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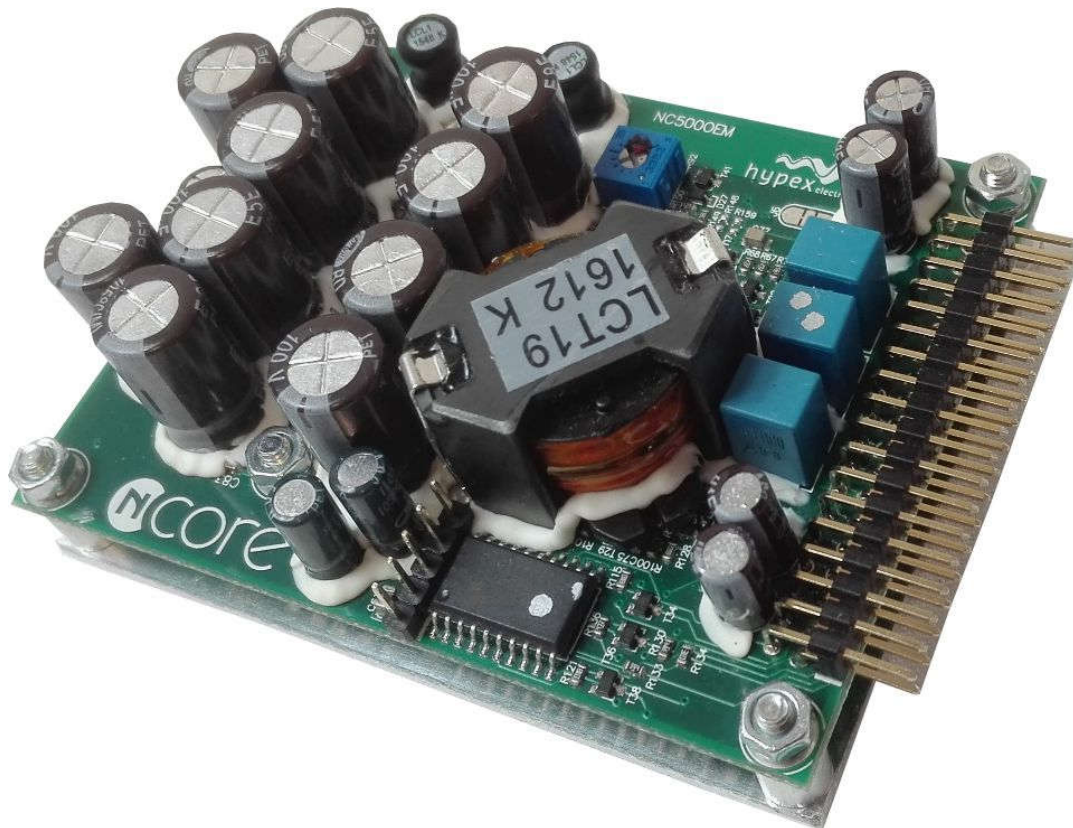
ncore
audio power by hypex ®

NC500 OEM

NC500 OEM Definitive performance class D amp

Image is for illustrative purposes only. Please refer to product description.

Highlights

- High efficiency
- Extremely low distortion and noise over frequency and power range
- Extremely low output impedance
- Very high power density
- Neutral and transparent reproduction: "Neither dirt nor fairy dust"

Features

- Unbuffered input
- Advanced over current protection
- Differential audio input
- 2Ω capable
- Low weight: 135g.
- Compact: 82 x 63 x 32mm

Applications

- Top-end stereo and multichannel amps
- Monitor loudspeakers for recording and mastering studios
- Audiophile power amplifiers for professional and consumer use.
- Public address systems
- Active loudspeakers

Introduction

The NC500 OEM amplifier module is an extremely high-quality audio power amplifier module which operates in class D. Not only does it offer a way for audiophile music reproduction to continue in an ever more energy-conscious world, its measured and sonic performance actually raises the bar for audio amplifiers of any description. Operation is based on a non-hysteresis 5th order self-oscillating control loop taking feedback only at the speaker output.
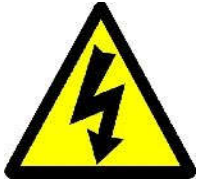
Furthermore, the NC500 OEM is an unbuffered amplifier leaving the implementation of an input buffer up to the manufacturer. The NC500 is practically devoid of any sonic signature so this external buffer is a good way of tuning in a "house sound".

Please make sure you always download the latest datasheet from our website.

# Contents

1 Safety precautions

This module operates at high voltage and carries hazardous voltages at accessible parts. These parts may never be exposed to inadvertent touch. Observe extreme care during installation and never touch any part of the unit while it is connected to the mains. Disconnect the unit from the mains and allow all capacitors to discharge for 10 minutes before handling it.

Attention: Observe precautions for handling electrostatic sensitive devices. This module uses semiconductors that can be damaged by electrostatic discharge (ESD).

Damage due to inappropriate handling is not covered by warranty.

This product has no user-serviceable parts.
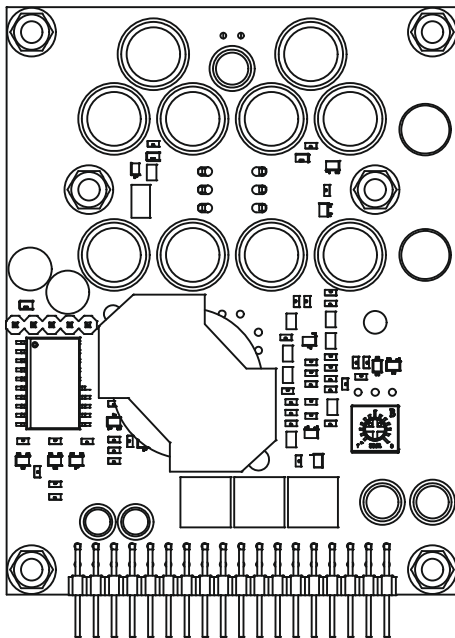
This symbol indicates the presence of hazardous voltages at accessible conductive terminals on the board. Parts that are not highlighted in red may also carry voltages in excess of 200 Vdc!

