Transistor Amplifier

1. Introduction

This article is about a simple feedback bias transistor amplifier circuit.

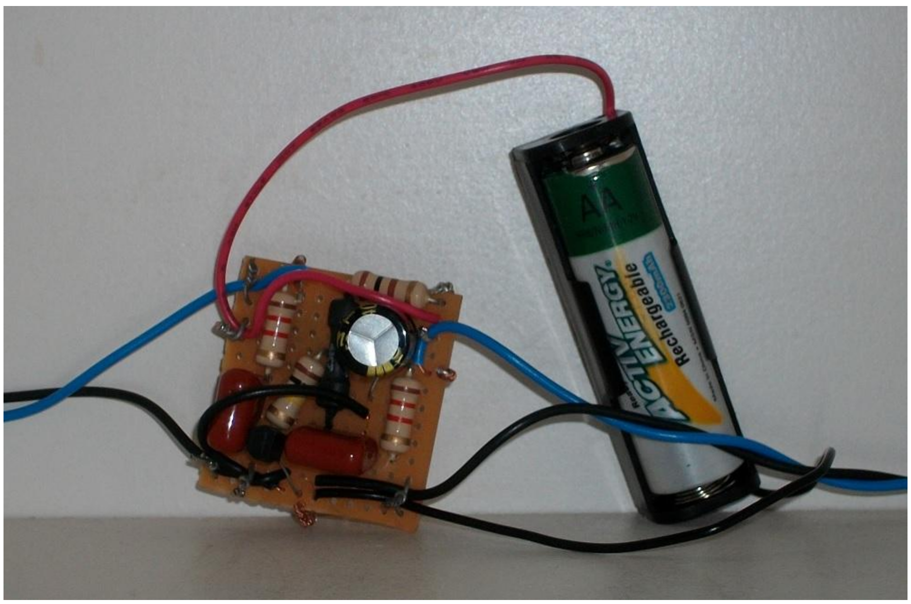

Figure 1: Feedback Bias Transistor Amplifier

Nowadays you can purchase instrumentation amplifiers for a very low cost. Well known companies include Maxim Integrated, Texas Instruments and Analog Devices.

Of all the one transistor amplifier configurations, this one is the most complicated.

2. Step 1: Design the Circuit

The design of the circuit is very simple:

