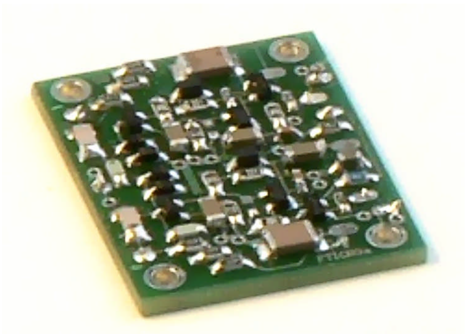
FTICR-3

2-Channel Low Noise FT-ICR Preamplifier, Version 3

- Printboard for Vacuum Mounting -



- Manual and Datasheet -

Features:

- **2 Independend Channels**
- **Designed as Front End Stage for FT-ICR Traps**
- **100K to 300K operating range**
- **Wide Frequency Range: 0.7 kHz to 30 MHz, customizable**
- **Low Noise Design**
- **Baking in Vacuum up to 125 °C**

Datsheet Version 3.1a, May 2017

Overview

The FTICR-3 is a 2-channel very sensitive voltage preamplifier, which is intended for low-noise and high-impedance applications like FT-ICR cells. This module contains 2 independend channels, all ranging from very low frequencies less than 1 kHz (Magnetron signals) up to more than 30 MHz (Cyclotron Signals) and is suited for mounting inside vacuum systems. This frequency range is also customizable. The high input impedance allows for direct connection to FT-ICR pickup electrodes. The FTICR-3 is implemented as printboard and intended for direct mounting inside vacuum close to a FT-ICR Penning Trap.

Additional DC lines allow for biasing the connected trap electrodes to DC voltages up to +/-250V.

The version 3.0 in contrast to 2.0 is routinely tested at temperatures down to 70K with slightly altered parameters with respect to the previous versions.

Pin Connections

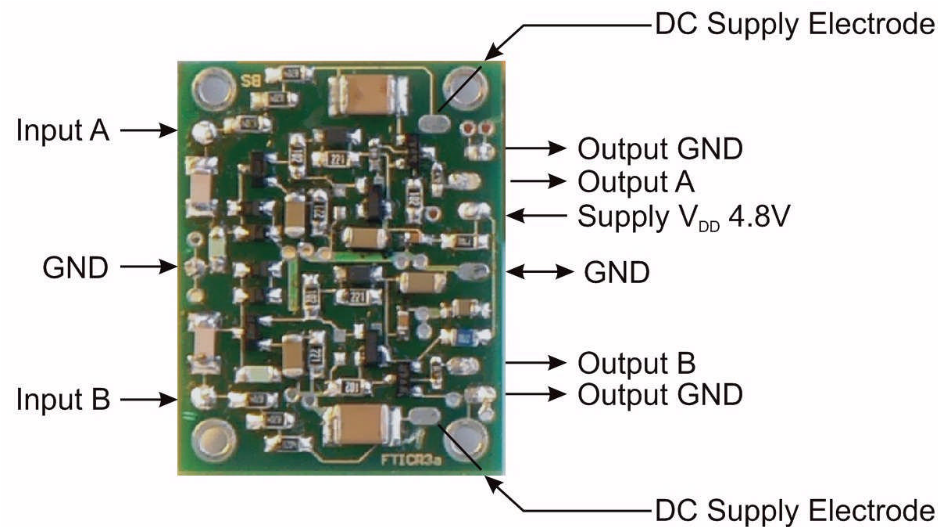


Fig. 1: How to connect the preamplifier board

Functional Description

The following diagram illustrates the internal structure (1 channel of 2 is shown). Every channel consists of two stages, formed by low noise FET transistors, and followed by buffer circuitry. The outputs provide the amplified signals (voltage amplification factor around x12) and a constant DC level of nominally 2.7V, wich allows subsequent circuitry to monitor the correct functionality of the FTICR-3 device. The input “DC Supply Electrode” allows to supply the signal pickup electrode with a constant DC voltage. In case the pickup electrode DC level shall be GND (0V), the input “DC Supply Electrode” must be connected to GND, in order to prevent electrodes from floating or charging up.