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

1. Read these instructions.
2. Keep these instructions.
3. Heed all warnings.
4. Follow all instructions.
5. Do not use this apparatus near water.
6. Protect the power cord from being walked on or pinched, particularly at plugs, convenience receptacles, and the point where they exit from the application.
7. Only use attachments/accessories specified or approved by the manufacturer.
8. Unplug this apparatus during lightning storms or when unused for long periods of time.
9. Refer all servicing to qualified service personnel. Servicing is required when the apparatus has been damaged in any way, liquid has been spilled or objects have fallen into the apparatus, the apparatus has been exposed to rain or moisture, does not operate normally or has been dropped.
10. Don't run any cables across the top or the bottom of the module. Apply fixtures to cables to ensure that this is not compromised.
11. Observe a minimum clearance of 6mm with all possible conducting parts (housing etc.).
12. Natural convection should not be impeded by covering the module (apart from the end applications housing).
13. This product is to be used with Hypex SMPS modules only.
14. Before using this product, ensure all cables are correctly connected and the power cables are not damaged. If you detect any damage, do not use the product.
15. Changes or modifications not expressly approved by Hypex Electronics will void compliance and therefore the user's authority to operate the equipment.
16. Service or modifications by any person or persons other than by Hypex Electronics authorized personnel voids the warranty.

2 Electrical Specifications

2.1 Recommended Operating Conditions and Supply Currents

Parameter		Symbol	Min	Typ	Max	Unit	Note
Input Voltage Main	Symmetric supply (+/-)	VB	35	84	98	V	
Input Voltage Vaux (Signal stage supply)	Symmetric supply (+/-) Formerly Vsig.	V_{aux}	10.5	15	16	V	
Input Current Vaux	Formerly IVsig.	I_{aux}		30	35	mA	
External driver supply voltage		V_{DR}	14	15	17	V	3)
Drive supply current		I_{DR}		70	75	mA	
Effective power supply storage capacitance	Per rail, per attached amplifier. 4Ω load presumed.	C_{SUP}	4700			μF	2)

Note 1: Unit protects if allowable range is exceeded.
Note 2: The effective power supply storage capacitance of a Hypex SMPS is already in excess of 4700uF. Do not add supplementary capacitance.
Note 3: Floating and referenced to VB-.

2.2 Absolute maximum ratings

Correct operation at these limits is not guaranteed. Operation beyond these limits may result in irreversible damage.

Parameter	Conditions	Symbol	Max	Unit	Note
Power supply voltage	See section 4.3	HV+/-	+/-100	V	
VDR supply voltage	See section 4.3	V_{DR}	20	V	
Peak output current	Guarded by current limit at 26A	$I_{OUT,P}$	28	A	
Signal Input voltage	Either input referenced to ground	V_{IN}	+/-15	V	
Input current	Logical inputs and buffer inputs	I_{IN}	10m	A	
Collector voltage	Open collector outputs when high	V_{OC}	35	V	
Collector current	Open collector outputs when low	I_{OC}	2m	A	

2.3 Protection limits

Parameter	Symbol	Max	Unit	Note
HV+/- Undervoltage-lockout	HV_{UVLO}	30	V	
HV+/- Overvoltage-lockout	HV_{OVLO}	101	V	
VDR Undervoltage-lockout	VDR_{UVLO}	13.5	V	
VDR Overvoltage-lockout	VDR_{OVLO}	19	V	
Overtemperature		85	ºC	
Overtemperature, lower hysteresis		75	ºC	

2.4 Ncore Amplifier Specifications

Power supply = SMPS1200A700, Load=4Ω, MBW=20kHz, Source imp=40Ω, unless otherwise noted

Parameter	Conditions	Symbol	Min	Typ	Max	Unit	Note
Peak Output Power	1KHz, THD=1%, all channels driven. Per channel.	$P_{R,\,2\Omega}$	-	550	-	W	
		$P_{R,\,4\Omega}$	-	700	-	W	
		$P_{R,\,8\Omega}$	-	400	-	W	
Continuous Output Power	Per channel, 25ºC ambient temperature.	$P_{R,cont}$	-	100	-	W	[1]
Distortion	20Hz<f<20kHz, 4Ω Pout<P_R/2	THD+N, IMD [1]	-	0.001	0.005	%	[2]
CMRR			50	65		dB	
Signal-to-Noise Ratio	(unweighted, add 2 dB for A-weighted), Re P_R.	SNR	134	135		dB	
	(unweighted, add 2 dB for A-weighted), Re 2.8Vrms	SNR	109	110		dB	
Output Noise	Unwtd, <10Hz-20kHz AES17, 0Ω termination	U_N	-	9	10	µV	
Output Impedance	f<16kHz	Z_{OUT}		1.5	2	mΩ	
	f<20kHz				5	mΩ	
Power Bandwidth		PBW	35			kHz	[3]
Frequency Response	+0/-3dB. All loads.		0		50	kHz	
Voltage Gain		A_V	11.9	12.4	12.9	dB	
Supply Ripple Rejection	Either rail, f < 1 kHz.	PSRR	75	85		dB	
Output Offset Voltage		$|V_{OO}|$		10	50	mV	
Efficiency	Full power	η		93		%	
Idle Losses	Per channel	P_0		6.3	7	W	
Current Limit per Ch.	Hiccup mode after 200ms limiting		25	26	28	A	

Note 1: Typically, this is 1/5 of the peak output power. Apply sufficient cooling.

Note 2: At higher audio frequencies there are not enough harmonics left in the audio band to make a meaningful THD measurement. High frequency distortion is therefore determined using an 18.5kHz+19.5kHz 1:1 two-tone IMD test.

Note 3: Dielectric losses in the output capacitor limit long term (>30s) full-power bandwidth to 5kHz.

2.5 Ncore Amplifier Audio IO Characteristics

Parameter	Conditions	Symbol	Min	Typ	Max	Unit	Note
DM Input Impedance	Per input, read section 2.5.1	$Z_{IN,DM}$		1.8		kΩ	
Source impedance	Differential, 25 per leg	Z_{SRC}			50	Ω	
Loudspeaker impedance range		$Z_{L,SE}$	1	-	-	Ω	

2.5.1   Audio input

The INH/INC inputs form a differential pair. Note that the input impedance is fairly low meaning that minimalist discrete circuits or valve input stages won't work. All op amps commonly used in audio can handle them though. See section 9 for suggested circuits and connections.

Do not drive the input with fully floating sources, be it electrically floating ones like line driver IC's intended for driving XLR outputs or transformers. Using a floating source will always result in a common mode component that will exceed the common mode input range and will manifest itself as gross distortion. Make sure to set the outputs of your distortion analyser to grounded, not floating.

