Transistor MF Amplifier

1. Introduction

This article is about building a transistor MF (medium frequency) amplifier.

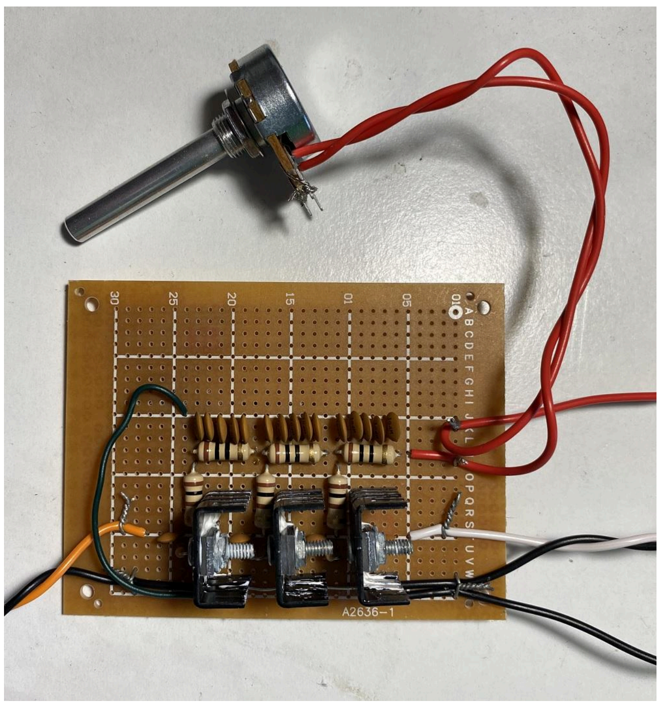

Figure 1: Device.

Instead of reading this article you can watch the video in the link below. However, I suggest that you read this article. There is not much to read.

https://www.youtube.com/watch?v=K4xLwzRa6mg

2. Step 1: Design the Circuit

I drawn the circuit in PSpice student edition version 9.1 to save time:

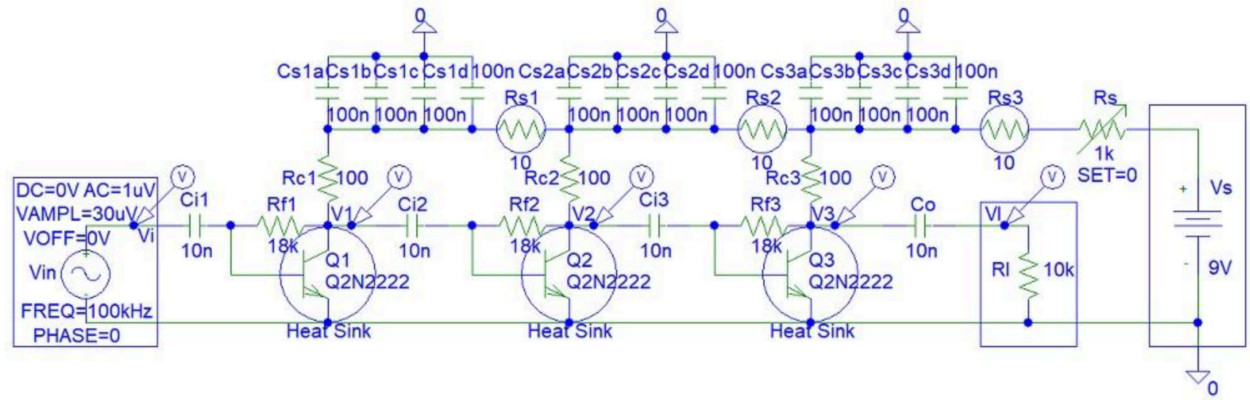

Figure 2: Circuit Design.

