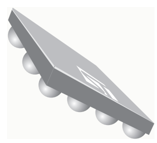
TS472

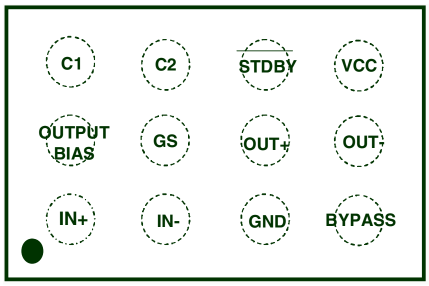
Very Low Noise Microphone Preamplifier with 2V Biased Output and Active Low Standby Mode

- Low noise: 10nV/√Hz typ. equivalent input noise @ F = 1kHz
- Fully differential input/output
- 2.2V to 5.5V single supply operation
- Low power consumption @20dB: 1.8mA
- Fast start up time @ 0dB: 5ms typ.
- Low distortion: 0.1% typ.
- 40kHz bandwidth @ -3dB and adjustable
- Active low standby mode function (1µA max)
- Low noise 2.0V microphone bias output
- Available in flip-chip lead-free package
- ESD protection (2kV)

Flip-chip - 12 bumps



Pin Connections (top view)



Description

The TS472 is a differential-input microphone preamplifier optimized for high-performance, PDA and notebook audio systems.

This device features an adjustable gain from 0dB to 40dB with excellent power-supply and common-mode rejection ratios. In addition, the TS472 has a very low-noise microphone bias generator of 2V.

It also includes a complete shutdown function, with active low standby mode.

Applications

- Video and photo cameras with sound input
- Sound acquisition & voice recognition
- Video conference systems
- Notebook computers and PDAs

Order Codes

Part Number	Temperature Range	Package	Packing	Marking
TS472EIJT	-40, +85°C	Flip-Chip	Tape & Reel	472

1 Typical Application Schematic

Figure 1 shows a typical application schematic for the TS472 with gain = 20dB. To change the gain see *Chapter 4.5: Gain settings* on *page 14*.

Figure 1. Application schematic

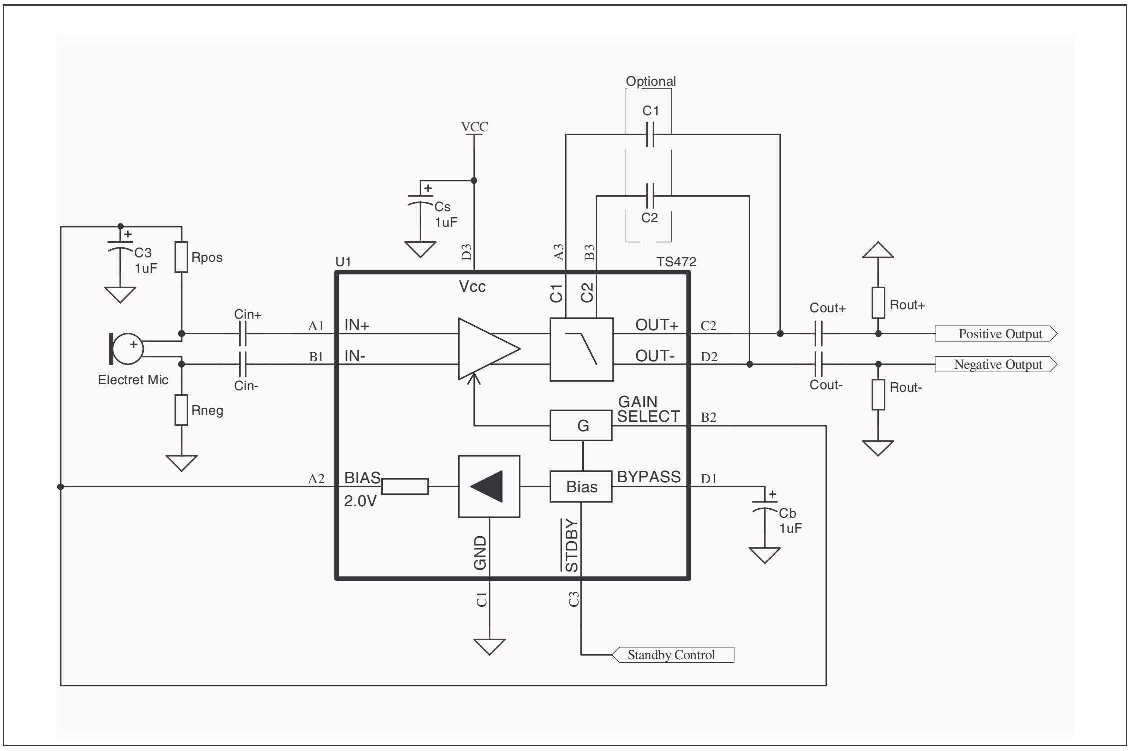


Table 1. External component descriptions

Components	Functional Description
Cin+, Cin-	Input coupling capacitors which blocks the DC voltage at the amplifier input terminal and determine *Lower cut-off frequency*.
Cout+, Cout-	Output coupling capacitors which blocks the DC voltage coming from the amplifier output terminal (pins C2 and D2) and determine *Lower cut-off frequency*.
Rout+, Rout-	Output load resistors which allow to charged the output coupling capacitors Cout. These output resistors can be represented by an input impedance of a following stage.
Rpos, Rneg	Microphone biasing resistors
Cs	Supply Bypass capacitor which provides power supply filtering.
Cb	Bypass pin capacitor which provides half supply filtering.
C1, C2	Low pass filter capacitors which can determine *Higher cut-off frequency*.
C3	Bias output capacitor which keeps voltage stabilized and provides 2.0V bias filtering.

2 Absolute Maximum Ratings

Table 2. Key parameters and their absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage (1)	6	V
V_i	Input Voltage	GND-0.3 to V_{CC}+0.3	V
T_{oper}	Operating Free Air Temperature Range	-40 to + 85	°C
T_{stg}	Storage Temperature	-65 to +150	°C
T_j	Maximum Junction Temperature	150	°C
R_{thja}	Flip-chip Thermal Resistance Junction to Ambient	180	°C/W
ESD	Human Body Model	2	kV
ESD	Machine Model	200	V
	Lead Temperature (soldering, 10sec)	250	°C

1. All voltages values are measured with respect to the ground pin.

Table 3. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage	2.2 to 5.5	V
G	Typical Differential Gain (GS connected to 4.7kΩ or Bias)	20	dB
V_{STB}	Standby Voltage Input: Device ON Device OFF	$1.5 \leq V_{STB} \leq V_{CC}$ $GND \leq V_{STB} \leq 0.4$	V
T_{OP}	Operational Free Air Temperature Range	-40 to +85	°C
R_{thja}	Flip-chip Thermal Resistance Junction to Ambient	150	°C/W