2.5.2   Signal Coupling

To achieve optimal signal coupling, the audio signal inputs are all DC coupled. One must make sure that the connected application is free of DC offset.

Input sensitivity

Below a formula is given to calculate the balanced input signal level for a desired output level. Furthermore, an example is given using P$_{RATED}$ 500W, Load 4Ω, Gain 12.4

|		
$$\frac{\sqrt{P_{RATED} * \Omega_{LOAD}}}{10^{\left(\frac{Gain}{20}\right)}} = Input\ V_{RMS}$$	$$V_{RMS} * \sqrt{2} = Input\ V_{Peak}$$	$$20 * log_{10}\left(\frac{V_{RMS}}{0.7746}\right) = Input\ dBu$$
⬇	⬇	⬇
$$\frac{\sqrt{500 * 4}}{10^{\left(\frac{12.4}{20}\right)}} = 10.73\ V_{RMS}$$	$$10.73 * \sqrt{2} = 15.17\ V_{Peak}$$	$$20 * log_{10}\left(\frac{10.73}{0.7746}\right) = 22.83\ dBu$$

3 Environmental Specifications

Parameter	Conditions	Symbol	Min	Typ	Max	Unit	Note
Ambient Temperature	Storage		-25	-	70	°C	
	Operation	T_{amb}	0	-	65	°C	1)
Heat-sink Temperature		$T_{h,max}$			90	°C	2)
Humidity	Max 85 percent relative humidity, non-condensing.						

Note 1: Lower improves lifetime
Note 2: Thermistor limited. User to select heat sink to insure this condition under most adverse use case

3.1 Heat dissipation

Class D amplifiers' known high efficiency often leads to a gross underestimation of the cooling required. Please apply adequate cooling to the module to ensure the module operates within specification. The following graphs provide an indication of the heat (in Watts) generated at different output levels. For more information regarding cooling, please refer to our application note "Thermal Design", available on our website. Defects caused by overheating due to poor thermal management are not covered by warranty.
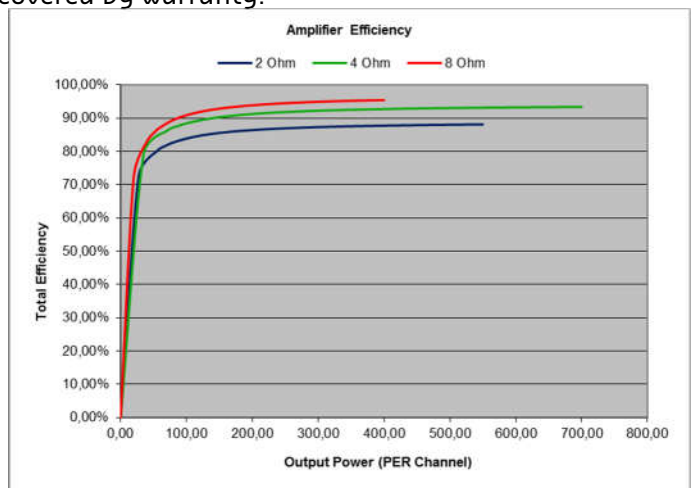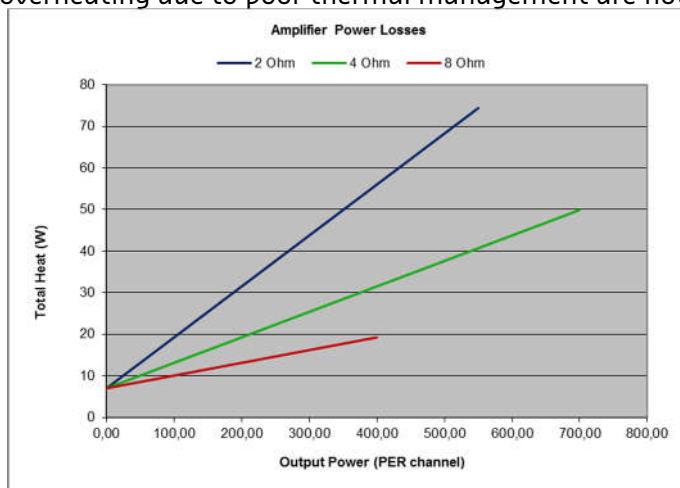
4 IO Specifications

Item	Symbol	Min	Typ	Max	Unit	Notes
Pull-up	$R_{WPU\ (internally)}$		27		kΩ	nAMPON, OPTION, To 3.3V
Logical high input voltage	V_{IH}	2.65		3.6	V	nAMPON, SCL, SDA
Logical low input voltage	V_{IL}	-0.3		0.5	V	nAMPON, SCL, SDA
Logical low output voltage	V_{OL}			0.4	V	nFATAL, SCCPIND, SDA, CLIP I_{OL}=1mA

4.1 Operation in Hardware mode

To operate in Hardware mode, leave the OPTION (pin 31) unconnected.

4.1.1 nAMPON

Pulling nAMPON low enables the amplifier as soon as all error conditions have been cleared for at least one second.

4.1.2 READY

The READY pin is pulled high whenever the amplifier is amplifying audio. When it mutes, for whatever reason, READY goes low. This includes periodic mutes after sustained overcurrent events.

4.1.3 CLIP

The CLIP indicator pin is active low, open collector, meaning that the CLIP indicator of several channels may be paralleled. An external pull-up resistor should be attached. The CLIP indicator is asserted whenever the amplifier is unable to track the input accurately:

- Normal clipping
- Current limiting
- Signal input during mute

Note that whilst muted the amplifier is clearly unable to track any input other than zero. The application circuit should ignore the CLIP flag during mute as it is likely that the CLIP indicator will be chattering most of the time.

4.1.4 SCCPIND

SCCP stands for single-cycle current protect. The amplifier has a two-stage overcurrent protection. Short overcurrent events are covered by a cycle-by-cycle limiter which clips the output signal in the current domain. When too many switching cycles are terminated by the cycle-by-cycle limiter, indicating a sustained overload, the amplifier will mute momentarily to allow the output devices to cool down.
SCCPIND is an open-collector, active low output that outputs the cycle-by-cycle pulses.

4.1.5 nFATAL

nFATAL is an open collector, active low output which is asserted when the amplifier senses a large DC voltage at the output. When a >15V DC potential is detected, the amplifier will first mute because the reason might well be DC at the input. If this fails to restore the output to zero, nFATAL will be pulled low to indicate catastrophic failure.
IMPORTANT: For safety reasons, the application must be able to respond to this line by turning the power supply off.
Do not use output relays. Apart from causing distortion, a relay is not suited to disconnect a heavily inductive load like a loudspeaker. Typical loudspeakers store enough energy to weld the relay shut, maintaining the safety hazard.

