Tontechnik-Rechner - sengpielaudio

Deutsche Version

# • Finding of input impedance and output impedance • Impedance calculated for audio amplifier, loudspeaker, or microphone

### The usual common question is: How to measure impedance?

The question of the input impedance of a microphone or the output impedance of a loudspeaker is nonsense.
There is only the output impedance of a microphone and the input impedance of a loudspeaker.
What is the load resistance of an audio amplifier? That is the loudspeaker.

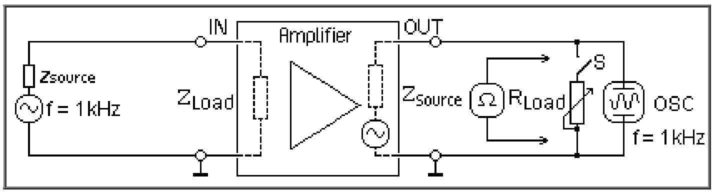
**In sound engineering there is no Impedance matching or Power matching.**
**In audio we use only high Impedance bridging or Voltage bridging.**

**'8 Ohm Output' and '150 Ohm Input' - What is that?**

**Amplifier, Loudspeaker, and Ohms - How do they work together?**

A resistance is a DC resistance, which can be measured with an ohmmeter. If there is a capacitor in the signal path we measure nothing. With a voice coil of a speaker we can measure a DC resistance. With a digital multimeter DMM resistances can be measured easily, but we cannot measure input impedances and output impedances. The capacitance and the resistance build as frequency-dependent form a complex resistance, the so-called impedance Z. The nominal impedance is in electrical engineering and electro-acoustic (audio), the frequency-dependent impedance at the input and / or at the output of an electrical device, which is specified in the middle frequency range at 1 kHz of a technical data sheet.
In electrical engineering and acoustics alternating quantities are always described with its effective value (RMS).

# Output Impedance Measurement and Calculator




| | | |
|---|---|---|
| Open-circuit voltage $V_1$ | 2.0 | volts |
| Load resistance $R_{\text{load}}$ | 10 | ohms |
| Loaded circuit voltage $V_2$ | 1.5 | volts |
| Reset ↓ | Calculate | |
| Output Impedance $Z_{\text{source}}$ | | ohms |

| | |
|---|---|
| **Output impedance** | $Z_{\text{Source}} = R_{\text{Load}} \times \left( \frac{V_1}{V_2} - 1 \right)$ |

Voltage measurement at the points at OUT:

$V_1$ = Open-circuit voltage ($R_{\text{load}}$ = ∞ Ω, that is without $R_{\text{load}}$, switch S is open)
$R_{\text{load}}$ = Load resistance ($R_{\text{test}}$ is resistor to measure Ω value)
$V_2$ = Loaded circuit voltage with resistor $R_{\text{load}}$ = resistance $R_{\text{test}}$
$Z_{\text{source}}$ = The output impedance can be calculated

**When the voltage $V_2$ is equal to half of $V_1$, then the measured resistance value $R_{\text{load}}$ (that is $R_{\text{test}}$) is equal to the output impedance $Z_{\text{source}}$.**

$Z_{source}$ = output impedance = source impedance = internal impedance.

The output impedance of a device can simply be determined. We use a load resistance $R_{load}$, to load the signal source impedance $Z_{source}$. The output voltage is open initially without load as open-circuit voltage $V_1$ (Switch is open, that means $R_{load}$ is infinity) and then measured as $V_2$ under load with $R_{load}$ at point IN (Switch is closed). Then the found values $V_1$, $R_{load}$ and $V_2$ are entered to calculate the output impedance. The load resistance $R_{load}$ should not be too small, because the output is too heavily burdened and should not be too large, as this will change the voltage very little and leads to measurement errors. For output impedance of a normal power amplifier to operate a speaker a $R_{load}$ resistance of about 10 ohms is favorable.
For other line-level $R_{Load}$ a resistance of 2 kilo ohms is useful.

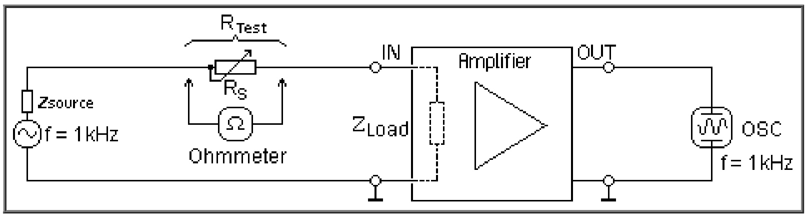
## Internal resistance of a power amplifier