3 Electrical Characteristics

Table 4. V_{CC} = 3V, GND = 0V, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
e_n	Equivalent Input Noise Voltage Density R_{EQ}=100Ω at 1KHz		10		$\frac{nV}{\sqrt{Hz}}$
THD+N	Total Harmonic Distortion + Noise 20Hz ≤ F≤ 20kHz, Gain=20dB, Vin=50mV_{RMS}		0.1		%
V_{IN}	Input Voltage, Gain=20dB		10	70	mV_{RMS}
B_W	Bandwidth @ -3dB Bandwidth @ -1dB pin A3, B3 floating		40 20		kHz
G	Overall Output Voltage Gain (Rgs variable) Minimum Gain, Rgs infinite Maximum Gain, Rgs=0	-3 39.5	-1.5 41	0 42.5	dB
Z_{IN}	Input impedance referred to GND	80	100	120	kΩ
R_{LOAD}	Resistive load	10			kΩ
C_{LOAD}	Capacitive load			100	pF
I_{CC}	Supply current, Gain=20dB		1.8	2.4	mA
$I_{STANDBY}$	Standby current			1	µA
PSRR	Power Supply Rejection Ratio, Gain=20dB, F=217Hz, Vripple=200mVpp, Inputs grounded Differential Output Single-Ended Outputs,		-70 -46		dB

Table 5. Bias output: V_{CC} = 3V, GND = 0V, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{OUT}	No load condition	1.9	2	2.1	V
R_{OUT}	Output resistance	80	100	120	Ω
I_{OUT}	Output Bias Current		2		mA
PSRR	Power Supply Rejection Ratio, F=217Hz, Vripple=200mVpp	70	80		dB

Table 6. Differential RMS noise voltage

Gain (dB)	Input Referred Noise Voltage (μV_{RMS})		Output Noise Voltage (μV_{RMS})	
	Unweighted Filter	A-weighted Filter	Unweighted Filter	A-weighted Filter
0	15	10	15	10
20	3.4	2.3	34	23
40	1.4	0.9	141	91

Table 7. Bias output RMS noise voltage

Cout (μF)	Unweighted Filter (μV_{RMS})	A-weighted Filter (μV_{RMS})
1	5	4.4
10	2.2	1.2

Table 8. SNR (signal to noise ratio), THD+N < 0.5%

Gain (dB)	Unweighted Filter (dB)			A-weighted Filter (dB)		
	Vcc=2.2V	Vcc=3V	Vcc=5.5V	Vcc=2.2V	Vcc=3V	Vcc=5.5V
0	75	76	76	79	80	80
20	82	83	83	89	90	90
40	70	72	74	80	82	84