4.2 Operation in Software mode

When OPTION (pin 31) is pulled-down, the amplifier is operated in Software mode. In software mode, pin 36 is configured as SCL and pin 35 as SDA. These lines should be pulled to 3.3V with 4.7k resistors externally. The I2C bus should be operated at the standard 100kHz rate. Please make sure the I2C bus to this amplifier is isolated from other I2C buses, in order to prevent an I2C bus hangup when the supply for the amplifier is turned off.

4.2.1 Address selection

The NC500OEM supports up to 16 I2C addresses. Set the address by pulling OPTION to GND through a resistor.

Pull-down resistor at Pin 31	Dec I2C address	Binary I2C address
0	88	1011000x
1.8k	89	1011001x
3.9k	90	1011010x
6.8k	91	1011011x
10k	92	1011100x
12k	93	1011101x
18k	94	1011110x
22k	95	1011111x
27k	96	1100000x
33k	97	1100001x
47k	98	1100010x
56k	99	1100011x
82k	100	1100100x
120k	101	1100101x
180k	102	1100110x
390k	103	1100111x

X=r/w bit.

4.2.2 Registers

Register 0: Status byte 1

Bit	R/W	Function
7	R	FATAL. Shut down power supply immediately when this bit it set. See 4.1.5.
6	R	FreqError. Indicates direct short very close to the connector.
5	R	OverLoadError. Flags amp is being muted due to sustained overcurrent
4	R	HV- undervoltage. Clears as soon as HV- is above HV_{UVLO}
3	R	HV+ undervoltage. Clears as soon as HV+ is above HV_{UVLO}.
2	R	HV- overvoltage. Clears as soon as HV- has returned below HV_{OVLO}
1	R	HV+ overvoltage. Clears as soon as HV+ has returned below HV_{OVLO}
0	R	DC error. Excessive DC content was found at the output.

Register 1: Status byte 2

Bit	R/W	Function
7	R	Always set to 0
6	R	Always set to 1
5		Reserved
4		Reserved
3	R	Overtemperature. Clears as soon as temperature has dropped back to the lower hysteresis limit.
2	R	Amplifier Ready. Set when the amplifier is working normally and not muted.
1	R	VDR undervoltage
0	R	VDR overvoltage

Register 2: Command byte

Bit	R/W	Function
0	R/W	AmpEnable, write 1 to enable (unmute) amp, clear to mute

Register 3-7: Measured parameters

Reg	Function
3	HV+, in volts
4	HV-, in volts
5	VDR, in tenths of volts
6	NTC reading, in degrees Celsius [1]
7	Frequency reading in units of 64kHz
8	Product number (5 for NC500)

Note 1: The NTC is mounted on the heatsink and therefore not able to instantly follow/measure temperature changes in the amplifiers FET's. Please note that drawing high current at the speaker output may cause the FET's to overheat before the NC500's internal protection kicks in.

4.3 Supply connections

A symmetrical supply must be connected to the HV-, GND and HV+ pins. The amplifier will operate from the minimum voltage mentioned in Section '2.1' upward but rated output power is not available at low voltages.
The floating V_{DR} supply should be connected between HV- and VDR. Any other connection may cause damage or excessive heat output.

All GND pins are directly connected to the same ground plane. A GND pin (27) is provided near the small-signal end of the connector for convenience only. No distinction is made between "signal ground" and "power ground" because both inputs and outputs are configured as differential signal pairs that do not rely on GND as a reference potential.

4.4 Speaker and feedback connections

The speaker output is the OUTH/OUTC signal pair. Strictly connect the speaker between OUTH and OUTC. Do not treat OUTC as a ground terminal. FBH and FBC must be connected to OUTH and OUTC not more than a few cm away from the amplifier. This is done to eliminate the contact resistance of J3 from the output impedance. The points where FBH/FBC take off from OUTH/OUTC may be used to branch off biwired connections. Otherwise, simply connecting all 6 pins 13…18 (and 19…24 likewise) with one wide trace is perfectly acceptable.
Using FBH/FBC to sense remotely (e.g. at the end of a speaker cable) does not work well. Do not leave FBH/FBC unconnected.
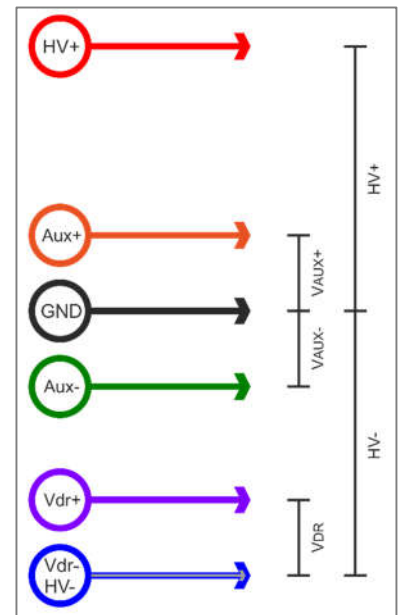
5 Connector Pinouts

This chapter describes the functional connectors of the amplifier module. A connector not stated in this chapter is only used for production or quality control and must remain unconnected in the end user application
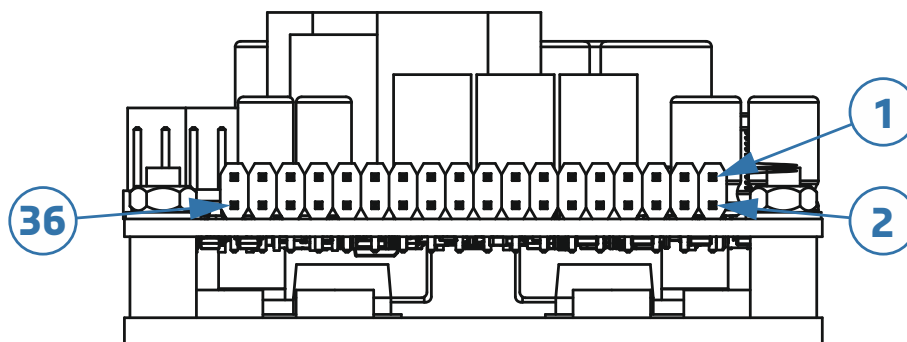
5.1 NC500 Interface