The transistor should be biased at half supply voltage (Vc = 4.5 V).

$$V_C = V_s - I_C R_C$$

Where: V_C = Transistor Collector Emitter Voltage (volts, V)

V_S = Supply Voltage (volts, V) = 9 V

R_C = Collector Resistor (ohms, **Ω**) = Rc1

I_C = Collector Current (amps, A)

$$V_C = V_s - \beta I_B R_C$$

I_B = Base Current (amps, A)

β = Transistor Current Gain (Ic / Ib)

$$V_C = V_S - \beta\left(\frac{V_C - V_{BE}}{R_f}\right)R_C$$

V_{BE} = Base Emitter Voltage = 0.7 V

R_f = Feedback Resistor (ohms, **Ω**) = Rf1

$$V_C = V_S - \left(\frac{V_C}{R_f}\right)\beta R_C + \left(\frac{V_{BE}}{R_f}\right)\beta R_C$$

$$V_C\left(1 + \frac{\beta R_C}{R_f}\right) = V_S + \frac{V_{BE}\beta R_C}{R_f}$$

$$V_C = \frac{V_S + \frac{V_{BE}\beta R_C}{R_f}}{1 + \frac{\beta R_C}{R_f}}$$

Find Rf and Rc:

$$V_C = V_S - \left(\frac{V_C - V_{BE}}{R_f}\right)\beta R_C$$

$$\left(\frac{V_C - V_{BE}}{R_f}\right)\beta R_C = V_S - V_C$$

$$R_C = \frac{\left(V_S - V_C\right)R_f}{\beta\left(V_C - V_{BE}\right)} \quad \text{and} \quad R_f = \frac{\beta\left(V_C - V_{BE}\right)R_C}{\left(V_S - V_C\right)}$$

Let Rc = 100 **Ω** (I have chosen a small Rc resistance to reduce the effect of transistor stray capacitance), β = 200, Vc = 4.5 V and Vbe = 0.7 V.

Therefore:

$$R_f = \frac{200\times(4.5\,V - 0.7V)\times 100\Omega}{(9\,V - 4.5\,V)}$$ =16,888 **Ω**

= 16.8 k**Ω**

We can use 18 k**Ω** resistor.

Calculating the capacitors is beyond the scope of this article.

3. Step 2: Simulations

Simulations show that the circuit works:

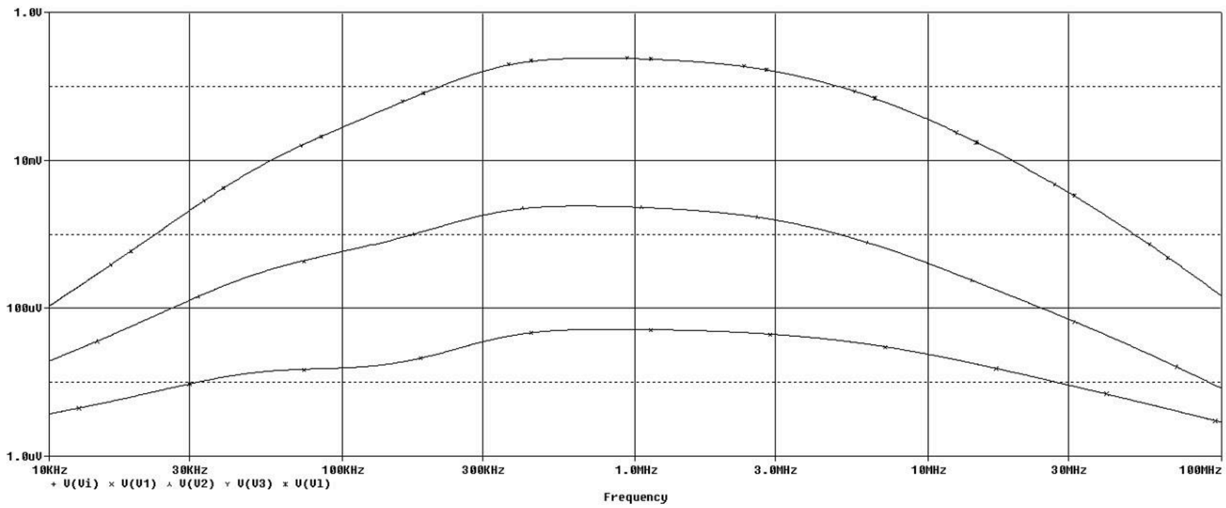

Figure 3: Frequency Domain Simulations.