"Measuring the output impedance by means of a burden": Suppose there is a **100 watt amplifier**. Then the output voltage at half power is $P$ = 50 W = $V^2$ / $R$. Loudspeaker impedance = 8 ohms. $V = \sqrt{(P \times R)} = \sqrt{(50 \times 8)}$ = 20 volts. (You can also use 10 V.) Give a sine voltage of 1 kHz to the amplifier input, until we get 20 volts at the output. Now we apply the "90% method", that is when we put an output resistance $R$, until there appear 90% of the open circuit voltage, in this case 18 volts. The internal resistance is then calculated with the 90% method:

**The 90% method**
$R_{internal} = R / 9$

At the output fix an oscilloscope, because the wave form should not show any distortion.
For example, if $R$ is measured 1 Ohm, then $R_{internal}$ = 0.11 Ohm.

# Input Impedance Measurement and Calculator




| | | |
|---|---|---|
| Generator signal $V_1$ | 2.0 | volts |
| Series resistance $R_{test}$ | 1000 | ohms |
| Signal after resistor $V_2$ | 1.0 | volts |
| Reset | ↓ | Calculate |
| Input impedance $Z_{load}$ | | ohms |

| | |
|---|---|
| **Input impedance** | $Z_{Load} = R_{Test} \times \left( \frac{V_2}{V_1 - V_2} \right)$ |

Voltage measurement at the points IN or at OUT:

$V_1$ = Generator signal voltage (at $R_s$ = 0 Ω, that is without series resistor $R_s$)
$R_s$ = Series resistance ($R_{test}$ is resistor to measure Ω value)
$V_2$ = Voltage with series resistor $R_s$ = resistance $R_{test}$
$Z_{load}$ = The input impedance can be calculated

**When the voltage $V_2$ is equal to half of $V_1$, then the measured**

**resistance value $R_s$ ($R_{test}$) is equal to the input impedance $Z_{load}$.**

$Z_{load}$ = input impedance = load impedance = external impedance = terminator

The input and output impedance of a four-terminal network can be determined by measuring the alternating current strength in amperes and the AC voltage in volts. The measurement of input impedance typically occurs as follows: The voltage is measured across the input terminals IN.
Then, the current in the circuit is done by the device in series with the signal generator. For circuits with high input impedance the current is very small and difficult to measure. $R = U / I$. Therefore, we choose for the measurement of high-impedance circuits, a better method. It puts a series resistor $R_s$ in the input circuit. First, we measure the input of the device at point IN with $V_1$, the AC voltage, if the resistor $R_s$ = 0 Ohm.
Then we measure the $R_S$ series resistor, the voltage $V_2$. Then these found values $V_1$, $R_s$ and $V_2$ is entered in the above calculator to find the input impedance to be calculated. Search for a suitable measuring resistance value $R_s$. For typical audio equipment that will be about 10 to 100 kilo-ohms.

You can use the digital voltmeter instead at the measuring point IN and
at point OUT to measure because the amplifier delivers an output voltage that is proportional to the voltage at its input.

### The impact of input impedance and output impedance of studio gear for bridging in audio engineering − $Z_{source}$ << $Z_{load}$

Amplifier, Loudspeaker, and Ohms - How do they work together?
'8 Ohm Output' and '150 Ohm Input' - What is that?
Calculations: voltage divider or potentiometer − Loaded and open circuit (unloaded)
Bridging (voltage) or matching (power) − Interface connecting Zout and Zin impedance
Voltage bridging or impedance bridging Zout < Zin − Interconnection of two audio units
Cable length, cable capacitance, and treble loss (Attenuation, cutoff frequency)

## Impedances of analog audio engineering for impedance bridging or voltage bridging $Z_{source}$ << $Z_{load}$

| Studio parts | Output impedance $Z_{source}$ | Input impedance $Z_{load}$ |
|---|---|---|
| Microphone | 35 Ω to 200 Ω | – |
| Microphone preamplifier | – | 1 kΩ to 2 kΩ |
| Power amplifier | **0.01 Ω to 0.1 Ω** | – |
| Loudspeaker | – | 2 Ω to 16 Ω |
| Studio gear (mixer) | 40 Ω | 10 kΩ to 20 kΩ |

**Fortunately, there are no amplifiers with an output impedance of 4-ohm or 8-ohm which have to fit to speakers with these values. We have no impedance matching (power matching), we use impedance bridging (voltage bridging), whereby the power amplifier often has an output impedance of only one hundredth of the speaker's input impedance.**

**At power amplifiers for musicians usually we can read at the output plugs: 4 ohms to 8 ohms − to tell the user that a 4-ohm speaker or an 8-ohm speaker has to be used and not to give the "correct" output impedance value, which is around 0.1 ohms. This is often not known by users.**