Pin	Direction	Function	Remarks
J3.1	Input	HV+	Unregulated supply
J3.2			
J3.3	-	GND	
J3.4			
J3.5			
J3.6			
J3.7			
J3.8			
J3.9	Input	HV-	Unregulated supply
J3.10			
J3.11	Input	V$_{DR}$	External driver supply connection.
J3.12	-	Reserverd	Do not connect
J3.13	Output	OUTC	Cold Loudspeaker Output
J3.14			
J3.15			
J3.16			
J3.17	Input	FBC	Cold Feedback (do not leave unconnected)
J3.18	Output	OUTC	Cold Loudspeaker Output
J3.19	Input	FBH	Hot Feedback (do not leave unconnected)
J3.20	Output	OUTH	Hot Loudspeaker Output
J3.21			
J3.22			
J3.23			
J3.24			
J3.25	Input	V$_{AUX-}$	Negative supply for modulator stage
J3.26	Input	V$_{AUX+}$	Positive supply for modulator stage
J3.27	-	GND	
J3.28	Output	Iout	Current monitor output, hot (0.1V per Ampere)
J3.29	Input	INH	Non-inverting audio input
J3.30	Input	INC	Inverting audio input
J3.31	Input [2]	OPTION	Control mode and I²C address selection
J3.32	Input [2]	nAMPON	HW mode: Amplifier enable control
J3.33	Output [1]	CLIP	Clip indication
J3.34	Output [1]	SCCPIND	Overcurrent indication
J3.35	Output [1]	SDA READY	SW mode: Data line of I²C bus HW mode: Operating indicator (active high)
J3.36	Output [1]	SCL nFATAL	SW mode: Clock line of I²C bus HW mode: Catastrophic fault indication, inverse of internal FATAL bit.

Connector type equivalent: Chyao Shiunn JS-1107-18x2
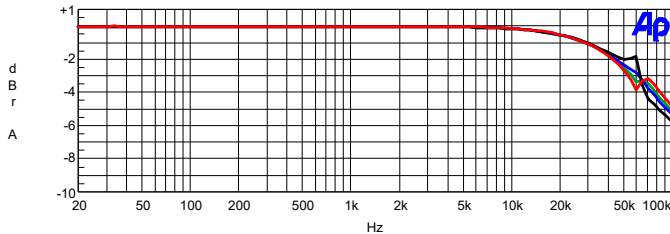**Contact material:** Brass, gold flash over nickel
Note 1: Open collector
Note 2: Weakly pulled up to 3.3V, not to be driven above 3.3V.
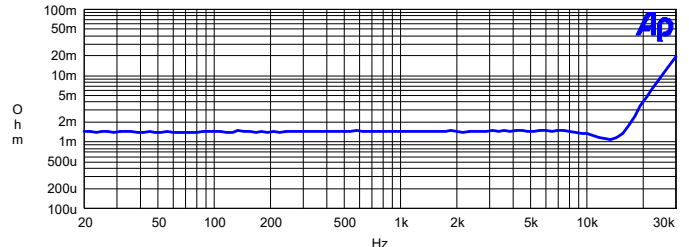
6 Typical performance graphs

Test conditions: one NC500 powered by SMPS1200A700 with 230Vac mains. Measurement bandwidth=20kHz except for small signal tests.
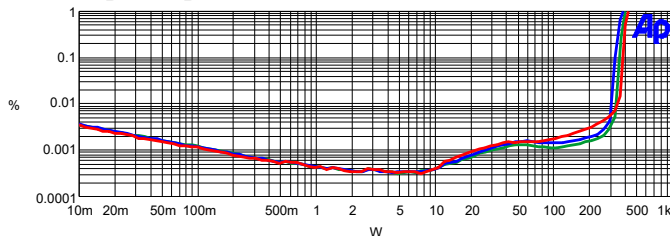
6.1 Small signal tests (all loads)

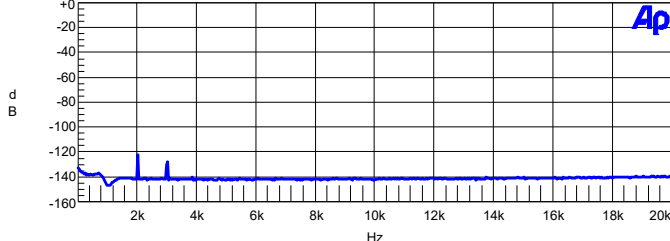Frequency response into 8 (green), 4 (blue) and 2 (black) ohms and into open circuit (red).

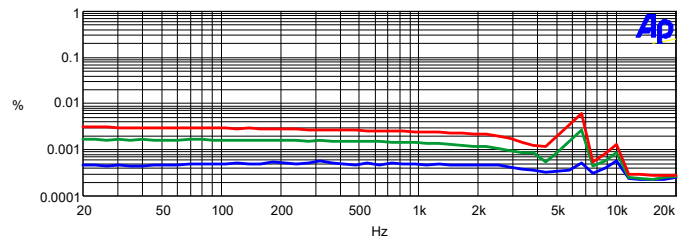Output impedance, four-wire test at speaker terminals.
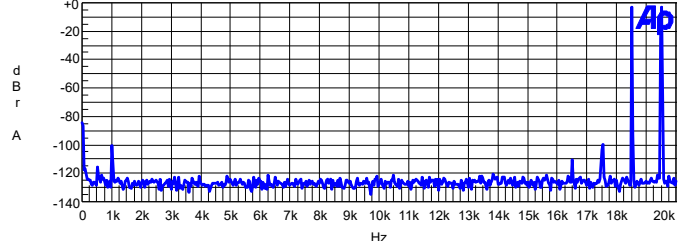
6.2 Large signal tests (8Ω)

THD+N vs. power at 100Hz (blue), 1kHz (green) and 6kHz (red)

THD vs. frequency at 10W (blue), 100W (green) and 250W (red)

Noise floor and distortion residual at 1W.