In a practical circuit the maximum frequency will be influenced by the type of radio frequency transistor that you are using.

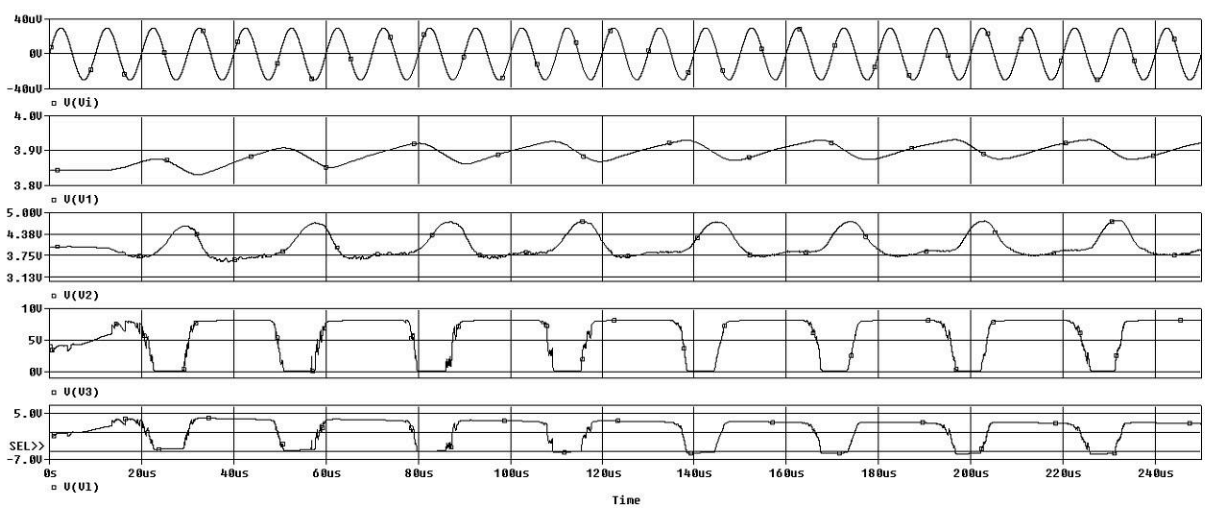

Figure 4: Time Domain Simulations.

4. Step 3: Make the Circuit

The circuit was made on a matrix board with a soldering iron:

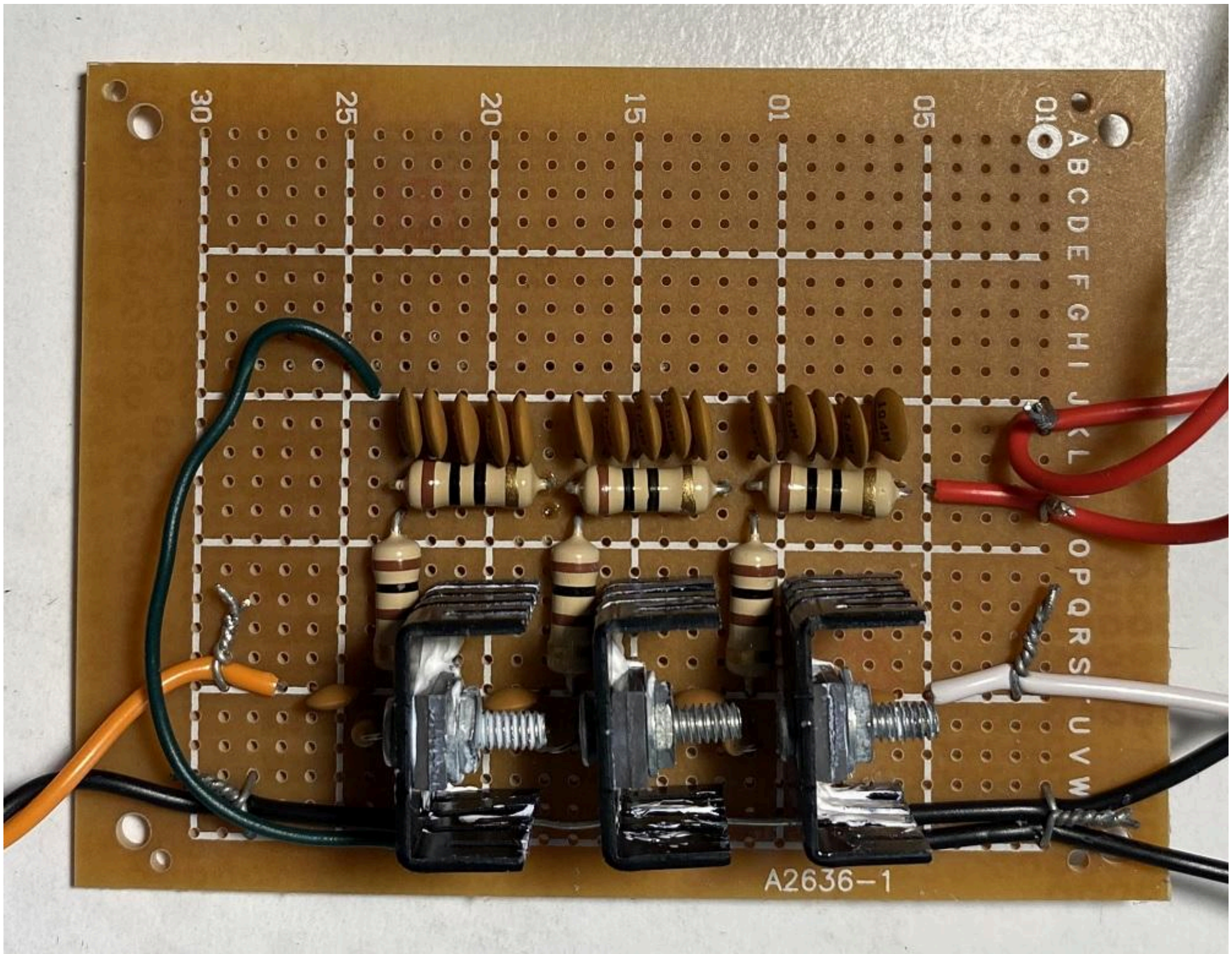

Figure 5: Make the Circuit.

I used BF469 transistors. Those transistors are made for AM radio. For FM you will need transistors that can work at higher frequencies. The current gain of the transistor can be anything from 100 to 700. Thus when you are building the amplifier you need to adjust the Rf resistor.

5. Step 4: Testing

I used a Hantek 6022BE USB Oscilloscope to test my circuit. The top yellow plot is the input and the bottom green plot is the output.