Note: Unweighted filter = 20Hz $\leq$ F $\leq$ 20kHz

Table 9. Index of graphics

Figure 2. Current consumption vs. power supply voltage

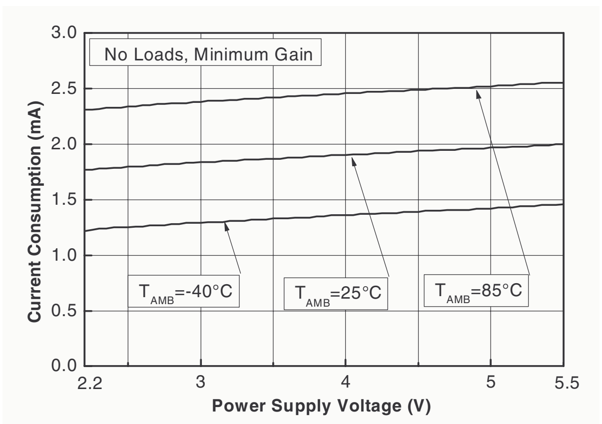


Figure 3. Current consumption vs. power supply voltage

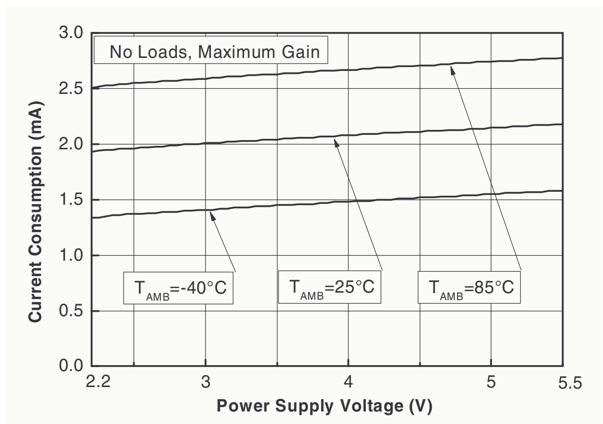


Figure 4. Standby threshold voltage vs. power supply voltage

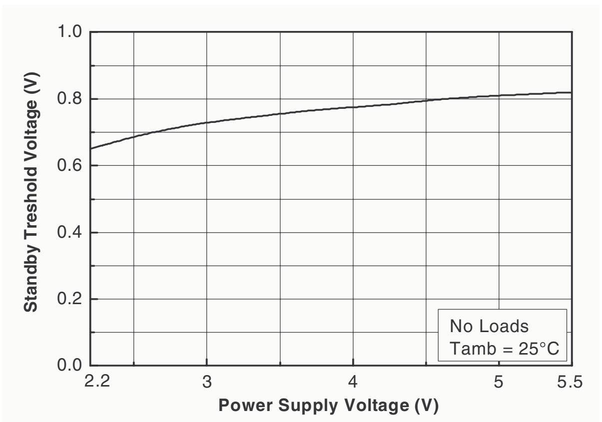


Figure 5. Frequency response

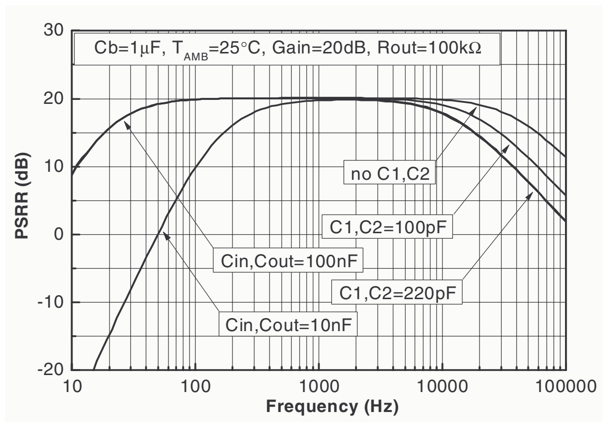


Figure 6. Bias output voltage vs. bias output current

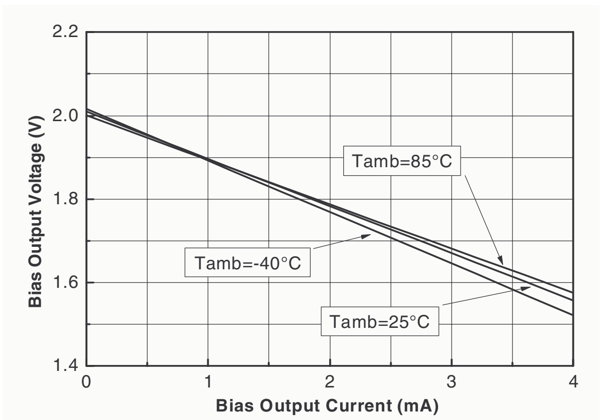


Figure 7. Bias output voltage vs. power supply voltage

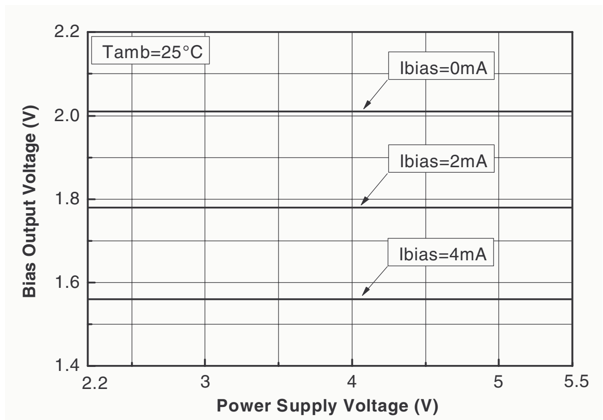


Figure 8. Bias PSRR vs. frequency

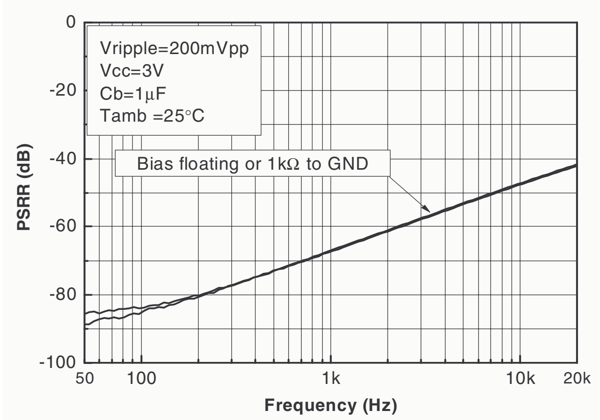


Figure 9. Bias PSRR vs. frequency

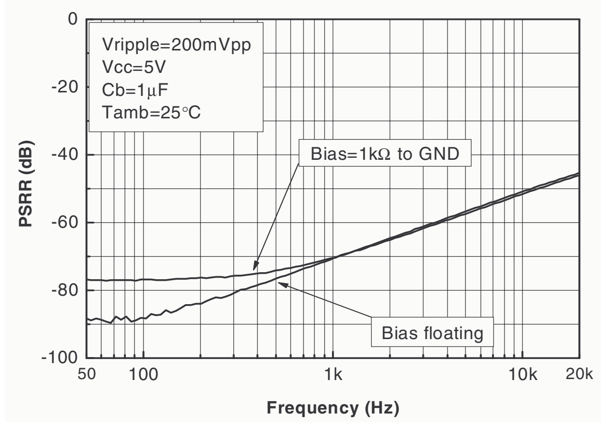


Figure 10. Differential output PSRR vs. frequency

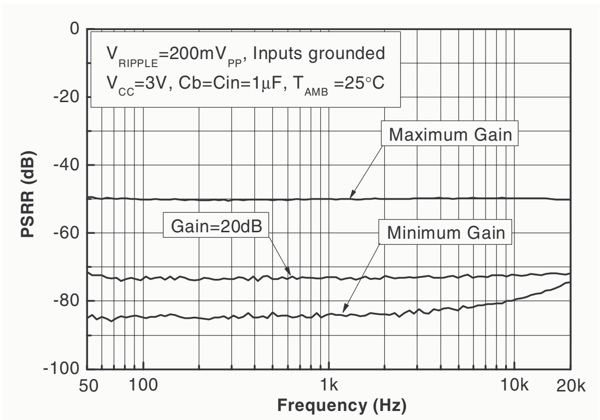


Figure 11. Differential output PSRR vs. frequency

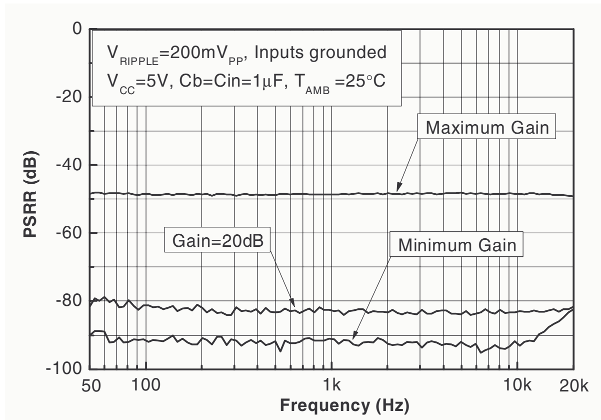


Figure 12. Differential output PSRR vs. frequency

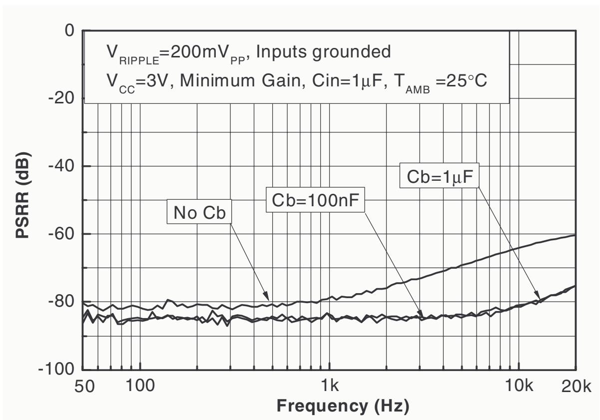


Figure 13. Differential output PSRR vs. frequency