18.5kHz (50W)+19.5kHz (50W) IMD. 0dB=100W

6.3 Large signal tests (4Ω)
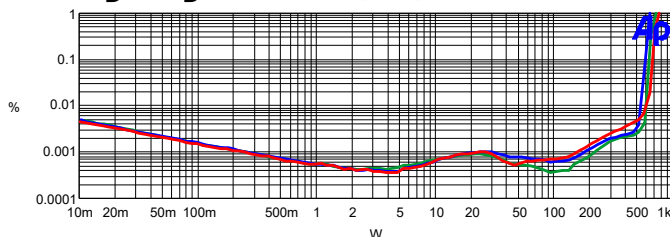
THD+N vs. power at 100Hz (blue), 1kHz (green) and 6kHz (red)
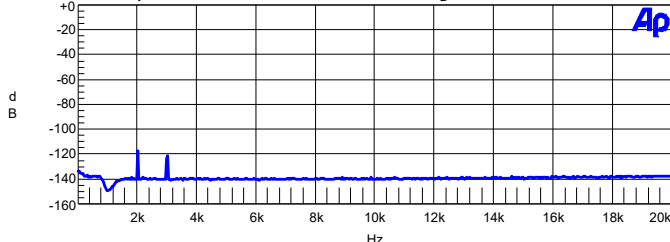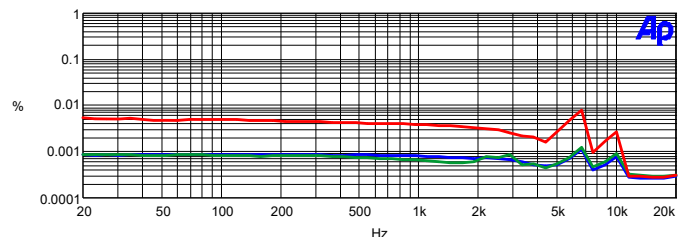
THD vs. frequency at 10W (blue), 100W (green) and 500W (red)

Noise floor and distortion residual at 1W.
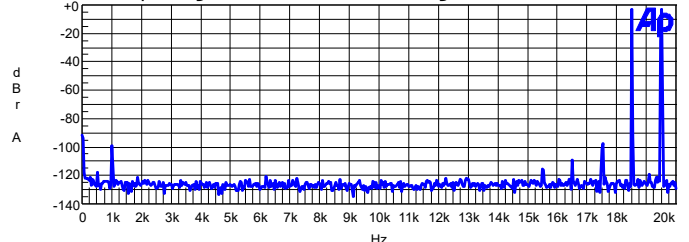
18.5kHz (100W)+19.5kHz (100W) IMD. 0dB=200W

6.4 Large signal tests (2Ω)

THD+N vs. power at 100Hz (blue), 1kHz (green) and 6kHz (red)

THD vs. frequency at 10W (blue), 100W (green) and 300W (red)

Noise floor and distortion residual at 1W.

18.5kHz (100W)+19.5kHz (100W) IMD. 0dB=200W
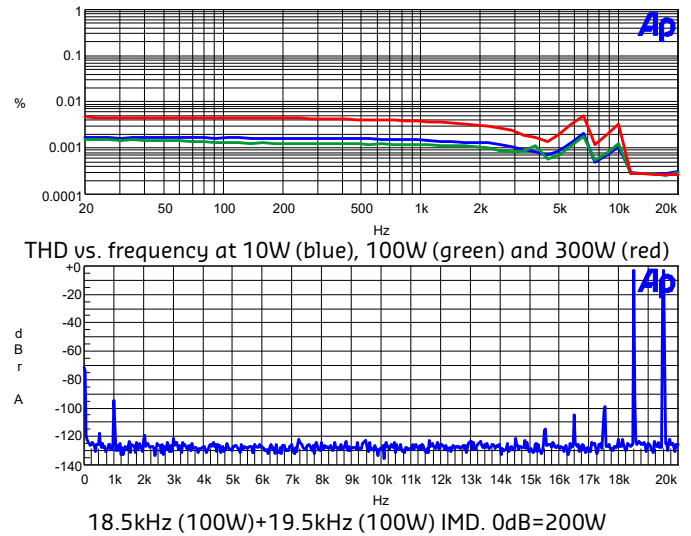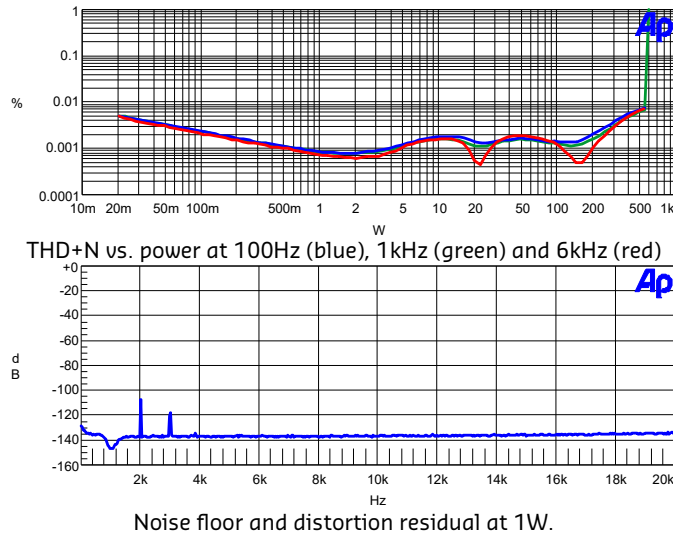
7 Frequently asked numbers

The following are neither specifications nor indicators of audio performance but engineering choices which in combination with the specific circuit topology lead to the performance found in section 2.4. They do not influence sound quality directly. Commonly expressed creeds that an amplifier's suitability for high quality audio can be read from these numbers (f_{SW} in particular) are ill informed.

Item	Symbol	Min	Typ	Max	Unit	Notes
Switching frequency	f_{SW}		450		kHz	Idle, see the white paper.
MOSFET ON resistance	R_{DSON}			100	mΩ	Over tolerance and temperature
Dead time	t_b		100		ns	"Soft" dead time. Effective value depends on load current
Output coil inductance	L		10		μH	Effective output inductance is this number divided by loop gain.
Output coil resistance	R_L		2		mΩ	
Output capacitance	C		2		μF	
Loop gain	A_L	53		60	dB	Loop gain peaks at 15kHz and drops back to 53dB at 20kHz.

8 Dimensions

8.1 Drill pattern

If printed correctly (scale 100%, A4), the scale of the image below should be 1:1. You may use it as a model to drill holes in your casing. Please verify before drilling!