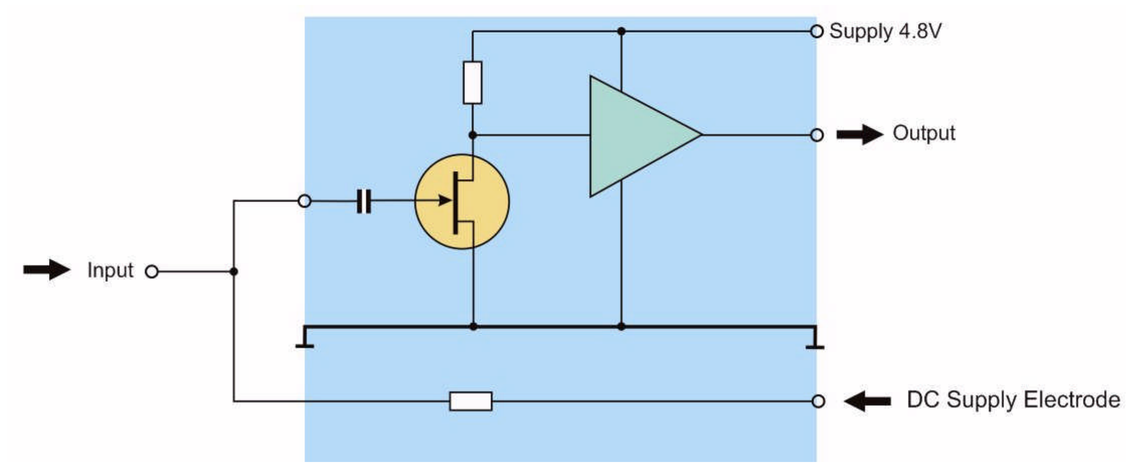


Figure 2: Simplified Diagram of Internal Structure

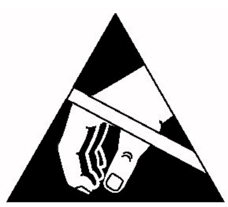
Absolute Maximum Ratings

Note: Stresses above these ratings may cause permanent damage or degradation of device performance. Exposure to absolute maximum conditions for extended periods may also degrade device parameters or reliability.

Quantity	Limits		Remarks
	min.	max.	
pos. Supply Voltage V_{DD}	-0.3V	+8V	
Input Voltage AC DC		$5V_{pp}$, f = 0 ... 5MHz +/-250V	derating inversely proportional with frequency above 5MHz
Admissible Input Current		40 mA_{eff} $3A_{pk}$	permanent current through protection circuitry maximum peak current for less than 10ms, at max. 1 Hz repetition rate
Storage Temperature		125°C	baking is possible up to 125°C, max. for 48 hours
Storage Humidity		65% @ 40°C	

Table 1: Absolute Maximum Ratings

Electrostatic Sensitivity



This device can be damaged by ESD (Electrostatic Discharge). It is recommended to handle the device with appropriate pre-cautions. Failure to observe proper handling and installation procedures can easily cause serious damage. This ESD damage can range from subtle performance degradation to complete device failure.

Typical Data and Operating Parameters, Model FTICR-3

Ambient temperature T = 298 K unless stated otherwise , V_{DD} = +5V

Parameter	typical Value	Remarks/Conditions
Freq. Range @ 300K for -3dB deviation (customizable)	2.5 kHz....28 MHz	medium impedance load, C_{Load} < 50pF ; see also figures 3,4,5,6 and 12
Gain Voltage gain @ f = 100kHz amplification factor mismatch between two channels	x 6.4 ± 8% x 3.2 ± 8% typ. ± 1.5% max. +/-5%	high impedance load, 50Ω load @ f = 10kHz…500kHz
Input Impedance at either input DC AC resistive impedance and input capacitance vs. GND	200 MΩ capacitively coupled 110MΩ noise related approx. 24 MΩ 18pF	measured vs. DC electrode bias line
Output Impedance (customizable)	50Ω +/-15%	T = 80K … 330K
Input Noise *noise figure per channel* voltage noise density current noise density	1.4 nV / √Hz @ 300K 0.9 nV / √Hz @ 125K 20 fA / √Hz @300K 15 fA / √Hz @125K	@ f = 50kHz to 1MHz see also performance graphs below @ f = 10kHz to 200kHz @ f = 10kHz to 200kHz
Operating voltages V_{DD}, positive supply voltage	+4.5 V…+6 V	
Channel Crosstalk Supression	> 55dB @ 30kHz to 500kHz	
Supply Current V_{DD} = 5.0V	9.3 mA	
Max. Operating Temperature Recommended Range	T = 70K ... 330K T = 110K ... 320K	Note: Amplification factor drops rapidly at temperatures smaller 100K (see also fig. 6)
Magnetic Properties	Device consists mostly of non-magnetic materials. spurious amounts of ferromagnetic substances < 0.05gr. possible	
Geometrical Size	26mm x 33mm x 5mm	
Weight	~5 gr.	