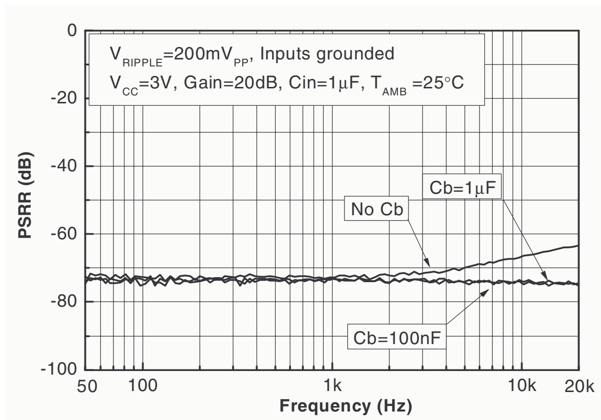


Figure 14. Single-ended output PSRR vs. frequency

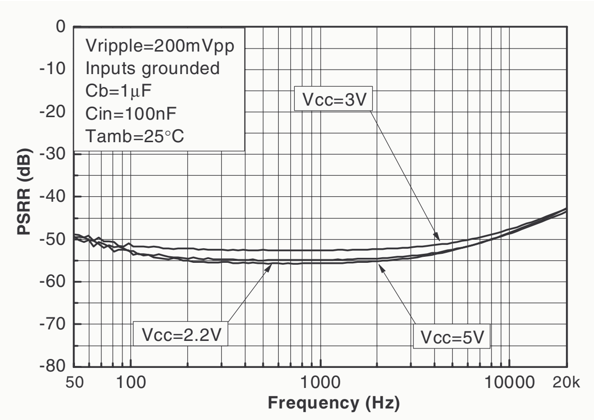


Figure 15. Equivalent input noise voltage density

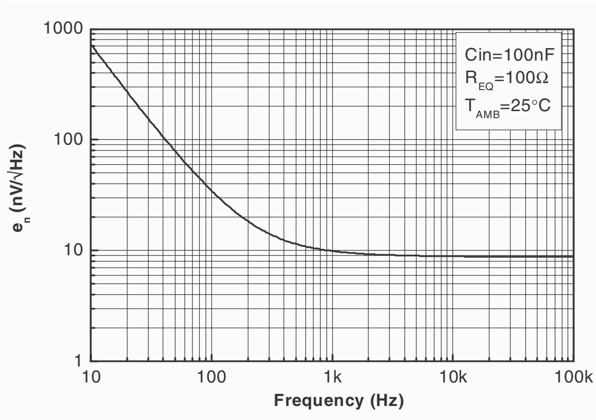


Figure 16. Δ gain vs. power supply voltage

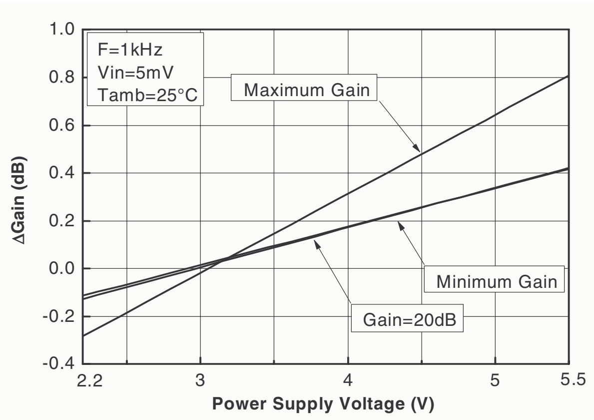


Figure 17. Δgain vs. ambient temperature

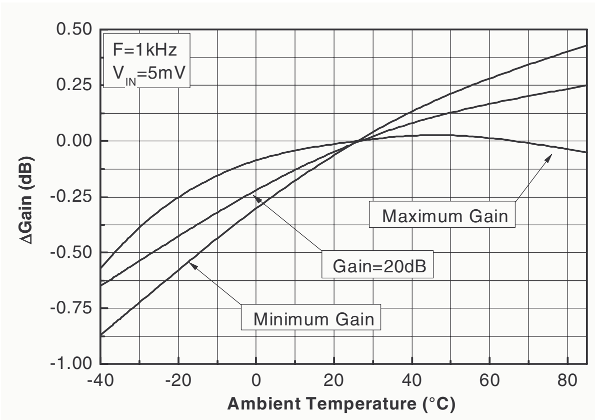


Figure 18. Maximum input voltage vs. gain, THD+N<1%

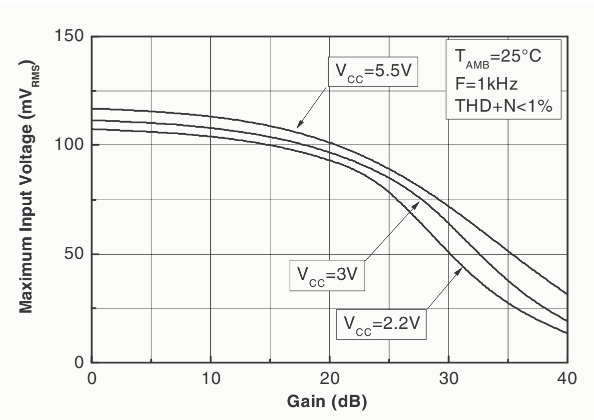


Figure 19. Maximum input voltage vs. power supply voltage, THD+N<1%

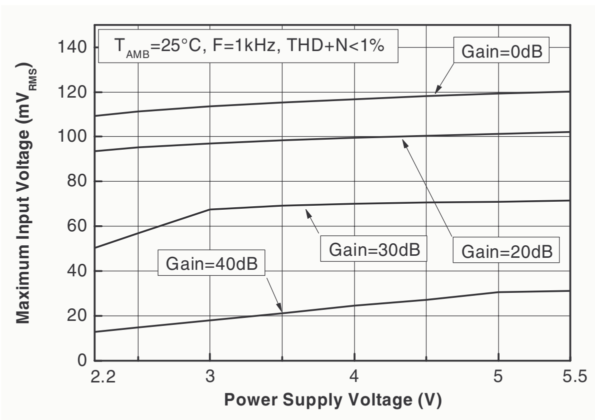


Figure 20. THD+N vs. input voltage

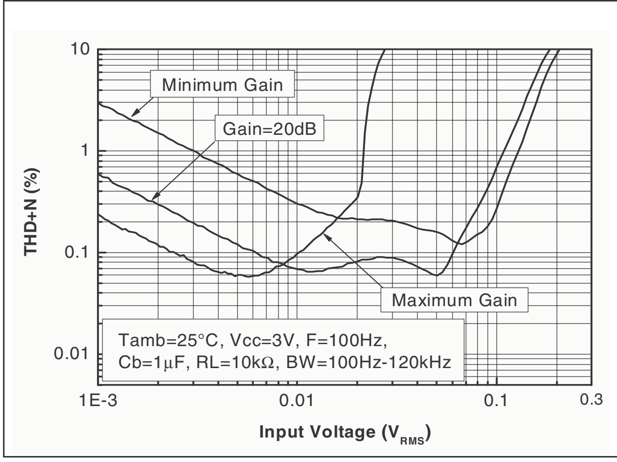


Figure 21. THD+N vs. input voltage

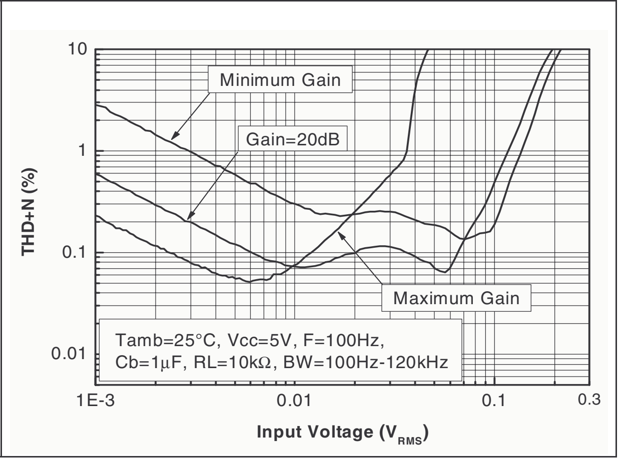


Figure 22. THD+N vs. input voltage

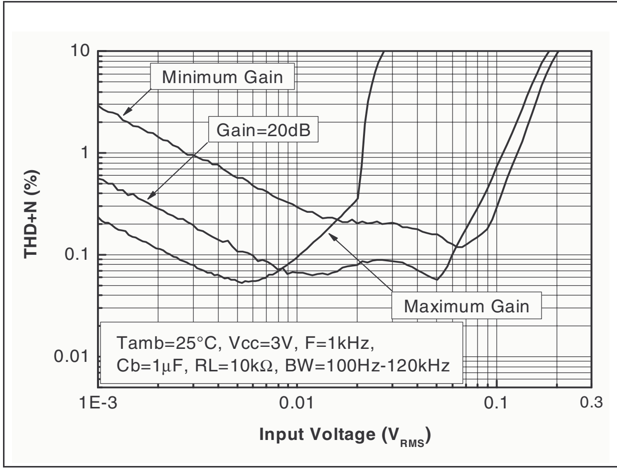


Figure 23. THD+N vs. input voltage

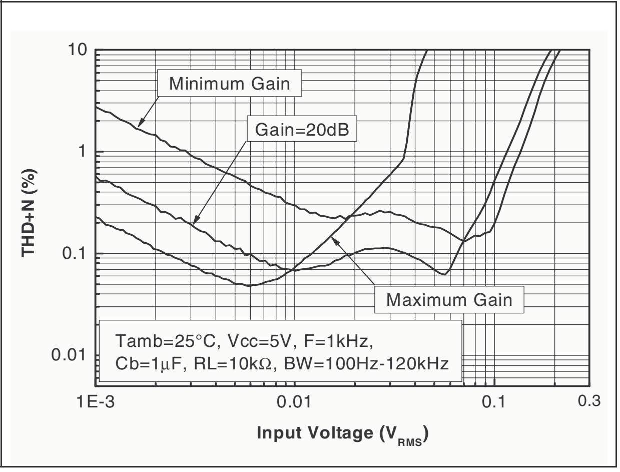


Figure 24. THD+N vs. input voltage

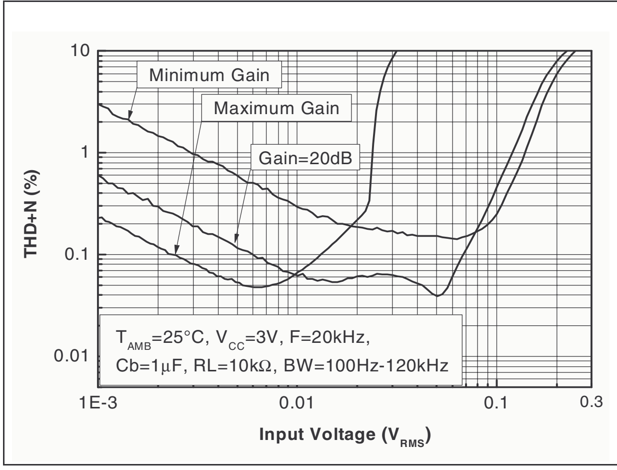


Figure 25. THD+N vs. input voltage

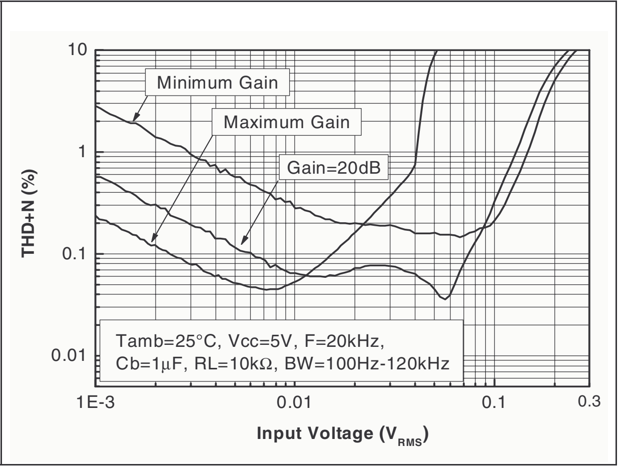


Figure 26. THD+N vs. frequency

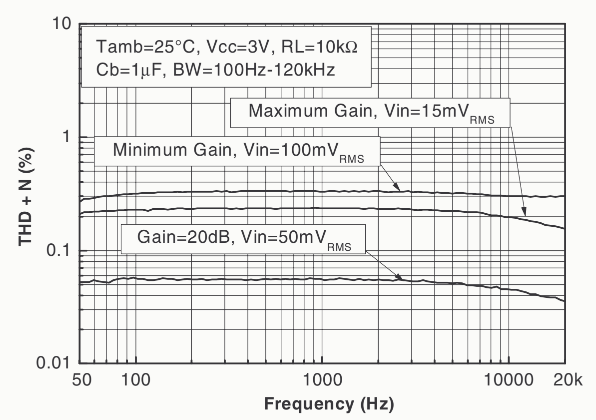