The NC500 features 4 mounting holes with M3 thread. Maximum allowed protruding depth inside each mounting hole is 4mm.
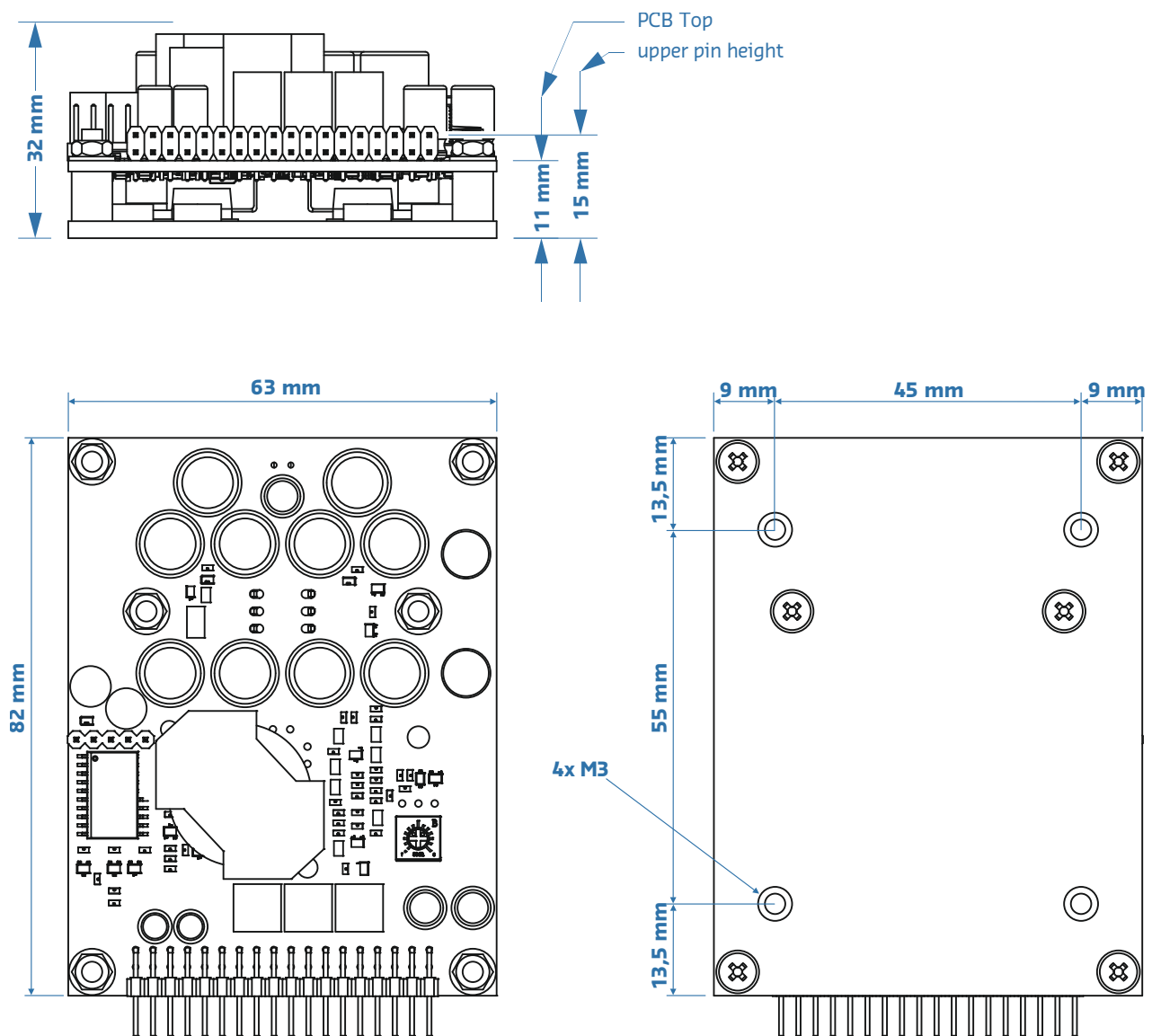
9   Application hints

9.1 Input Conditioning / Buffering

Unlike in many other Hypex products, no input buffer is present as manufacturers of audiophile equipment tend to bypass it anyway and design their own. The NC500 is practically devoid of any sonic signature so this external buffer is a good way of tuning in a "house sound". For direct connection to external equipment, the recommended input circuit is given in Figure 1. EMC/ESD countermeasures are left out for clarity.
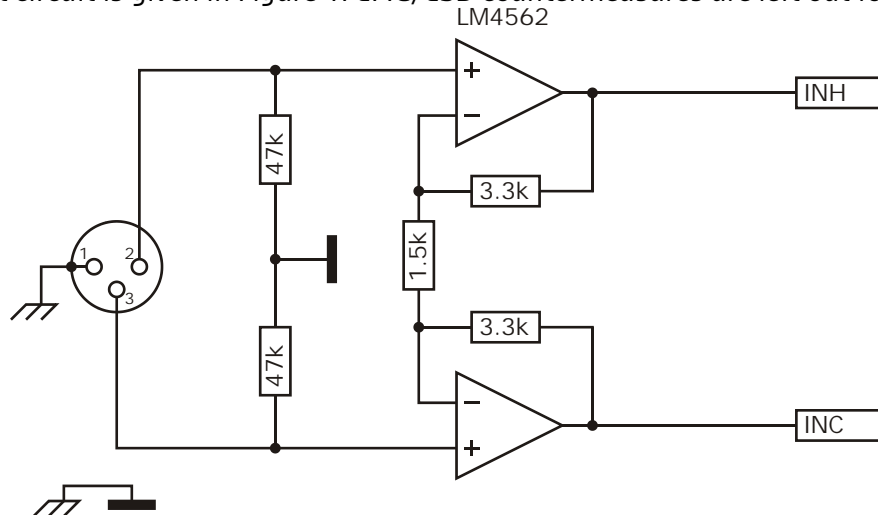

Figure 1: Recommended circuit for XLR inputs

For further clarification of how to connect RCA inputs, please refer to the application note "*Dealing with Legacy Pin-1 Problems*" on the Hypex web site. It and the further reading referenced in it are a good refresher course in the use of balanced signalling.