Table 2: Typical data

Operation in vacuum

The FTICR-3 is generally vacuum suited for pressures down to about 2x 10^{-7}mbar. In order to improve the outgassing behaviour, it is possible to bake out the device at temperatures up to 125°C. The maximum allowed (short term) ambient temperature is 145°C. Please note that the device must NOT be baked out, while powered on with the external 4.8V supply. In this case the (electrical) heat dissipation may easily exceed the maximum admissible board temperature and destroy the device.

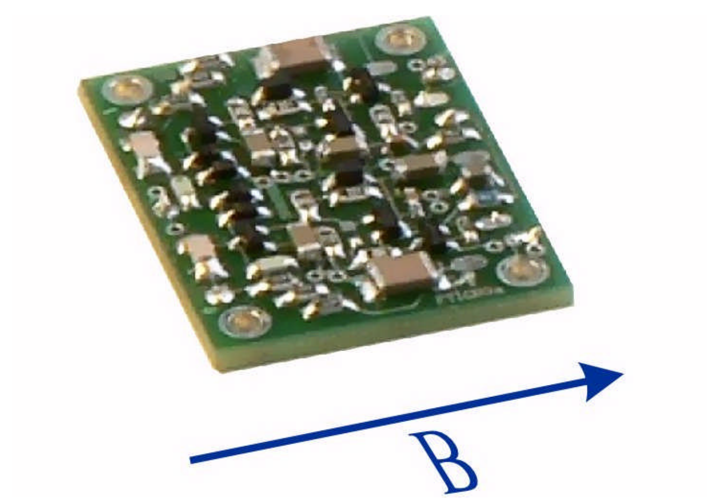
Grounding and Shielding

Grounding and Shielding are generally important issues, especially in connection with high-impedance input amplifiers. A proper grounding and shielding geometry is essential to maintain good device performance and to achieve the low noise characteristics, described in the specifications. The typical RF-(radio-frequency) design rules for proper grounding and shielding apply. To ensure a reliable functionality, good ground connections around the amplifier have to be provided, avoiding ground loops, keeping lines as short as possible and of low inductance-style. Signal connections may be implemented as coaxial or twisted-pair lines, to avoid external interference and unwanted feedback from the output to the input.

Please ensure that the printboard is tighly fixed to a proper ground plane, using all mounting holes. This is also relevant for speading the dissipated power away from the printboard substrate, in order to prevent it from overheating under vacuum conditions.

Mounting Position

It is recommended to place the device in close proximity to a FT-ICR cell, with the short side in parallel to the external magnetic field (see below). With respect to axial FT-ICR cell location it is recommeded to place the device in about 5 to 7 cm distance to the trap (FT-ICR cell) center.