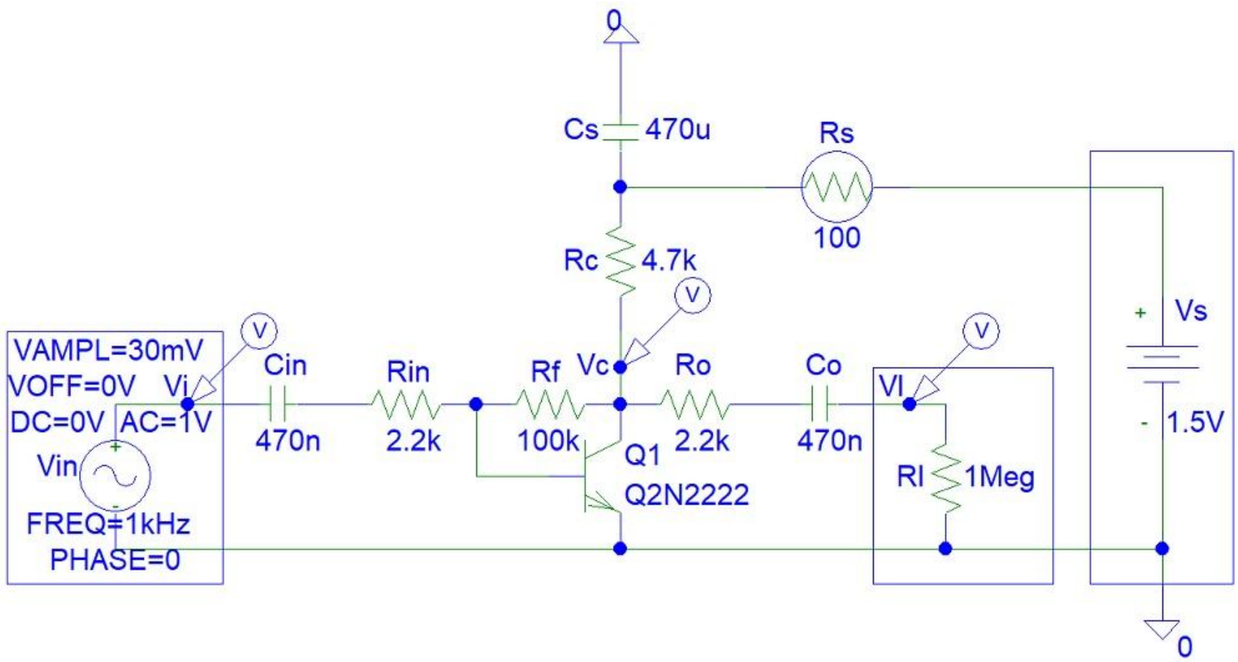

Figure 2: Feedback Bias Transistor Amplifier Design

Calculate the collector biasing voltage:

$$Vc = Vs - Ic*Rc$$

$$= Vs - Beta*Ib*Rc$$

$$= Vs - Beta*((Vc - Vbe)/Rb)*Rc$$

$$Vs = Vc + Beta*((Vc - Vbe)/Rb)*Rc$$

$$Vs*Rb/Rc/Beta = Vc*Rb/Rc/Beta + Vc - Vbe$$

$$Vs*Rb/Rc/Beta + Vbe = Vc*Rb/Rc/Beta + Vc$$

$$Vs*Rb/Rc/Beta + Vbe = Vc*(Rb/Rc/Beta + 1)$$

$$Vc = (Vs*Rb/Rc/Beta + Vbe)/(Rb/Rc/Beta + 1)$$

$$= (Vs + Vbe*Beta*Rc/Rb)/(1 + Beta*Rc/Rb)$$

Vbe is usually about 0.7 V. If Vbe is small in value when compared to Vs then:

$$Vc = Vs/(1 + Beta*Rc/Rb)$$

$$1 + Beta*Rc/Rb = Vs/Vc$$

$$Rc/Rb = (Vs/Vc - 1)/Beta$$

$$Rb/Rc = Beta/(Vs/Vc - 1)$$

You can Google feedback bias transistor amplifier design for more information.

3. Step 2: Simulations

Simulations show a how the transistor is amplifying the signal with a 1 Megohm load:

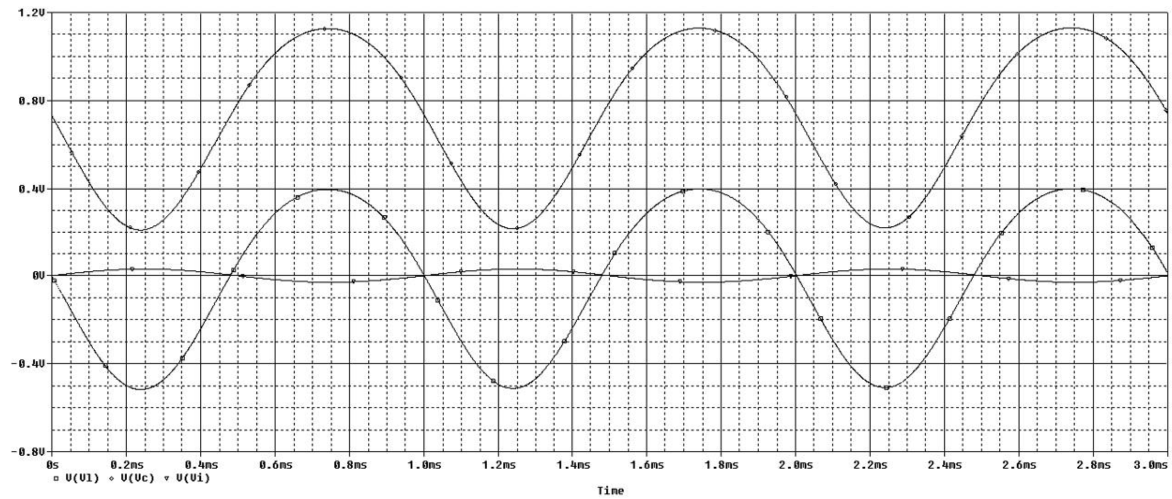

Figure 3: Feedback Bias Transistor Amplifier Transient Simulations

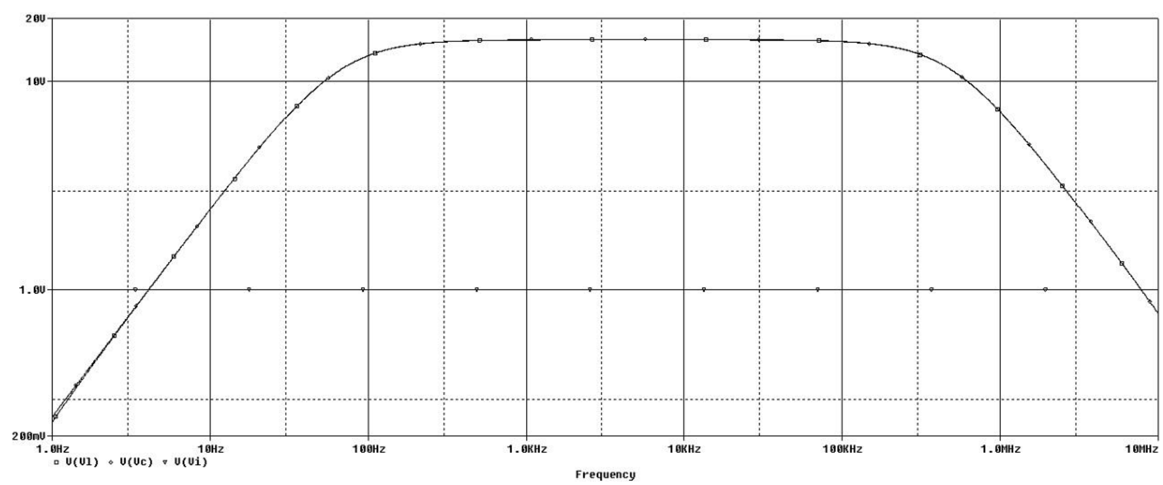

Figure 4: Feedback Bias Transistor Amplifier Frequency Simulations

A general purpose transistor would not have such wide bandwidth in practice.

4. Step 3: Make the Circuit

I made the circuit on a very small matrix board:

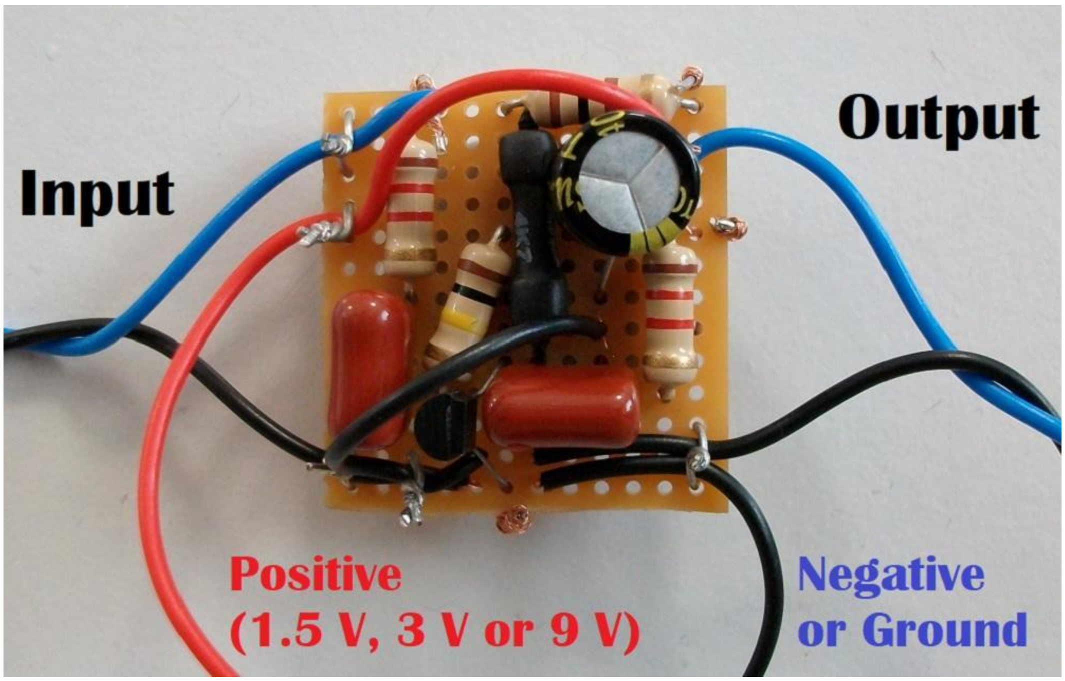

Figure 5: Building the Circuit

I should have used a bigger matrix board. However, this is what I had in stock.