Figure 27. THD+N vs. frequency

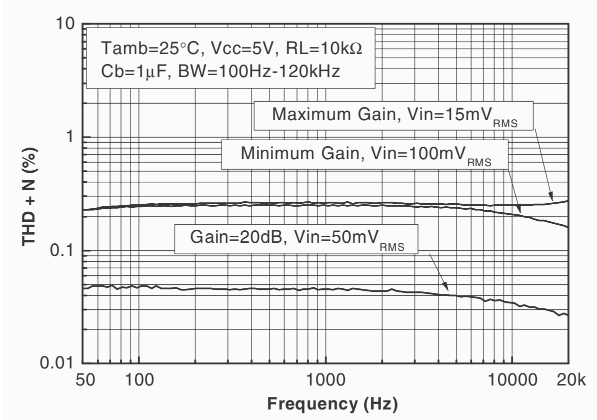


Figure 28. Transient response

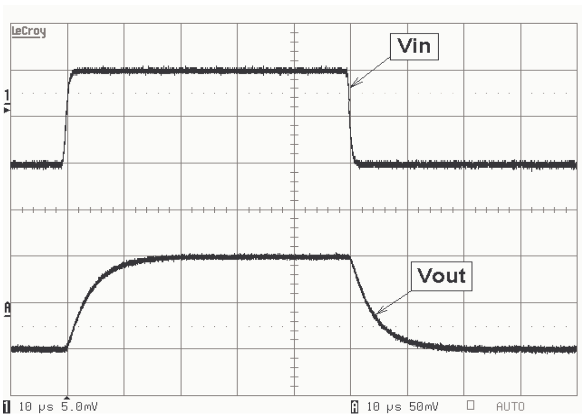
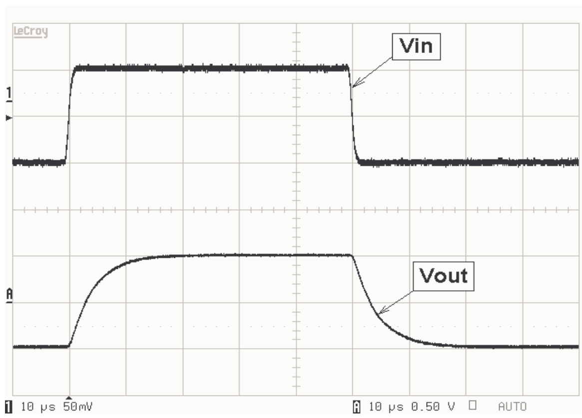


Figure 29. Transient response



4 Application Information

4.1 Differential configuration principle

The TS472 is a full-differential input/output microphone preamplifier. The TS472 also includes a common mode feedback loop that controls the output bias value to average it at Vcc/2. This allows the device to always have a maximum output voltage swing, and by consequence, maximize the input dynamic voltage range.

The **advantages** of a full-differential amplifier are:

- Very high PSRR (Power Supply Rejection Ratio).
- High common mode noise rejection.
- In theory, the filtering of the internal bias by an external bypass capacitor is not necessary. But, to reach maximum performances in all tolerance situations, it's better to keep this option.

4.2 Higher cut-off frequency

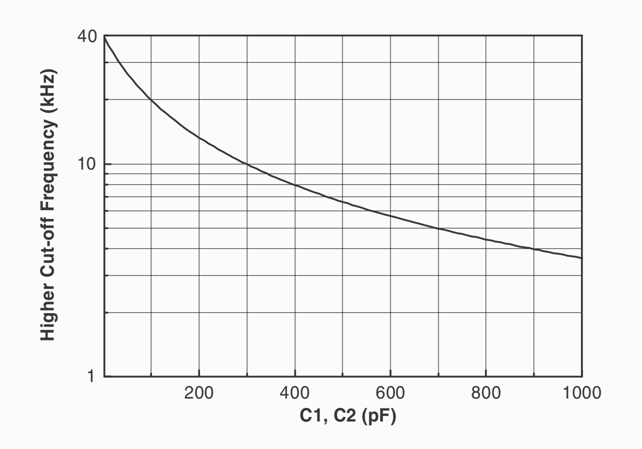
The higher cut-off frequency F_{CH} of the microphone preamplifier depends on an external capacitors C_1, C_2.

