AC power supply

The above-described sequence avoids any audible noise during switching on or off.

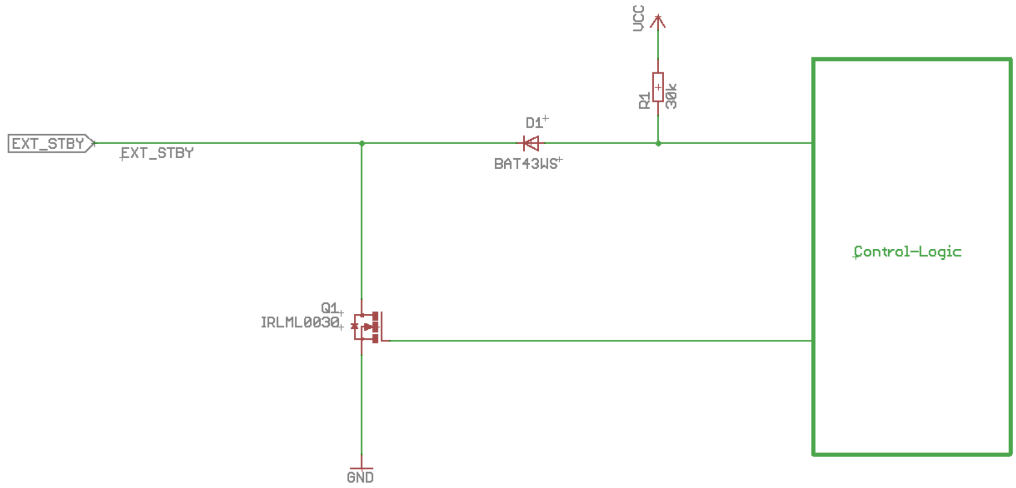

Figure 9: MUTE and Standby Input Interface

Audio IN

The Drive Module offers a differential Input circuit with high common mode suppression.

The driving impedance of the AC-PAZ75 should be close to zero for both inputs in order to achieve the maximum common mode suppression.

Recommendation: Connect X4-4 to the Ground (GND) of the driving side of a single ended driver stage and drive X4-2 by the output of an OpAmp

Ensure a common GND reference of the Driving Amplifier and the PA by an appropriate connection between these two Grounds. All uneven numbered X4 pins are connected to the PA GND and can be used for this purpose (see Figure 10).