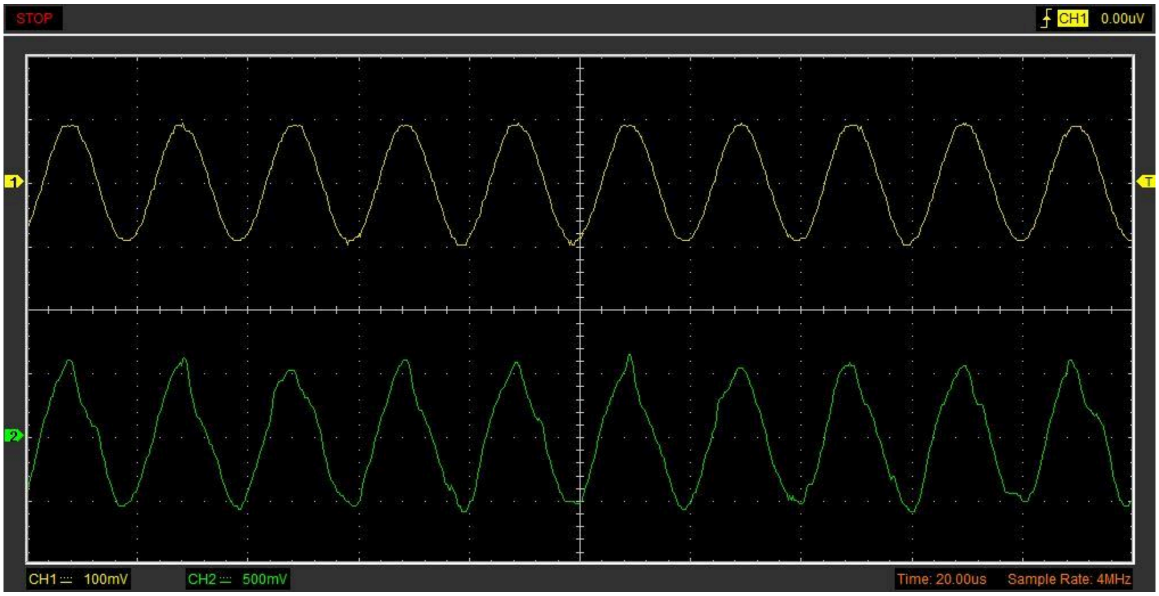

Figure 6: 50 kHz Input (Gain = 1 V / 200 mV = 5).

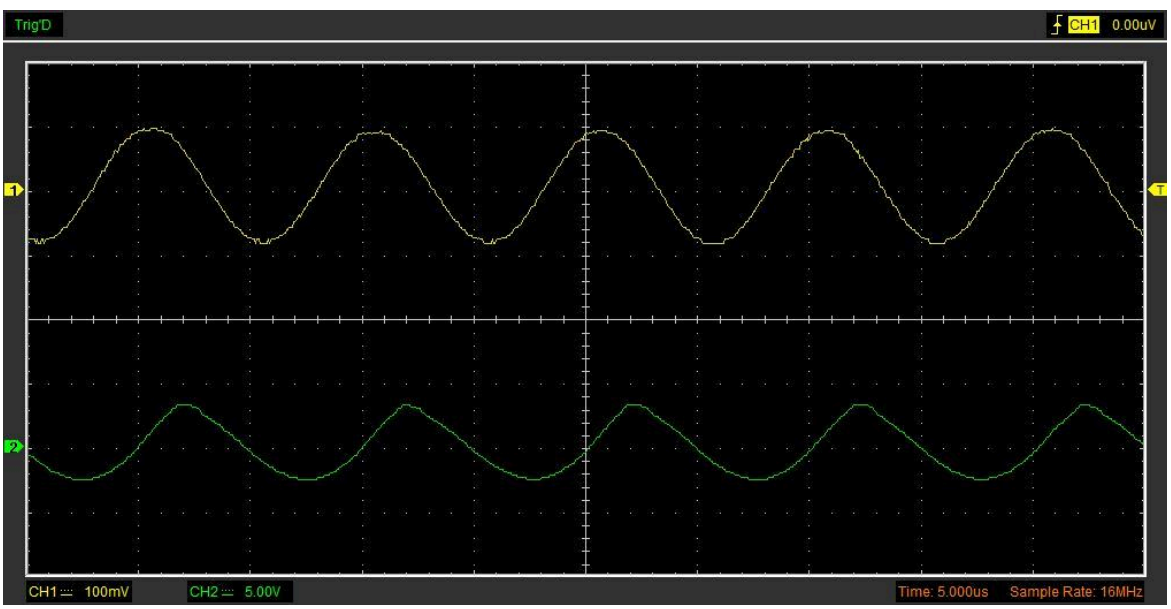

Figure 7: 100 kHz Input (Gain = 5 V / 0.2 V = 25).