Typical Performance Characteristics

Voltage Amplification Factor vs. Frequency

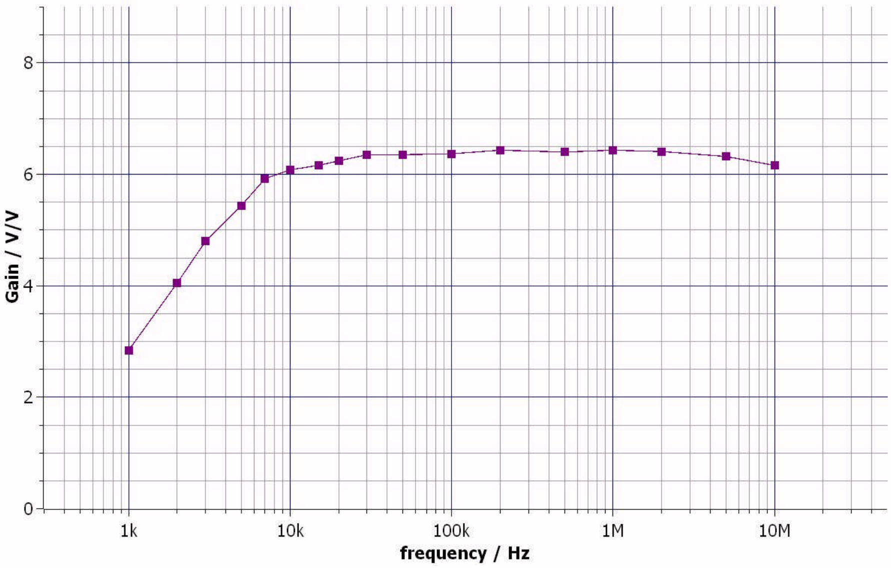


Fig. 3: Voltage Amplification Factor vs. frequency, low frequency regime, open output, T = 300K; Measurement device: Rigol function generator and Tektronix oscilloscope TDS210
Note that the frequency range is also customizable.

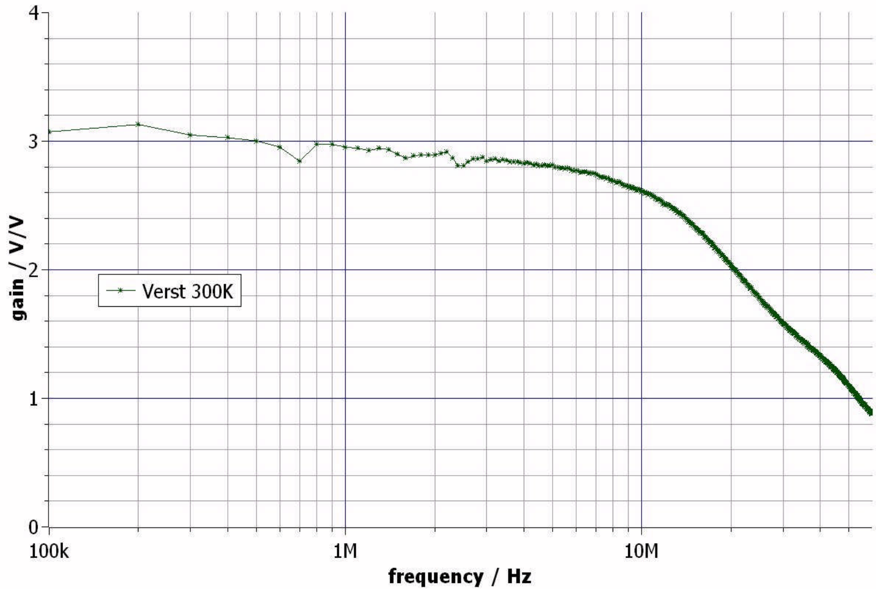


Fig. 4: Voltage Amplification Factor vs. frequency, high frequency regime, T = 300K. Output terminated with 50Ω. Measurement device: Rigol DSA815

