Ham Radio 101
SOARA Workshop
3 Stage General Purpose Amplifier

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Several months ago I started to put together a workshop where students could breadboard and test different circuits that are found in traditional ham radio rigs.

The first of these circuits is a 3 stage general purpose amplifier. This circuit could be used as a microphone amplifier or an output to a speaker.

It also could be used with either vacuum tubes or power FETS, for those who still like AM, as an AM modulator.

The circuit consists of three stages. In some cases the circuit could be reduced to a single stage or a two stage circuit.

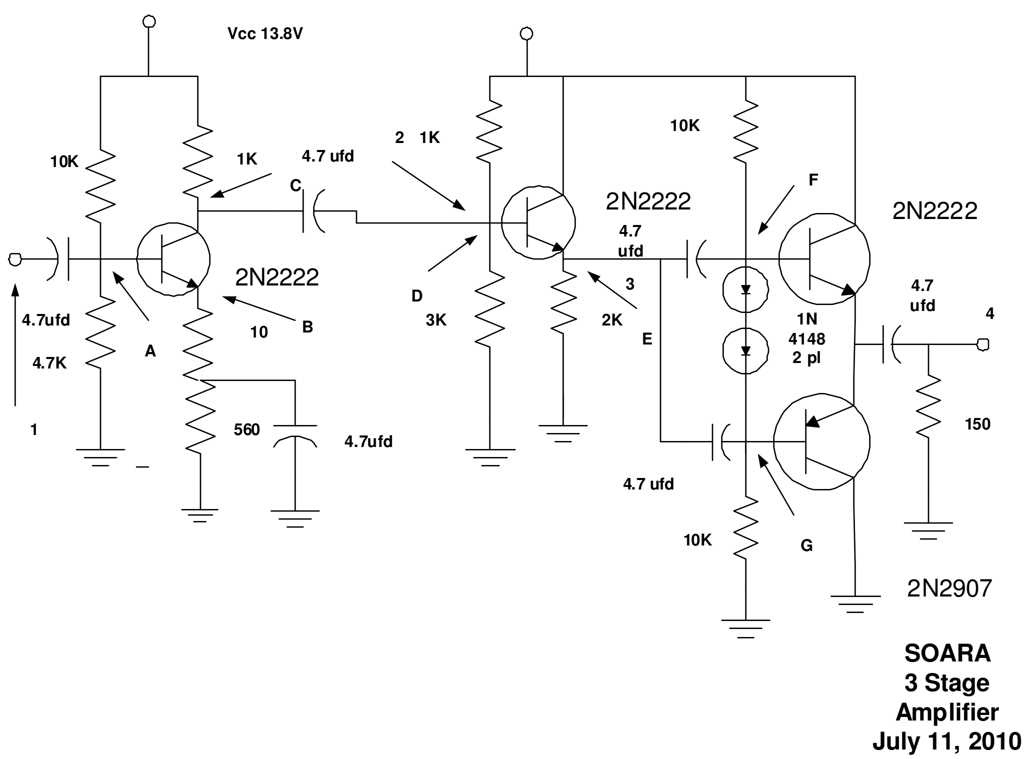

Figure 1
Schematic Diagram

The input stage is a traditional Class A amplifier. The device is a 2N2222A bi-polar transistor. A vacuum tube or general purpose N-Channel FET could be substituted.

The class A amplifier provides gain and boosts the incoming signal to provide a larger signal to drive the next stage.

The second stage is an emitter follower or a common collector circuit. This could easily be a FET follower or in the case of a vacuum tube a cathode follower.

I mention vacuum tubes in this article as some of you still tinker with old boat anchors like the Heath DX100. This an AM/CW rig that has found its way back to the 80M AM net.

The emitter does not provide any voltage gain but does provide current gain. The voltage gain of this stage is approximately 1.

The last stage is a Class B push-pull circuit. During the positive half cycle of the sine wave, the NPN transistor conducts and the PNP transistor does not conduct. In the negative half cycle of the input signal the PNP transistor conducts and the NPN transistor does not conduct.

This stage provides sufficient power gain to drive an 8Ω speaker or a plate of an AM modulator.