TS472 has an internal first order low pass filter (R=40kΩ, C=100pF) to limit the highest cut-off frequency on 40kHz (with a 3dB attenuation). By connecting C_1, C_2 you can decrease F_{CH} with regard to following formula:

$$F_{CH} = \frac{1}{2\pi \cdot 40\times10^{3} \cdot (C_{1,2} + 100\times10^{-12})}$$

Figure 24, which follows, directly shows the higher cut-off frequency in Hz versus the value of the output capacitors C_1, C_2 in nF:

Figure 30. Higher cut-off frequency vs. output capacitors



For example, F_{CH} is almost 20kHz with $C_{1,2}$=100pF.

4.3 Lower cut-off frequency

The lower cut-off frequency F_{CL} of the microphone preamplifier depends on the input capacitors C_{in} and output capacitors C_{out}. These input and output capacitors are mandatory in a application because of DC voltage blocking.

The input capacitors C_{in} in serial with the input impedance of the TS472 (100kΩ) are equivalent to a first order high pass filter. Assuming that F_{CL} is the lowest frequency to be amplified (with a 3dB attenuation), the minimum value of C_{in} is:

$$C_{in} = \frac{1}{2\pi \cdot F_{CL} \cdot 100\times10^{3}}$$

The capacitors C_{out} in serial with the output resistors R_{out} (or an input impedance of the next stage) are also equivalent to a first order high pass filter. Assuming that F_{CL} is the lowest frequency to be amplified (with a 3dB attenuation), the minimum value of C_{out} is:

$$C_{out} = \frac{1}{2\pi \cdot F_{CL} \cdot R_{out}}$$

Figure 31. Lower cut-off frequency vs. input capacitors

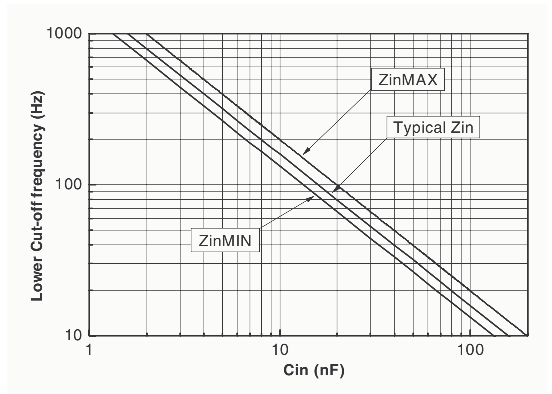


Figure 32. Lower cut-off frequency vs. output capacitors

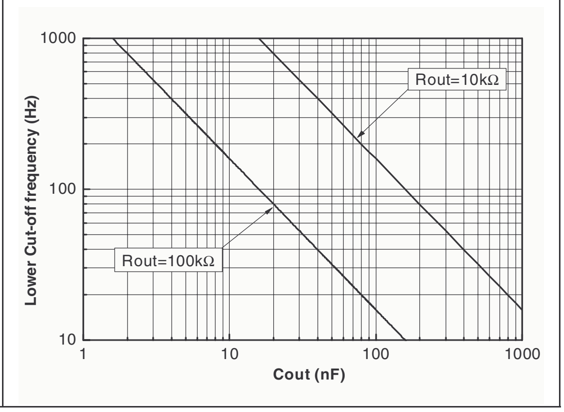


Figure 30 and *Figure 32* give directly the lower cut-off frequency (with 3dB attenuation) versus the value of the input or output capacitors

Note: In case F_{CL} is kept the same for calculation, It must be taken in account that the 1st order high-pass filter on the input and the 1st order high-pass filter on the output create a 2nd order high-pass filter in the audio signal path with an attenuation of 6dB on F_{CL} and a rolloff of 40db⁄decade.

4.4 Low-noise microphone bias source

The TS472 provides a very low noise voltage and power supply rejection BIAS source designed for biasing an electret condenser microphone cartridges. The BIAS output is typically set at 2.0 V_{DC} (no load conditions), and can typically source 2mA with respect to drop-out, determined by the internal resistance 100Ω (for detailed load regulation curves see *Figure 6*).

4.5 Gain settings

The gain in the application depends mainly on:

- the sensitivity of the microphone,
- the distance to the microphone,
- the audio level of the sound,
- the desired output level.

The sensitivity of the microphone is generally expressed in dB/Pa, referenced to 1V/Pa. For example, the microphone used in testing had an output voltage of 6.3 mV for a sound pressure of 1 Pa (where Pa is the pressure unit, Pascal). Expressed in dB, the sensitivity is:

20Log(0.0063) = -44 dB/Pa

To facilitate the first approach, the following table gives voltages and gains used with a low cost omnidirectional Electret Condenser Microphone of -44dB/Pa.

Table 10. Typical TS472 gain vs. distance to the microphone (sensitivity -44dB/Pa)

Distance to microphone	Microphone output voltage	TS472 Gain
1 cm	30 mV_{RMS}	20
20 cm	3 mV_{RMS}	100

The gain of the TS472 microphone preamplifier can be set:

1. From -1.5 dB to 41 dB by connecting an external grounded resistor R_{GS} to the GS pin. It allows to adapt more precisely the gain to each application.

Table 11. Selected gain vs. gain select resistor

Gain (dB)	0	10	20	30	40
R_{GS} (Ω)	470k	27k	4k7	1k	68

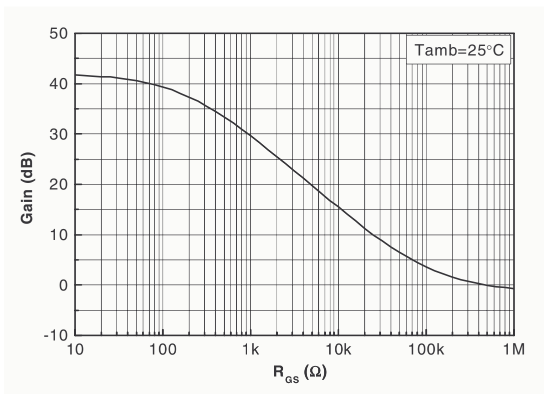


Figure 33. Gain in dB vs. gain select resistor

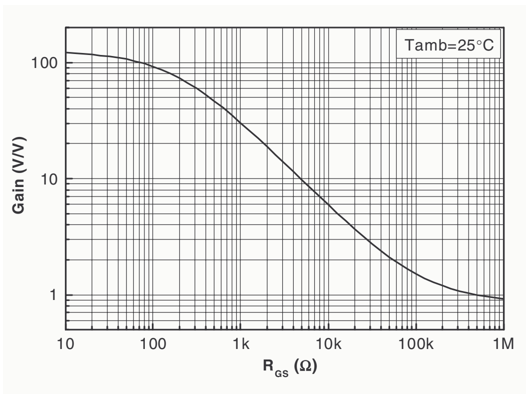
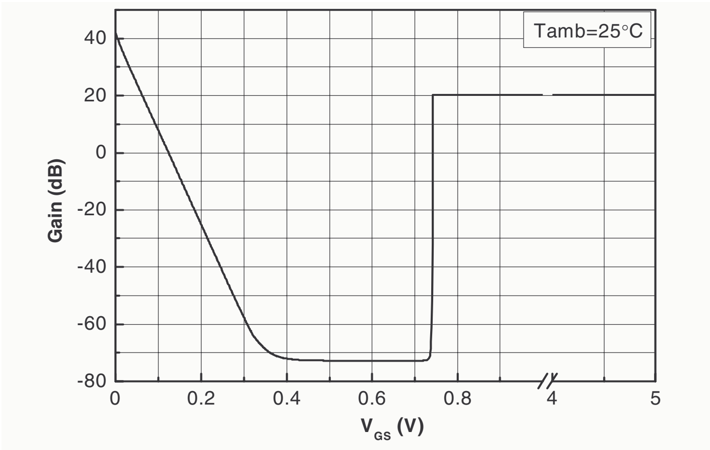


Figure 34. Gain in V/V vs. gain select resistor

2. To 20dB by applying $V_{GS} > 1V_{DC}$ on Gain Select (GS) pin. This setting can help to reduce a number of external components in an application, because 2.0 V_{DC} is provided by TS472 itself on BIAS pin.