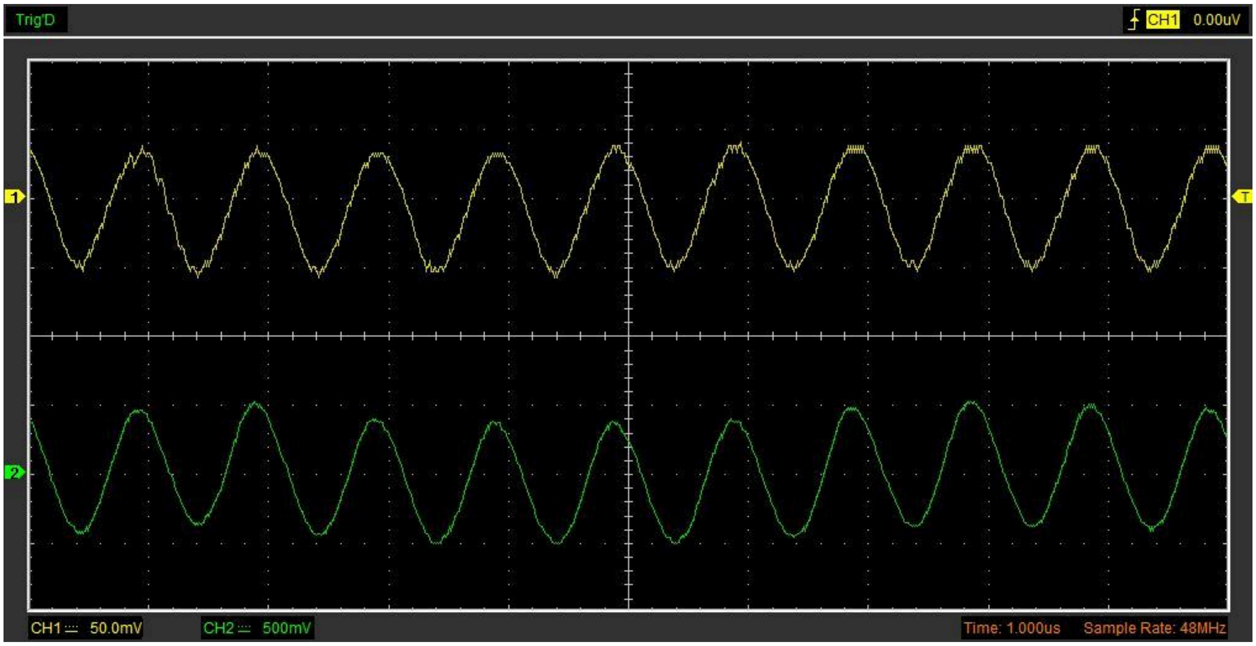

Figure 8: 1 MHz Input (Gain = 1 V / 100 mV = 10).

The gain is high at 1 MHz and low at 2 MHz.