In this example I use a 150Ω 1/2 Watt resistor as a load. With the proper biasing and the proper selected devices an audio transformer with an 8Ω secondary could be used to drive a speaker.

There are 2 1N4148 diodes in the base circuit of the two transistors. These are used to keep the emitter-base junction forward biased during the half cycle that the transistors are not conducting.

If they were not used, then there would be a dead time where neither transistor was forward biased causing distortion in the output of the circuit.

The resultant is a non distorted sine wave across the 150 Ω resistor.

In the input stage, there is a 10Ω resistor in the emitter leg of the 2N2222A. Generally this extra resistor is not necessary but for demonstration purposes, I added it to the circuit.

This resistor does diminish the gain of the circuit but it keeps the circuit stable over the frequency range.

There are a number of arrows on the schematic and are to be used by the students taking the workshop as measurement points.

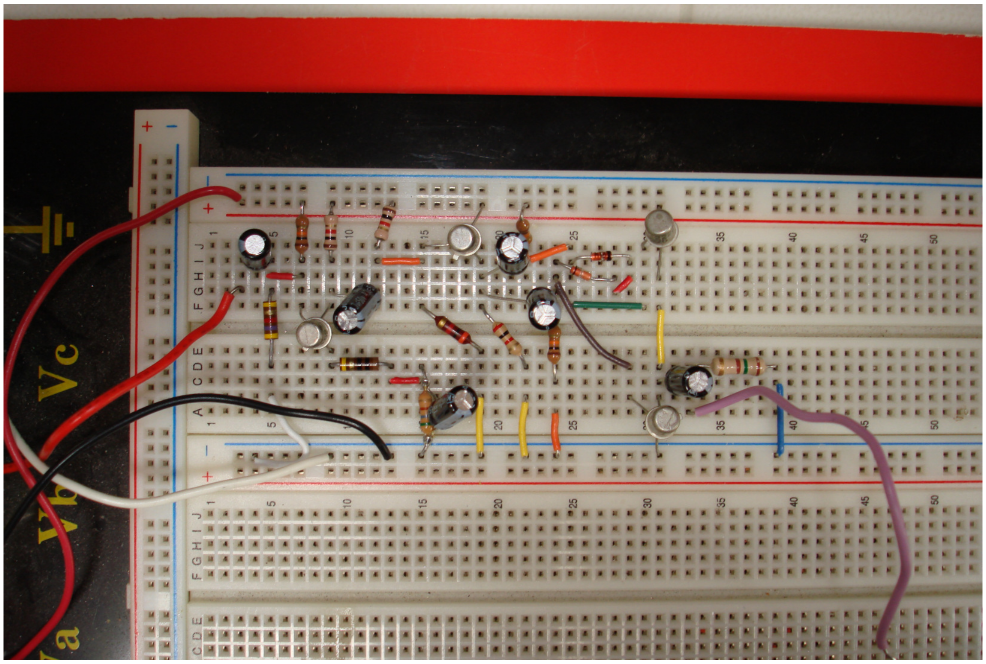

Figure 2

Circuit Board Layout

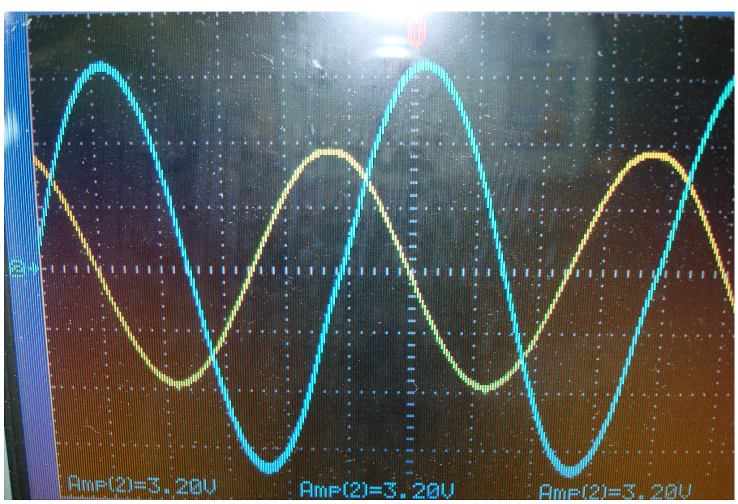

Figure 3
Input (Yellow) and Output (Blue) Waveforms

In figure 3, I present a picture of an oscilloscope that has a data point taken at 1000 Hz. The input in yellow is 400mV p/p and the output in blue is 3.2V or 3200 mV p/p.