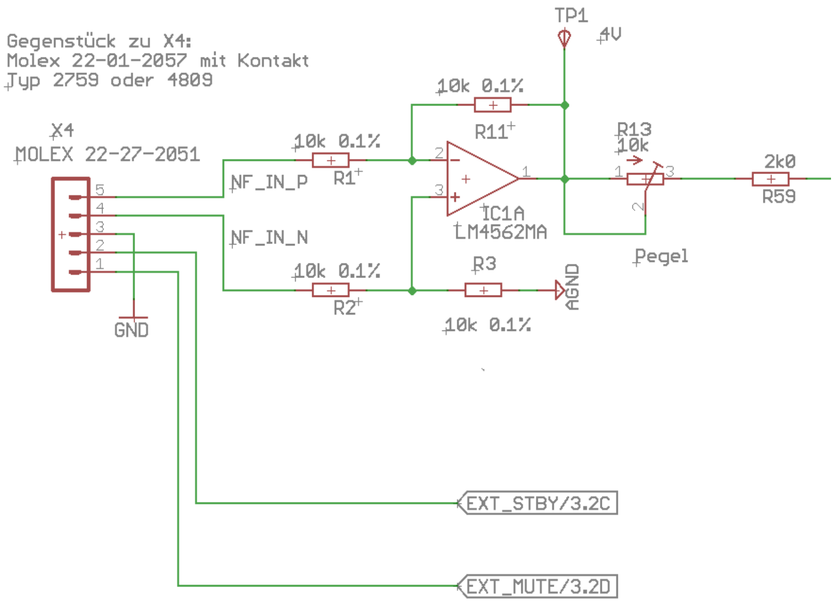

Figure 10: Audio Input Interface

Typical Operation of the Drive Module

Figure 11 shows the typical implementation of the AC-PAZ75

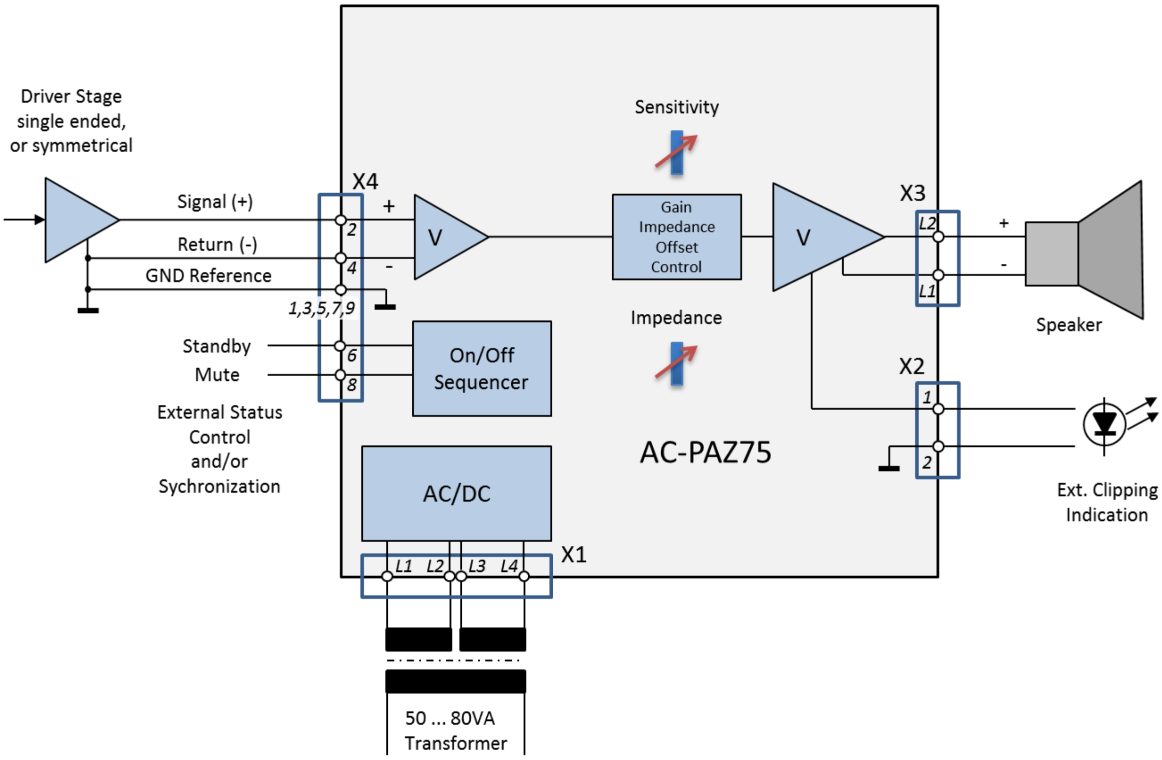

Figure 11: Typical Implementation of the Module

Proposed Adjustment Procedure

1. Set the sensitivity adjustment potentiometer to zero (counter CW)
2. Set the optional offset potentiometer to middle position (5 turns from either side)
3. Optionally bridge X2 pin 1 and 2 in order to enable the on-board clipping indicator
4. Adjust the impedance potentiometer to maximum (turn clockwise)
5. Connect the secondary windings of the transformer (Figure 8)
   (L2 and L3 are internally connected, L1 and L4 need to be 180 degree out of phase).
6. Connect the dynamic driver (loudspeaker) to the AC-PAZ75
7. Power the circuit and optionally disable MUTE and STDBY. If MUTE and STDBY are not externally controlled, the AC-PAZ75 switches automatically into the active mode.
8. Measure the DC output voltage at X3 pin L2 and adjust it via the optional offset potentiometer to zero. In case the optional offset potentiometer is not in the circuit, the control loop ensures automatically zero DC offset voltage at the output.
9. Increase the sensitivity (turn clock wise) to the desired level.
10. Measure the low-end frequency response of the SPL and adjust via the impedance potentiometer the quality factor of the resonance peak to the desired value.
11. Re-Adjust the sensitivity to its final value. The impedance setting influences the sensitivity setting to a small degree.

Caution:

1. The AC-PAZ75 is a DC coupled power amplifier. Any DC-Voltage at the Input will therefore appear amplified at the output. The Offset control loop will eliminate small DC voltages present at the input with a long time constant. Larger DC voltages at the input would, however, saturate the offset control loop.
2. If the output impedance potentiometer is adjusted to very low values, the stability of the amplifier may be sacrificed depending on the voice coil impedance of the connected driver – avoid oscillations, which could harm the AC-PAZ75 and/or the driver. Always adjust the output impedance coming from its maximum value. Too low output impedance would result in over damping the driver resulting in a weak low frequency response.

Connected Tweeters / Dome Drivers:

Tweeters (especially dome drivers) are very often acoustically highly damped and may not need any additional damping from the driving PA. In that case one can disconnect (remove) the Impedance control potentiometer completely which results in a pure current control mode of the PA. The PA shows then its maximum output impedance, which adds no additional damping to the tweeter, extending in this way its low frequency response. In addition, the usually observed high frequency roll-off due to the voice coil series inductance disappears, as the current through the driver is controlled, not any more the voltage across its terminals.