5. Step 4: Testing

I used an Instrustar USB oscilloscope for testing. The red curve is the input and the green is the output.

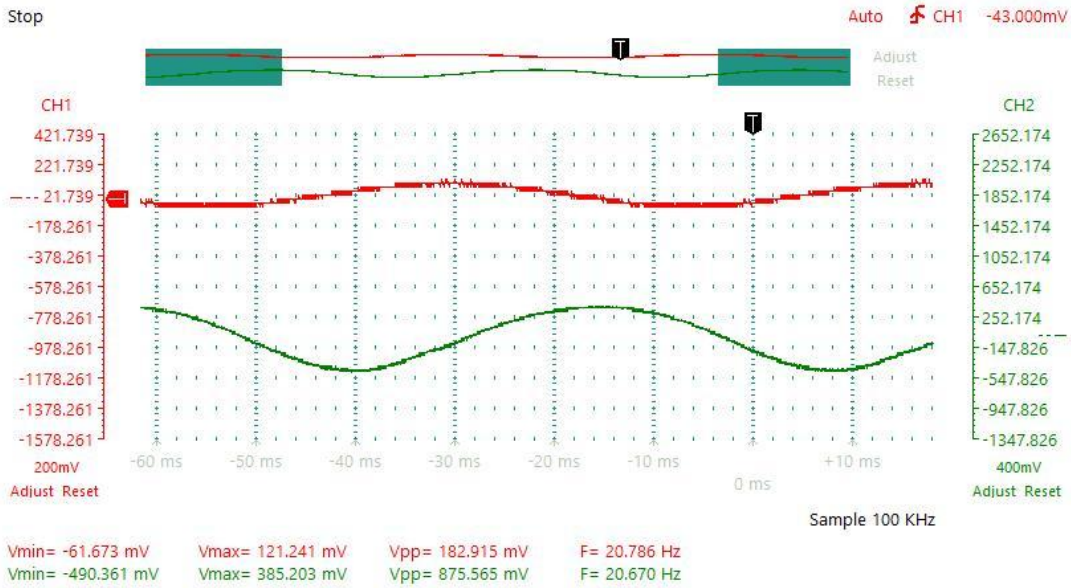

Figure 6: 20 Hz Input

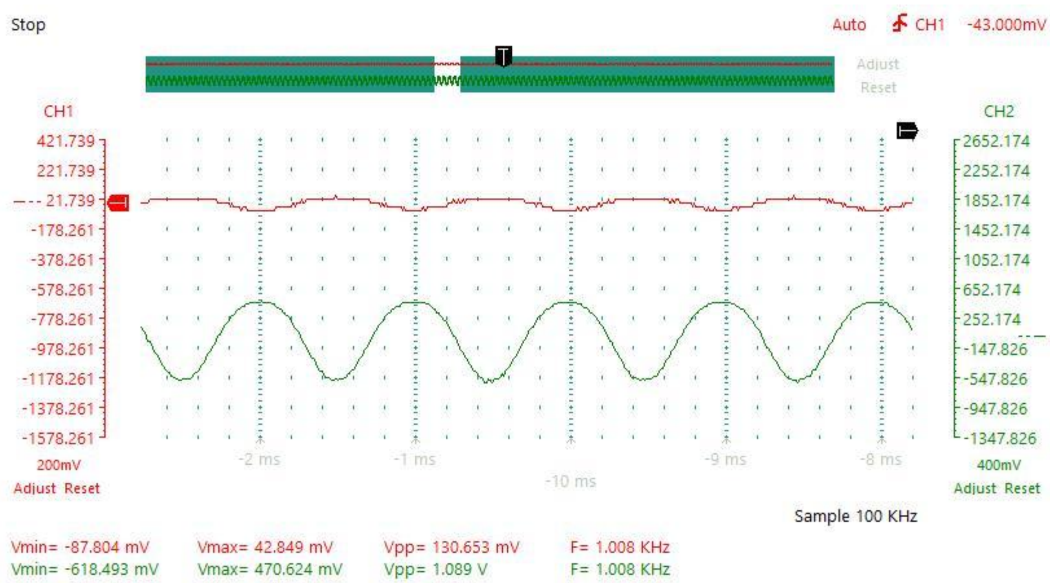

Figure 7: 1 kHz Input

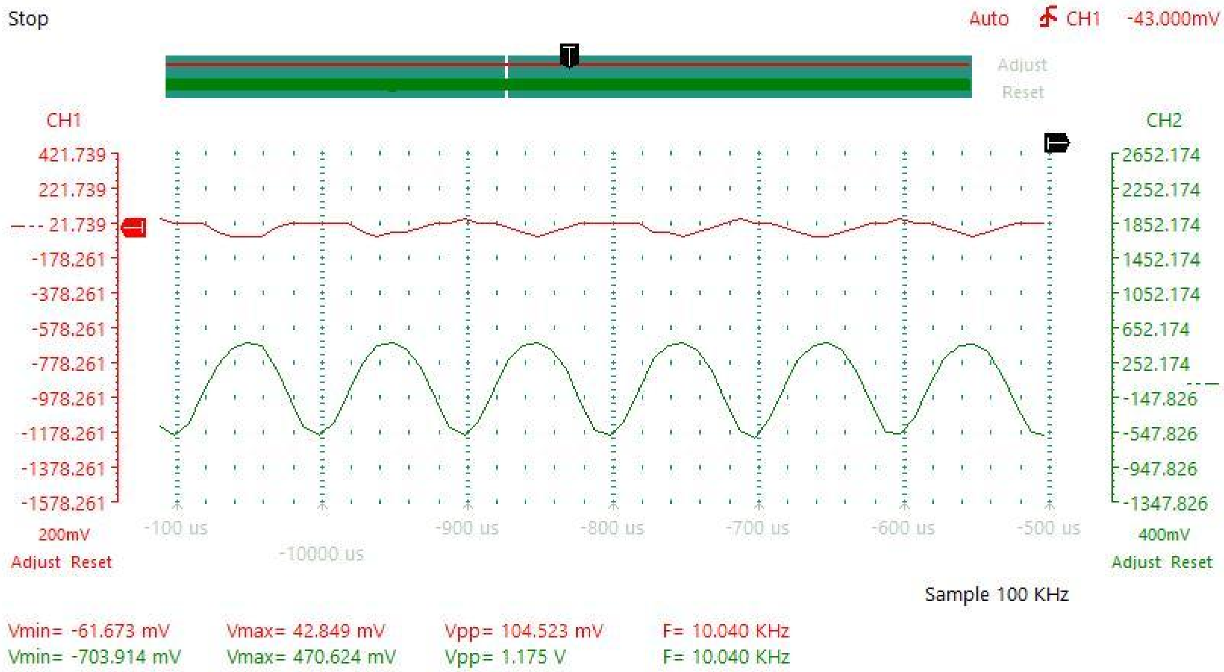