The overall voltage gain of the circuit is $A = V_{out} / V_{in}$. This translates to 3200mV/400mV or a gain of 8.

The circuit also delivers approximately 8.5mW (RMS) to the 150 Ω load.

If we calculate the peak power delivered to the load then the peak power is calculated by $(3200mV/2)^2 / 150$ or 17.1mW peak. $(E^2 / R) = P$

There are a number of different exercises that can be performed. The load resistor can be decreased to see how much power can be delivered to the load.

The gain can be measured over a wide frequency range to determine the bandwidth of the circuit.

The two push/pull transistors can be replaced with ones that can deliver more power to the load with out damaging the circuit.

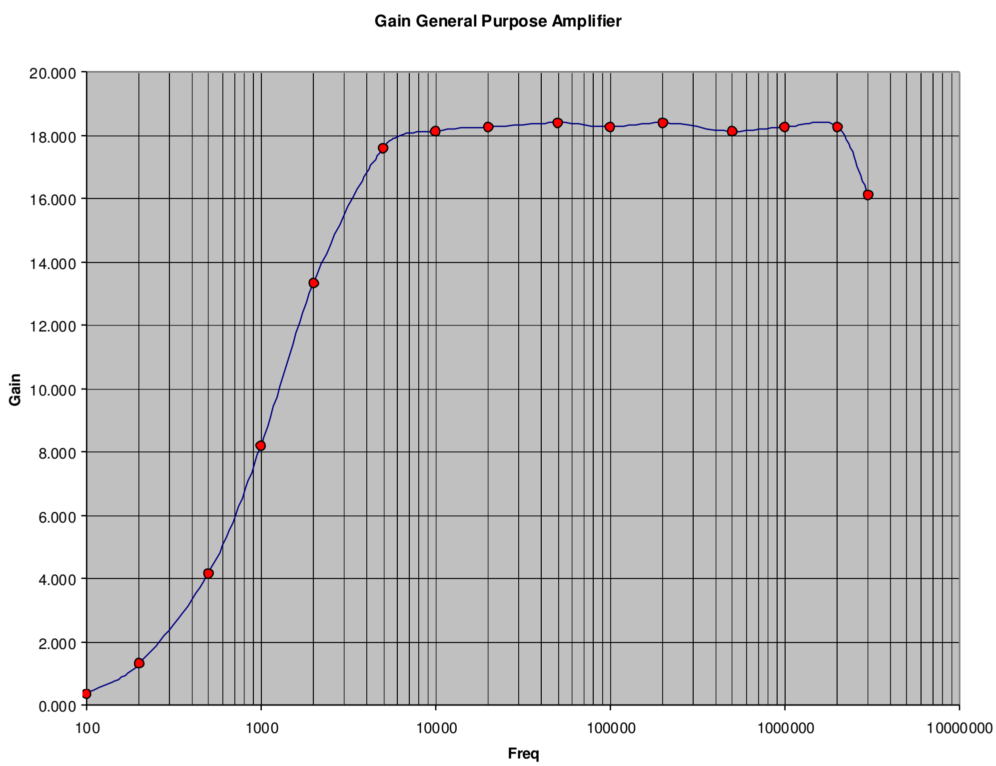

Figure 4
Gain vs. Frequency Measurements

Figure 4 is a graph of the circuit gain vs. the frequency. As designed, the circuit is useful over a frequency from 2KHz to 3Mhz. As I have mentioned before, this was constructed with low cost parts that I had on hand.

The circuit could also be re-designed as a CW QRP rig with the addition of an oscillator circuit and transistors designed for RF performance

I plan to leave the circuit assembled on the proto board to make additional measurements and further characterize the circuit.

If there are any comments, please feel free to contact me at WB6WXO@SOARA.org