The impedance of the NC500 input is relatively low and because of the specific configuration, drive currents may become higher than expected. Use the model of Figure 2 to estimate input current:
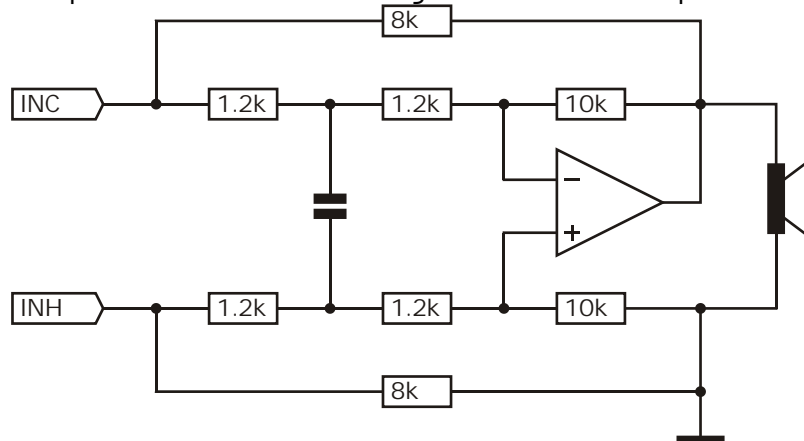

Figure 2: Equivalent model of NC500 for input current estimation

The input is clearly differential. The optimum choice of input circuit depends on the situation. Most audio designers incorrectly assume that it is necessary to drive differential inputs with symmetrical signals. This is entirely unnecessary. For instance, a single op amp suffices to interface most DAC chips with the NC500 as shown in Figure 3. Circuit values depend on the DAC output voltage and the required maximum output from the amplifier.
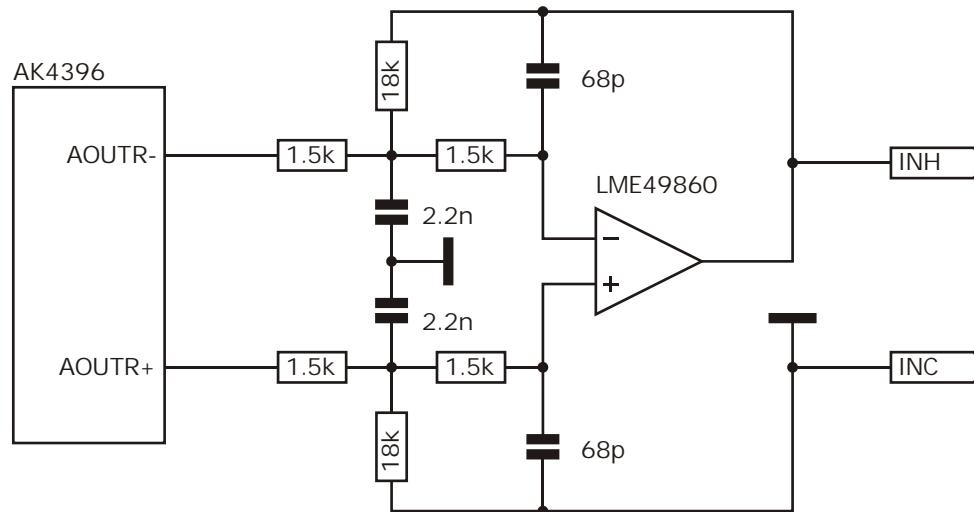
Figure 3: Recommended interface between Voltage-out DAC and NC500

The only potential drawback to this method is, depending on the maximum required speaker voltage, the need for fairly high supply rails for the op amp. A symmetrical output voltage solves this but again, this is only a practical consideration. There are no inherent performance benefits attached to symmetry. In fact, in order not to lose performance the drive circuit needs some forethought in order to keep the number of amplifying stages minimal (i.e. one).

The neatest and probably best, but not necessarily the cheapest, is to use an op amp with two outputs as shown in Figure 4.
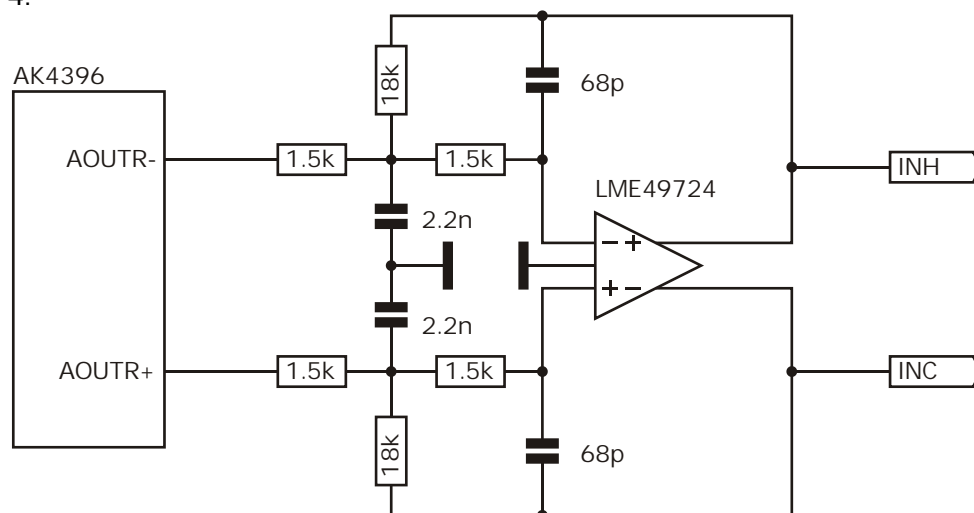

Figure 4: Interface circuit for low supply rails

A low-cost alternative is building the circuit of Figure 3 twice, once with the inputs reversed and tying INC to the other output. You get double the number of passives but this will be more than offset by the availability of much cheaper lower-voltage duals.

10 Revisions

Document revision	Module revision	Change log	Date
00	NC500OEM 00xx	Draft/Preliminary	09-05-2014
01	NC500OEM 01xx	New test data, section on audio input revised	
02	NC500OEM 01xx	Thermal considerations section revised	11-09-2014
03	NC500OEM 01xx	Dimensions heatsink added	29-09-2014
04	NC500OEM 01xx	Clip function description changed	10-10-2014
05	NC500OEM 01xx	I2C hang-up prevent information added	
06	NC500OEM 01xx	Mechanical drawings updated	24-04-2015
07	NC500OEM 02xx	Migration to new datasheet format Mounting screw depth added Under voltage protection updated Temperature protection updated	Oct '16
08	NC500OEM 02xx	Typographical inaccuracies revised	Nov '16
09	NC500OEM 02xx	Typical DC-offset characteristic added	Dec '16
10	NC500OEM 02xx	Correction in table I2C address Added explanation functionality nAMPON	14-06-2019
11	NC500OEM 02xx	Small lay-out changes	22-04-2020

11 Disclaimer

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