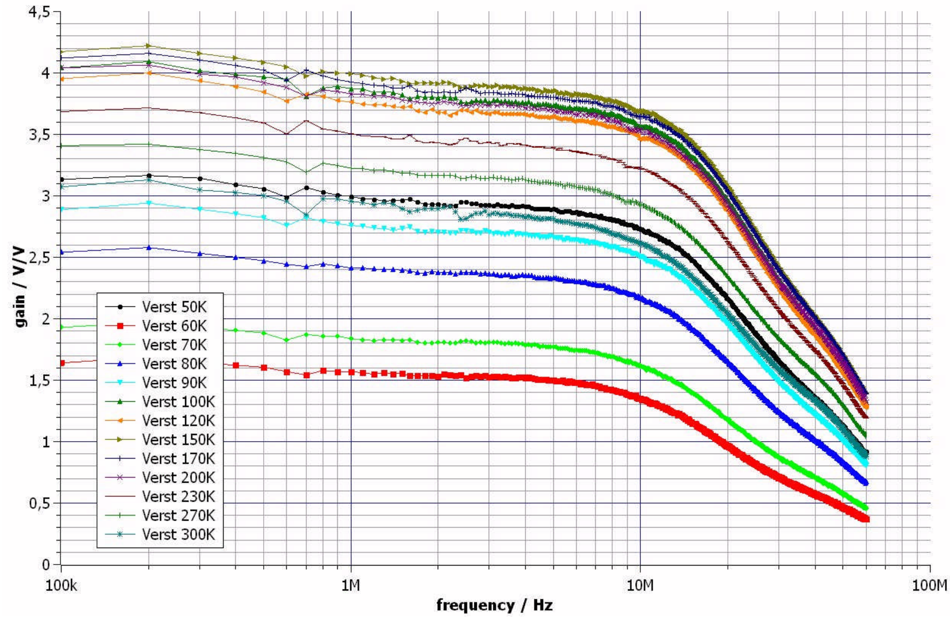


Fig. 5: Voltage Amplification Factor vs. frequency, high frequency regime, at various temperatures between 50K and 300K. Output terminated with 50Ω. Measurement device: Rigol DSA815

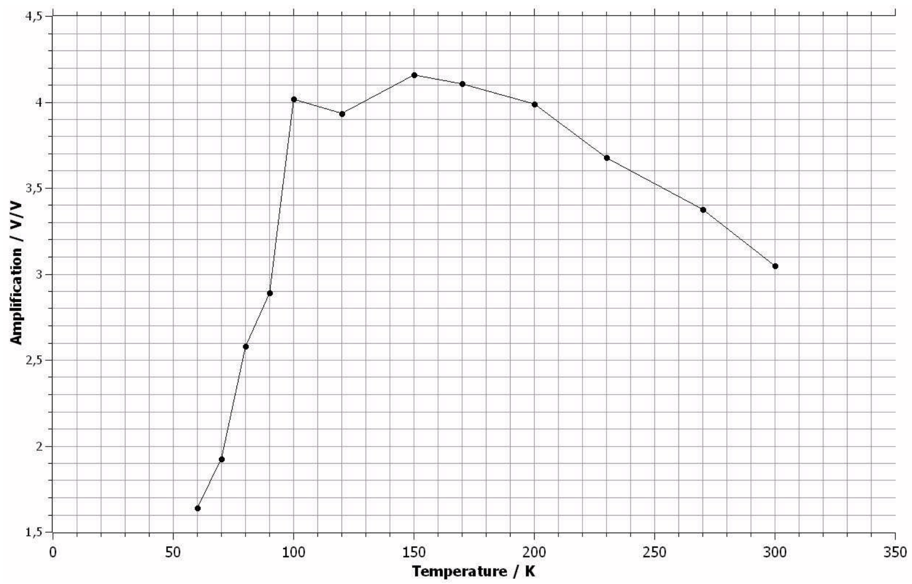


Fig. 6: Voltage Amplification Factor at fixed frequency of 300kHz at different temperatures. Values refer to 50 Ohm termination. Numbers double in case of high-Z output termination.