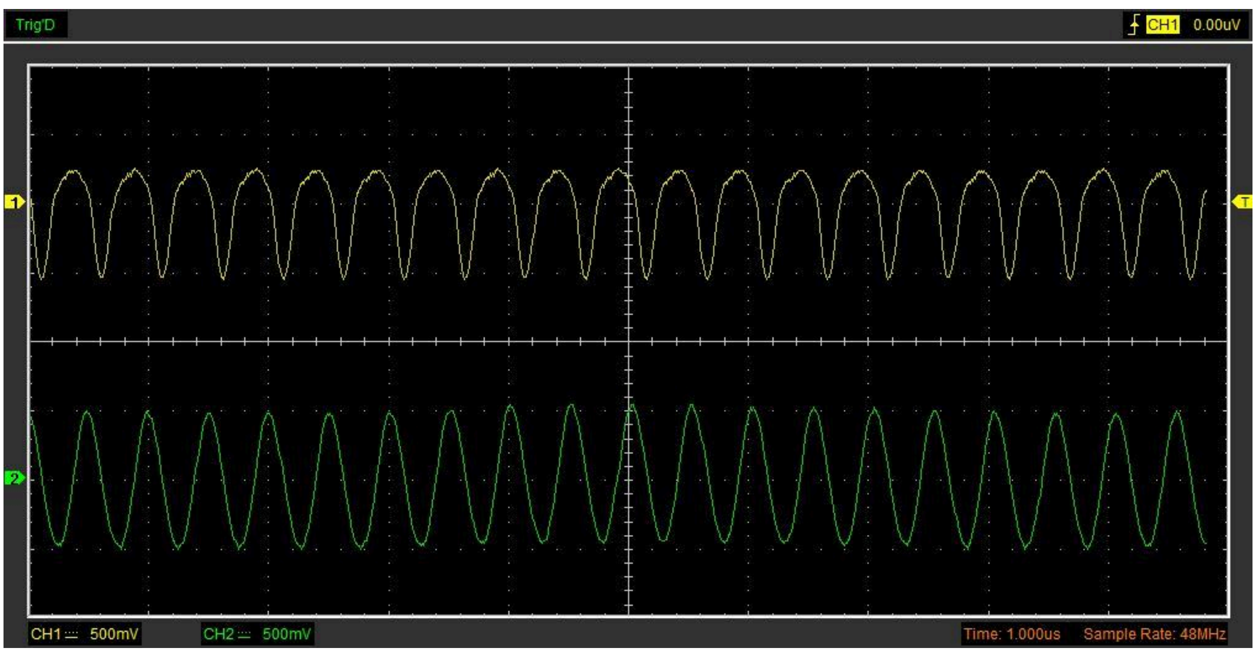

Figure 9: 2 MHz Input (Gain = 1 V / 750 mV = 1.333).

