

# TRANSISTOR AMPLIFIERS 1.0

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## INTRODUCTION

The goal of this short series of articles is to help you understand how a simple transistor amplifier – using a simple transistor such as the dirt cheap 2N3904 – can be a microphone preamp, or even a wide band RF amplifier, with just pennies worth of additional components mounted near it and a 9volt battery.

We'll take this step by step.

## VACUUM STATE VERSUS SOLID STATE

Transistors work by having charge carriers move inside a solid piece of semiconductor, so they are called “solid state.” Vacuum tubes work by having their charge carriers (principally ELECTRONS) moving through a vacuum. (“Vacuum state” devices).

A change in the voltage applied to the input of a vacuum tube causes a change in the current that flows in its output circuit. The “gain” (output current change divided by input voltage change,  $\Delta I / \Delta V$ ) is called transconductance.

A change in the current applied to the input of a (common emitter) transistor causes a change in the current that flows in the output circuit. The gain (output current change divided by input voltage change,  $\Delta I_{out} / \Delta I_{in}$ ) is called BETA or  $H_{fe}$ .

## SIMPLE MAGIC AMPLIFIER

So for a minute we will dispense with important things like “DC biasing circuitry” and “resting current” etc and just look at the **alternating current gain of a transistor**. *We'll assume that some brilliant person has magically biased the device so that it is in a comfortable portion of its operating range, and the input signal is fairly small and easily amplified.*

And we'll just assume that the **input impedance of this transistor for our small AC input is 1000 ohms**. So if the input voltage changes by 1 millivolt, the input current will change by 1 micro-amp. (due to ohms law:  $I = E / R$  and here,  $R=1000$ )

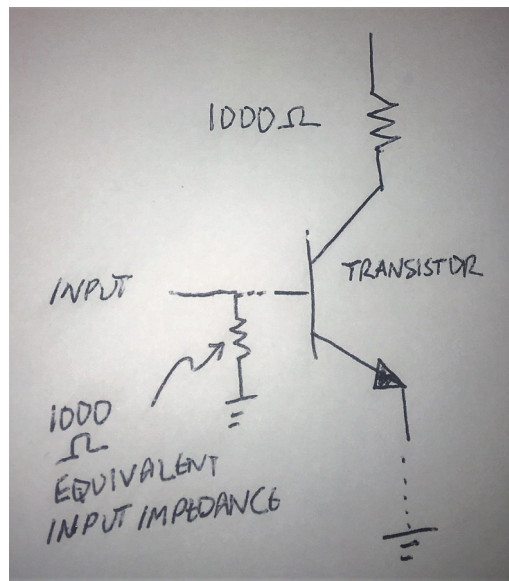
We will also assume the BETA of this transistor is 200, so the small input current change will be multiplied by 200.

So if we have a 1 millivolt input signal change, causing a 1 microampere input current change (that makes  $1 \times 10^{-9}$  watt power change) – the due to the BETA of 200, the output current will change by 200 micro amperes.

And we will arrange for a resistor of 1000 ohms to be in the output through which this current change is forced to traverse, so we will get a voltage change from ohm's law of

$E = I R = 200 \text{ microamperes} \times 1000 \text{ ohms} = 200 \text{ millivolts.}$

Since we ignored all the biasing and such, the following is a stylized view of how our small transistor amplifier looks:



### **BIG TIME VOLTAGE GAIN!**

**So our 1 millivolt input signal has gotten us a 200 millivolt output signal, a voltage gain of 200!**

Not bad!

In a future lesson, we'll begin to figure out how to “magically” get this transistor into its “happy place” where it is quite comfortable, and we'll also work at making it an even better amplifier.

### **So in this lesson we learned:**

- Solid state devices are named that because the charge carriers move inside a solid
- We can ignore the biasing and other set up considerations and look at the AC gain of a system
- BETA is the current gain of a transistor (typically measured at DC or audio frequencies)
- We use a resistor in the output circuit to make the current gain turn into a voltage gain