Input Voltage Noise Density vs. Frequency, T = 300K and T = 125K

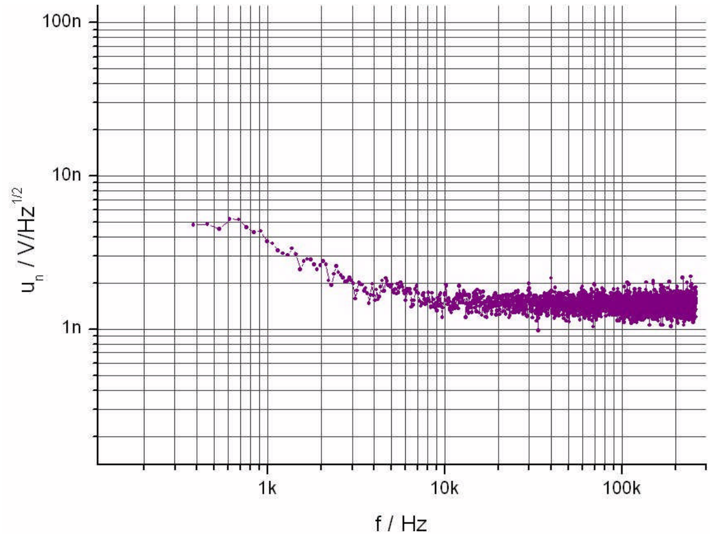


Fig. 7: Input voltage noise density vs. frequency, low frequency regime (T = 300K).

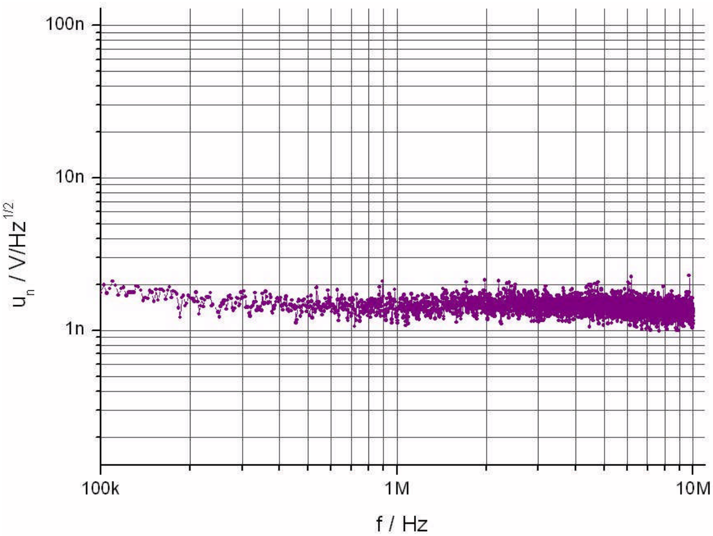


Fig. 8: Input voltage noise density vs. frequency, high frequency regime (T = 300K).

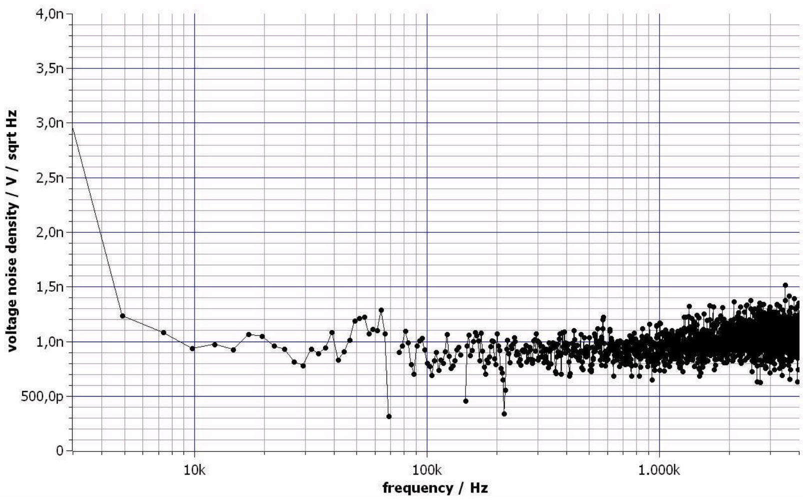


Fig. 9: Input voltage noise density vs. frequency, medium frequency regime (T = 125K).