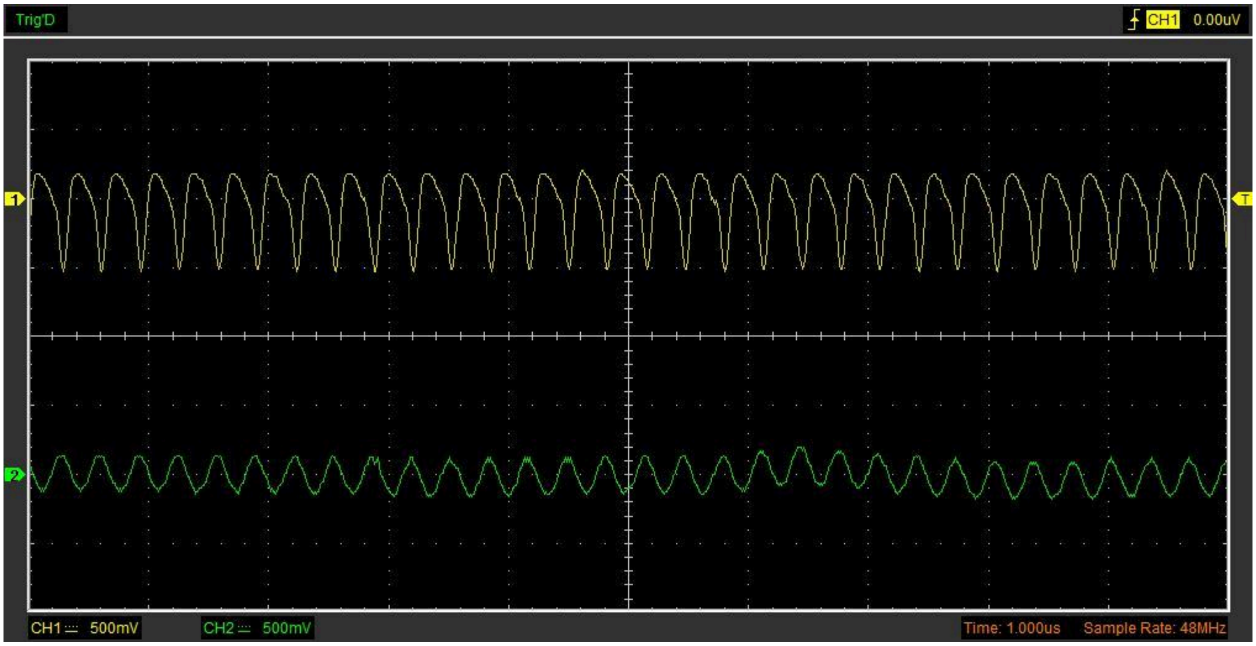

Figure 10: 3 MHz Input.

At 3 MHz the amplifier is an attenuator.

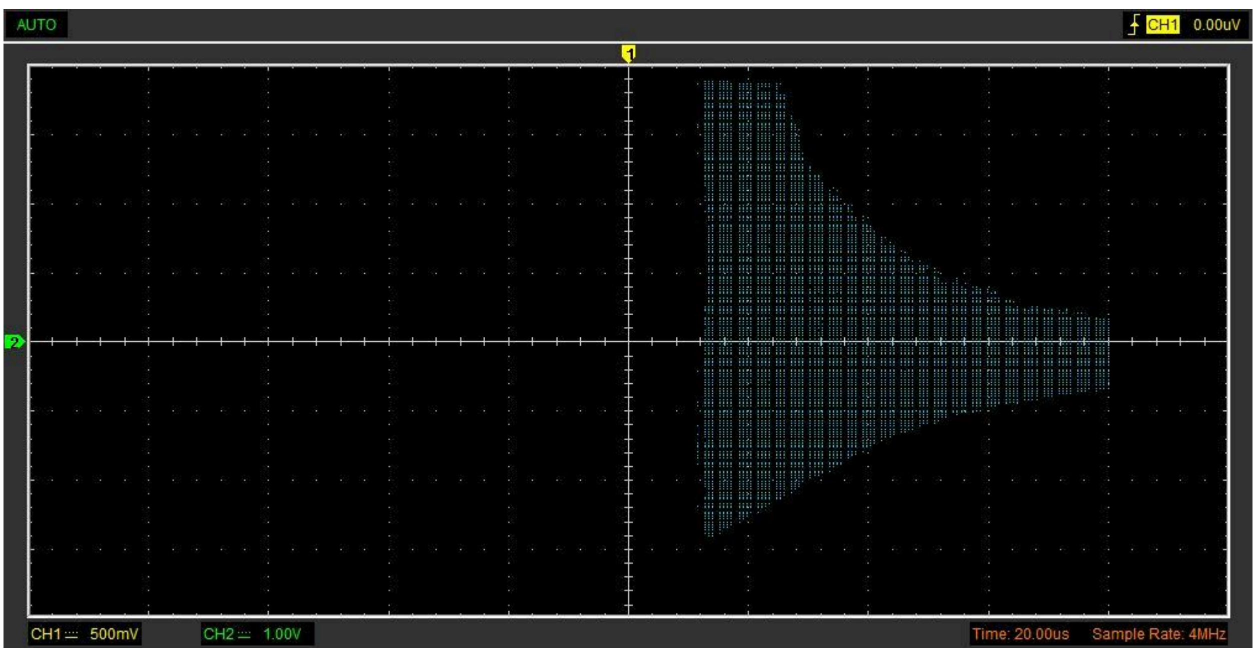

Figure 11: Amplifier Transfer Function (X = Input, Y = Output).

6. Discussion

I calculated the gain by estimating the peak to peak of input and output waveforms.

I used frequency sweep to plot the transfer function of the amplifier.

The article is just to give you an idea on how to design a MF amplifier. The amplifier might not work for real AM radio because the input and output resistances are not matched to antenna output resistance.

7. Conclusion

The amplifier worked well at AM frequency range (535 kHz to 1605 kHz).