Following *Figure 26* gives other values of the gain vs. voltage applied on GS pin

Figure 35. Gain vs. gain select voltage

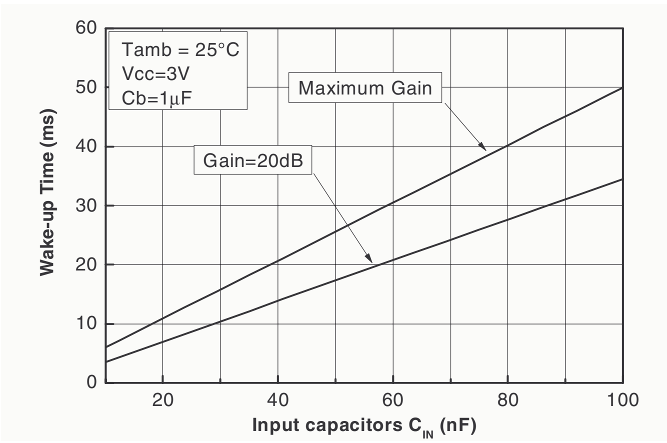


4.6 Wake-up time

When the standby is released to put the device ON, a signal appears on the output a few microseconds later, and the bypass capacitor Cb is charged in a few milliseconds. As Cb is directly linked to the bias of the amplifier, the bias will not work properly until the Cb voltage is correct.

In the typical application, when a biased microphone is connected to the differential input via the input capacitors (Cin), (and the output signal is in line with the specification), the wake-up time will depend upon the values of the input capacitors Cin and the gain. When gain is lower than 0dB, the wake-up time is determined only by the bypass capacitor Cb, as described above. For a gain>0dB, see *Figure 36*

Figure 36. Wake-up time in the typical application vs. input capacitors



4.7 Standby mode

When the standby command is set, the time required to set the output stages (differential outputs and 2.0V bias output) in high impedance and the internal circuitry in shutdown mode is a few microseconds.

4.8 Layout considerations

The TS472 has sensitive pins to connect C1, C2 and Rgs. To obtain high power supply rejection and low noise performance, it is mandatory that the layout track to these component is as short as possible.

Decoupling capacitors on Vcc and bypass pin are needed to eliminate power supply drops. In addition, the capacitor location for the dedicated pin should be as close to the device as possible.

4.9 Demoboard

A demoboard for the TS472 is available.

For more information about this demoboard, please refer to **Application Note AN2240**, which can be found on **www.st.com.**

Figure 37. Top layer

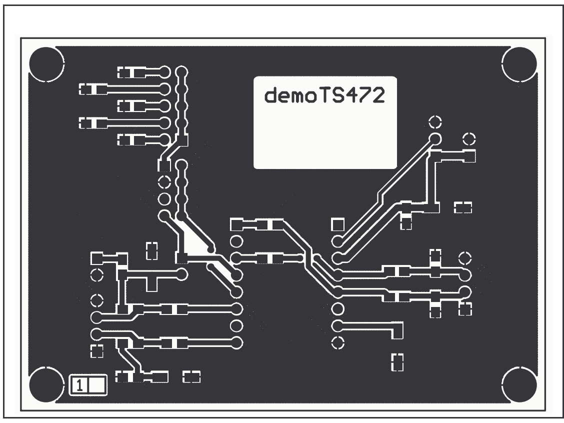


Figure 38. Bottom layer

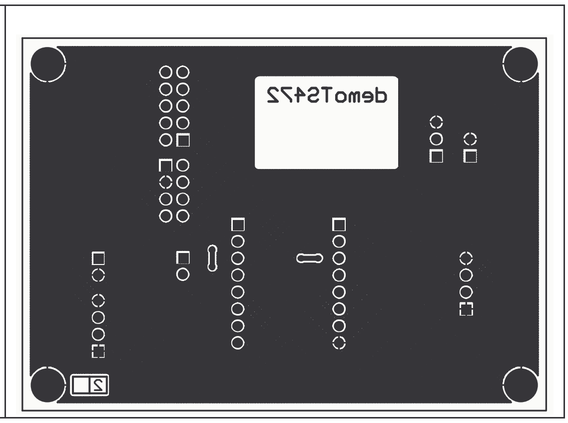


Figure 39. Component location

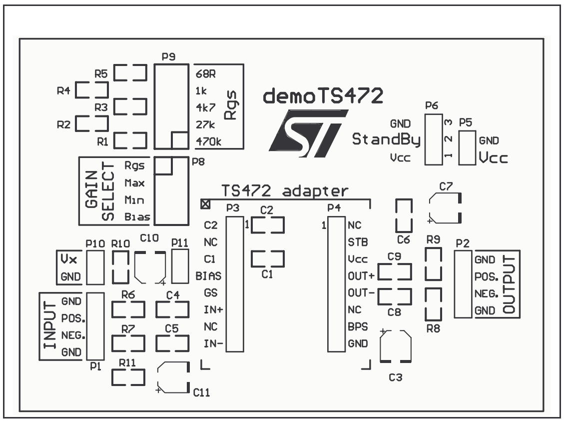
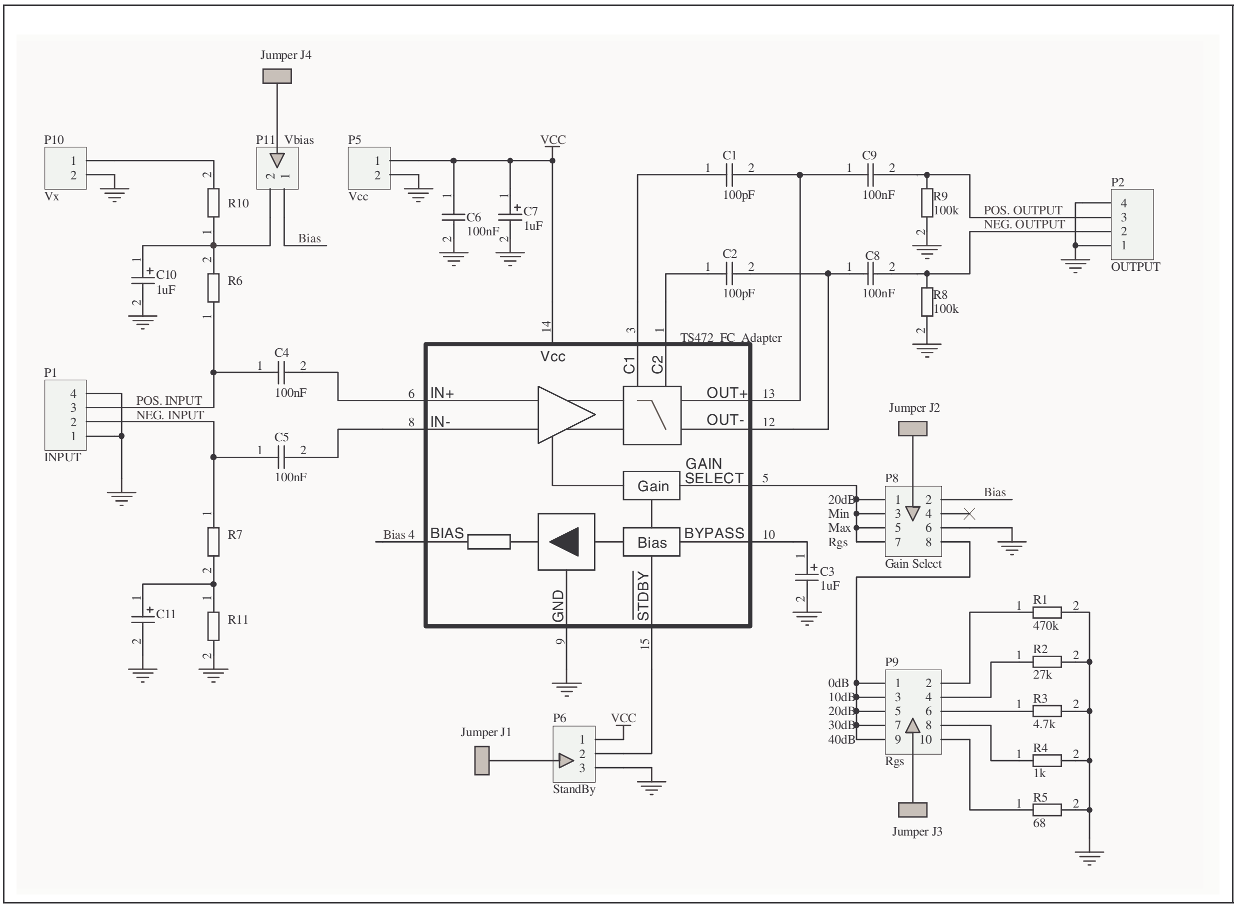