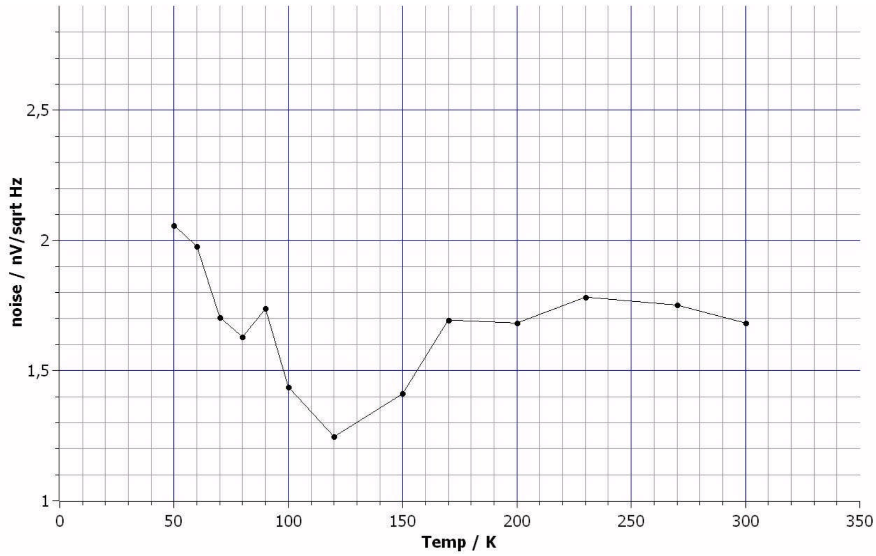


Fig. 10: Input voltage noise density at fixed frequency of 300kHz at various temperatures.

Current Input Noise Density vs. Frequency, T = 125K, T = 300K

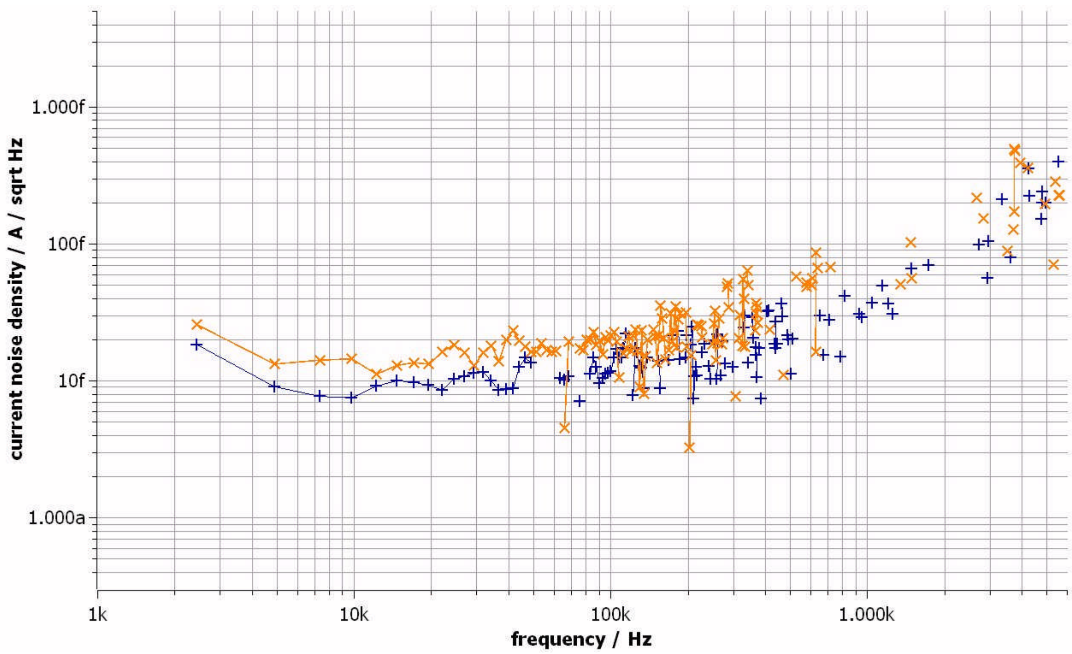


Fig. 11: Input current noise density vs. frequency, medium frequency regime at T = 300K (orange upper curve) and T = 125K (lower dark-blue curve).