Figure 8: 10 kHz Input

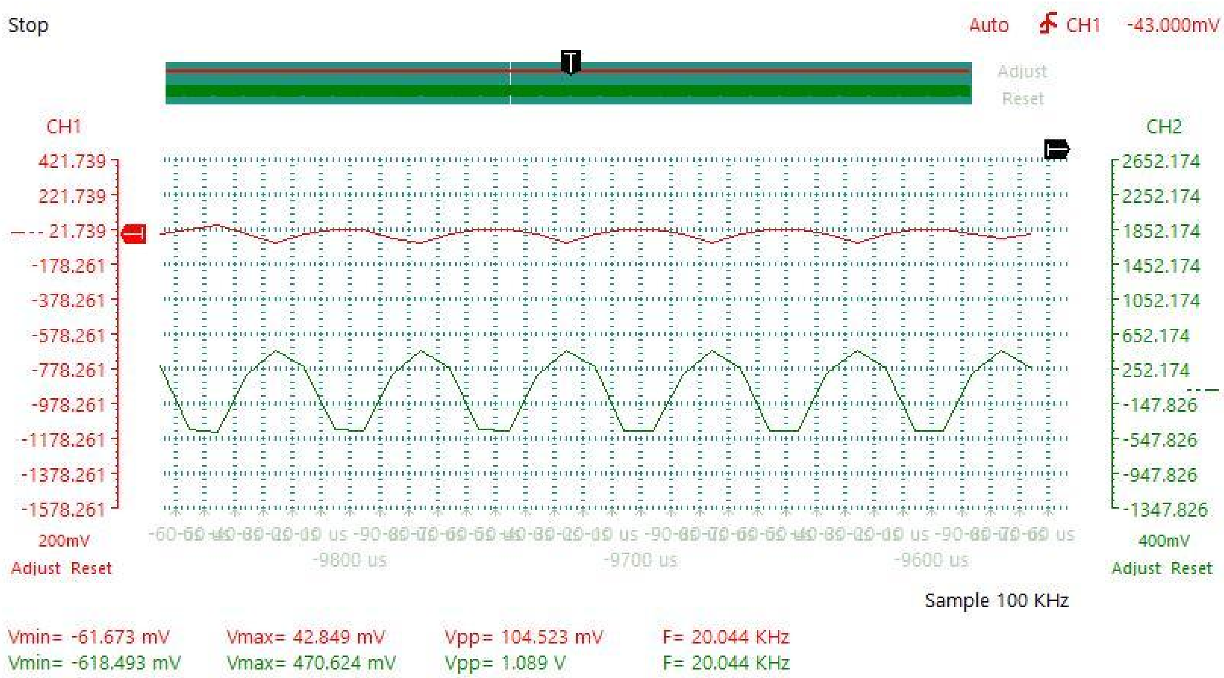

Figure 9: 20 kHz Input

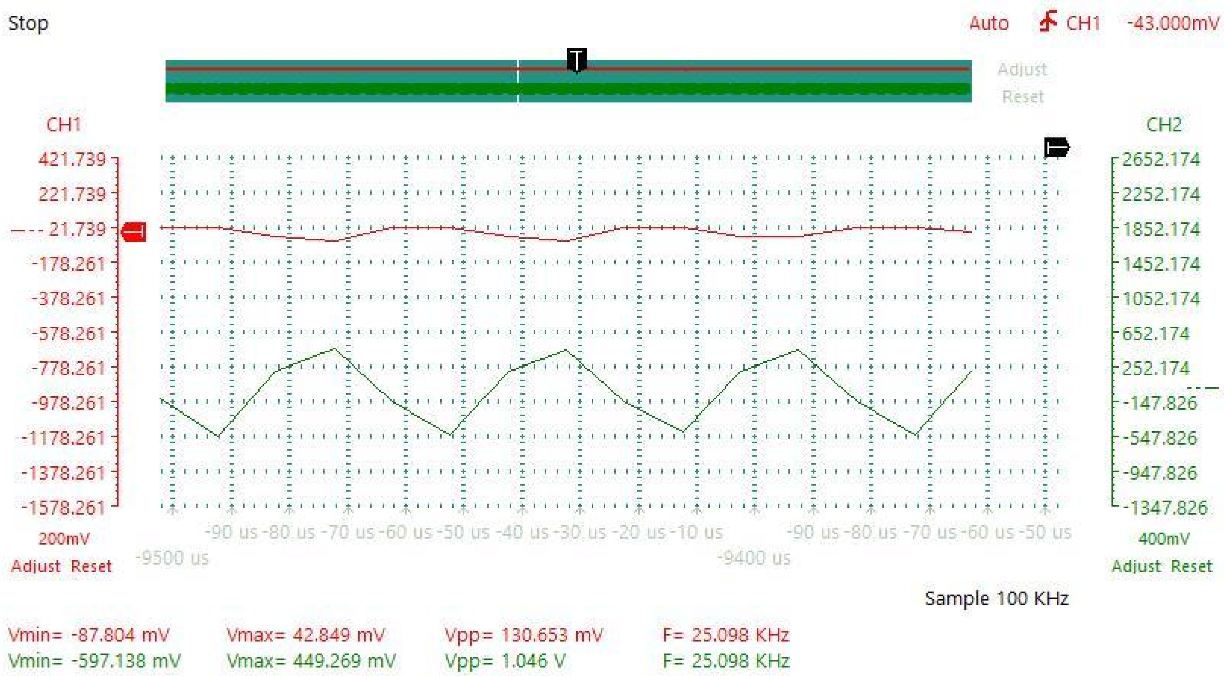

Figure 10: 25 kHz Input

Testing showed that the feedback transistor amplifier has a lower gain than a fixed bias transistor amplifier:

6. Conclusion

Other transistor amplifiers include fixed bias and stabilised bias configurations that you can research on the internet.

7. References

1. https://www.allaboutcircuits.com/textbook/semiconductors/chpt-4/biasing-calculations/
2. https://en.wikipedia.org/wiki/Bipolar_transistor_biasing