Figure 40. Demoboard schematic



5 Package Mechanical Data

Figure 41. TS472 footprint recommendation

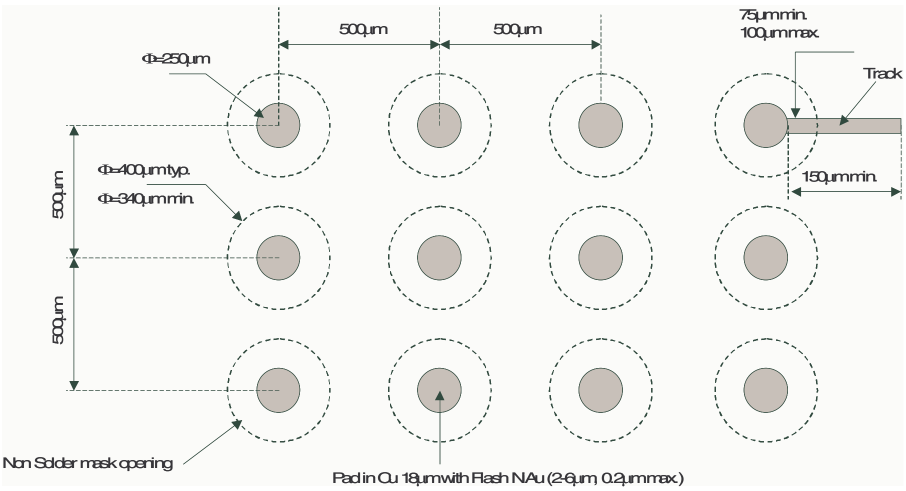
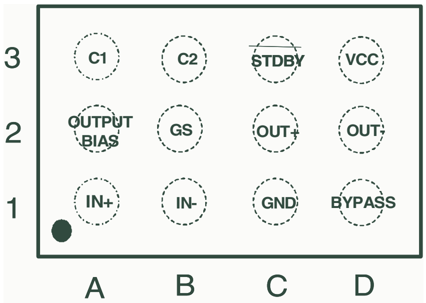


Figure 42. Pin-out (top view)

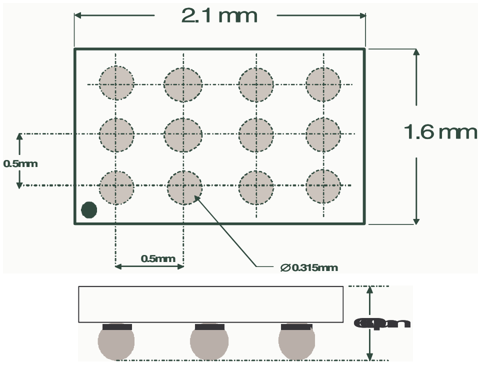


- Balls are underneath

Figure 43. Marking (top view)

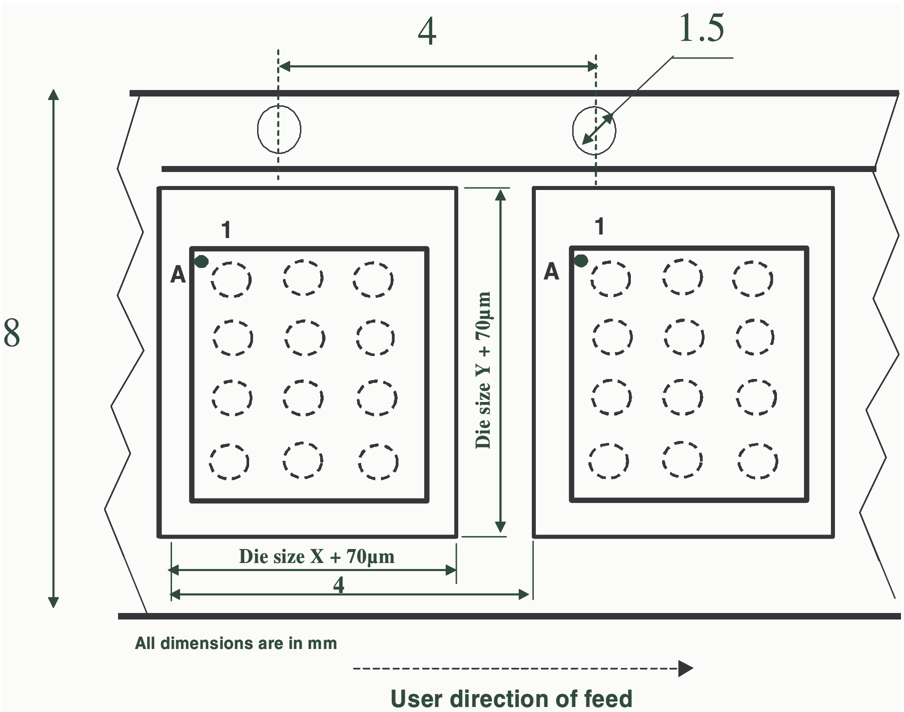
- ST Logo
- Part number: 472
- E Lead free Bumps
- Three digits Datecode: YWW
- The dot is for marking pin A1

Figure 44. Flip-chip - 12 bumps



- Die size: **2.1mm x 1.6mm** ± 30µm
- Die height (including bumps): **600µm**
- Bumps diameter: **315µm** ±50µm
- Bump Diameter Before Reflow: **300µm** ±10µm
- Bumps Height: **250µm** ±40µm
- Die Height: **350µm** ±20µm
- Pitch: **500µm** ±50µm
- Coplanarity: **50µm max**

Figure 45. Tape & reel specification (top view)



6 Revision History

Date	Revision	Changes
July 2005	1	First Release corresponding to the product preview version.
Oct. 2005	2	First release of fully mature product datasheet.