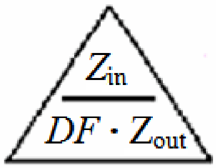
**The word "power amplifier" is a misnomer - especially in audio engineering. Voltage and current can be amplified. The strange term "power amplifier" has become understood to mean an amplifier that is intended to drive a load such as a loudspeaker.**
**We call the product of current and voltage gain "power amplification".**

## Loudspeaker input impedance $Z_{in} = DF \times Z_{out}$
## Amplifier output impedance $Z_{out} = Z_{in} / DF$
## Damping factor $DF = Z_{in} / Z_{out}$

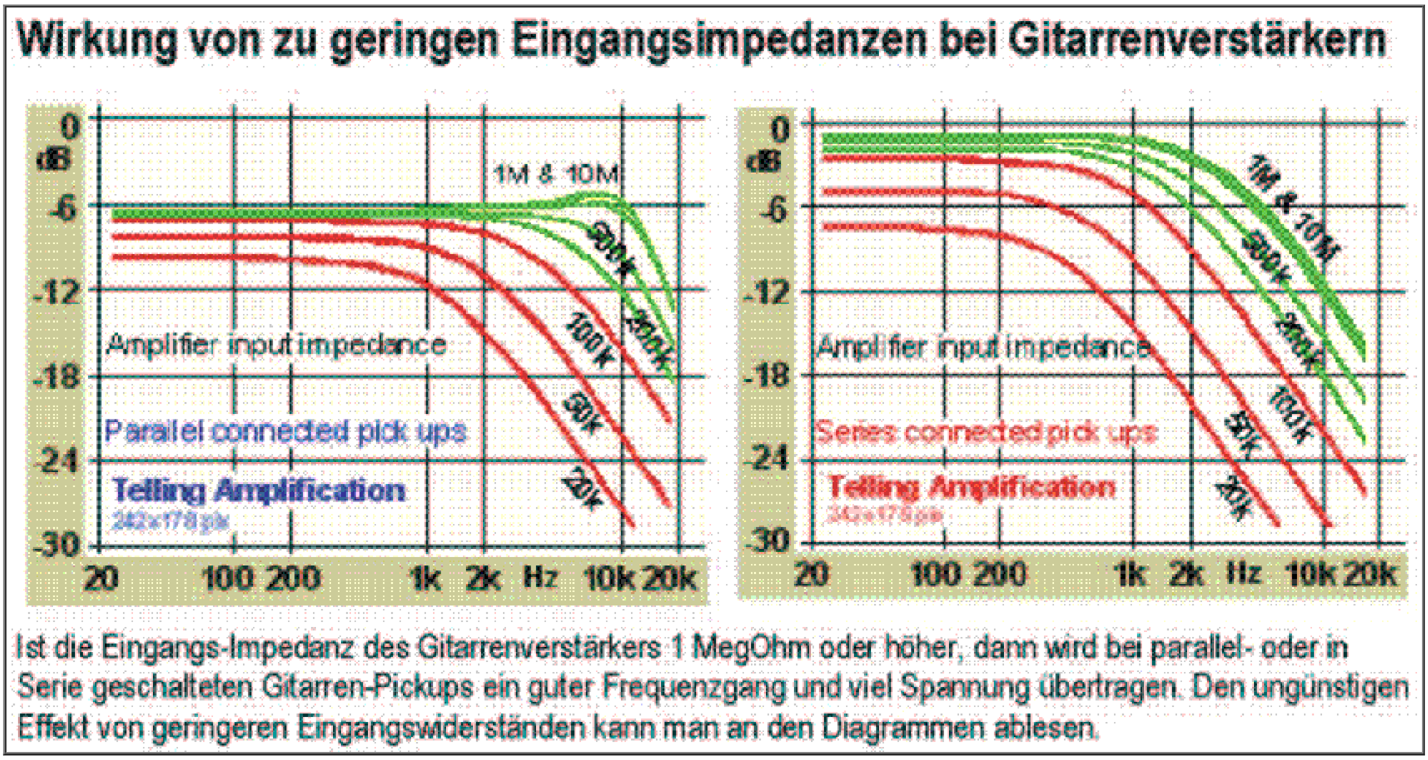
Output impedance $Z_{out}$ = input impedance $Z_{in}$ / damping factor $DF$

Please enter **two** values, the third value will be calculated.

| | | |
|---|---|---|
| Source impedance (output impedance) $Z_{out}$ | | ohm |
| Load impedance (input impedance) $Z_{in}$ | | ohm |
| Damping factor $DF$ | | – |
| reset | calculate | |




# Effect of the input impedance on guitar amps

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