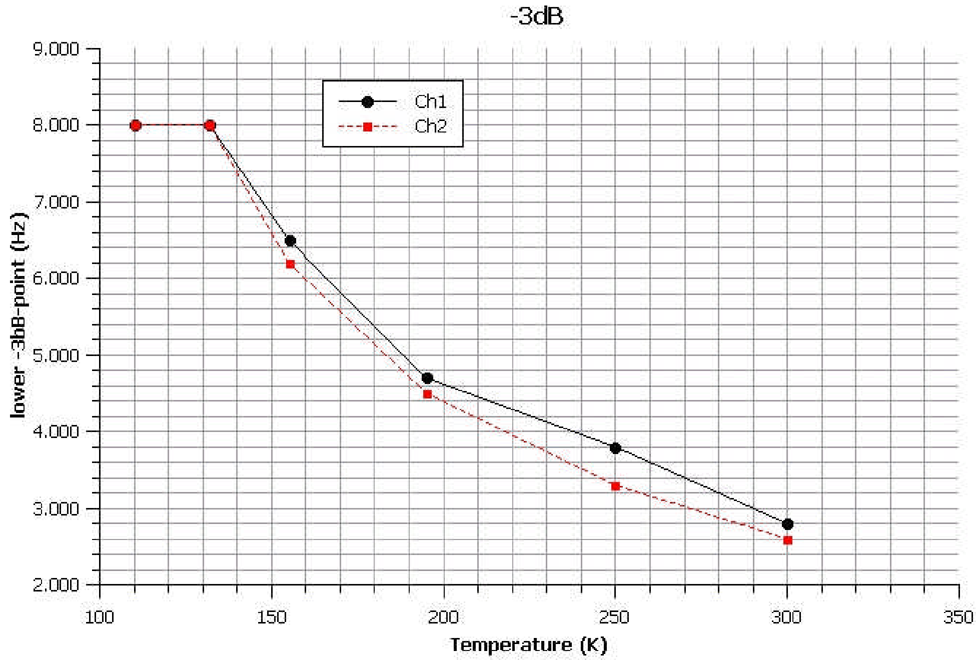


Fig. 12: Lower frequency range end (-3dB point) as function of temperature with 50Ω load

Case Style

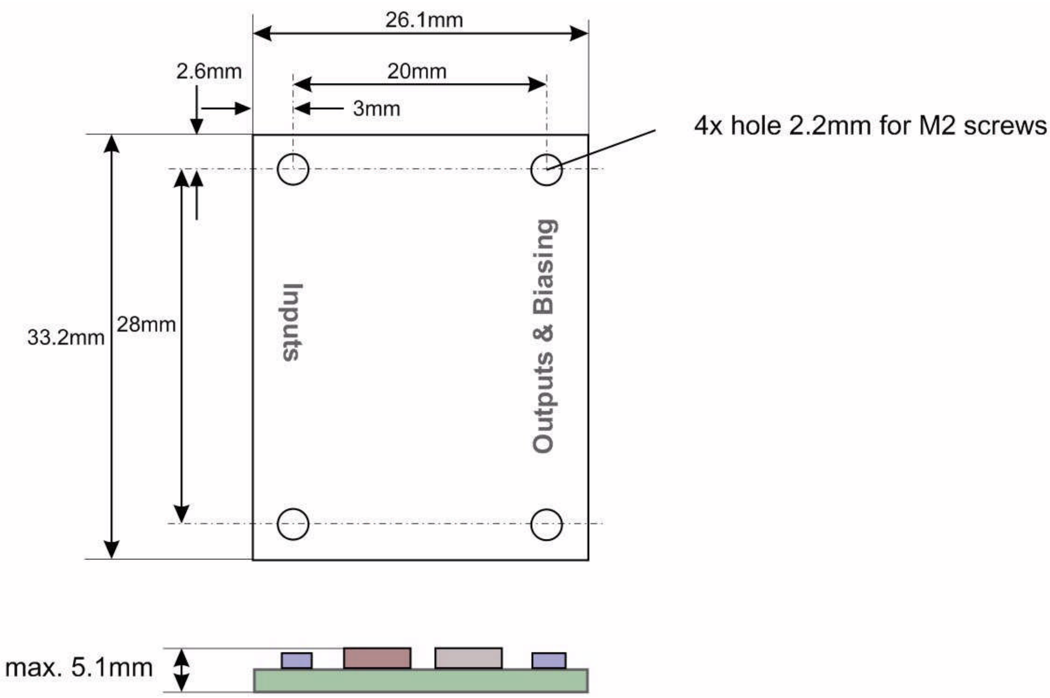


Fig. 13: Geometrical dimensions.

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