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StudentZone—ADALM2000 Activity: Tuned Amplifier Stages—Part 2

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Objective

The objective of this lab activity is to continue the study of tuned amplifier stages that were started in "ADALM2000 Activity: Tuned Amplifier Stages."

Background

As we learned in the previous set of activities, second-order LC tank circuits are commonly used as the tuned element in amplifier stages. The simple parallel LC tank, as shown in Figure 1, can produce voltage gain at the expense of current to drive a resistive load. A buffer amplifier such as an emitter follower can supply the required current (or power) gain to drive a load.

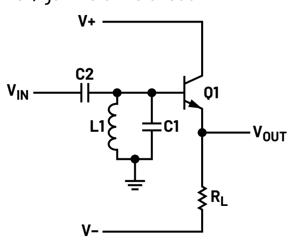


Figure 1. A parallel resonant LC tank circuit.

The second coupling capacitor, C2, must be included in the calculation of the resonant frequency. Equation 1 gives us the resonant frequency for the circuit in Figure 1:

$$F_R = \frac{1}{2\pi\sqrt{L(C1 + C2)}} \tag{1}$$

Prelab Simulations

Build a simulation schematic of the tuned emitter follower amplifier as shown in Figure 1. Calculate a value for emitter resistor R_L such that the current in NPN transistor Q1 is approximately 5 mA. Assume the circuit is powered from ±5 V power supplies (10 V total). Hint: the DC voltage at the base of Q1 is set by the DC path through L1 to the ground. Calculate a value for C1 and C2 such that the resonant frequency, with L1 set equal to 100 µH, will be close to 350 kHz. Generally, C1 and C2 are of equal value. Perform a small signal AC sweep of the input and plot the amplitude and phase seen at the output. Save these results to compare with the measurements you take on the actual circuit and to include with your lab report.

Materials

- ADALM2000 Active Learning Module
- Solderless breadboard and jumper wire kit
- One 2N3904 NPN transistor
- One 100 µH inductor (various other value inductors)
- Two 1.0 nF capacitors (marked 102)
- Two 1 kΩ resistors
- One 2.2 kΩ resistor
- Other resistors and capacitors as needed

Directions

Build the circuit shown in Figure 2 on your solderless breadboard. Use a 100 µH inductor for L1 and 1 nF capacitors for C1 and C2. The peak gain of this tuned amplifier can be very high at the resonant frequency. We will need to slightly attenuate the output signal of AWG1 using resistor divider R_S and R1.

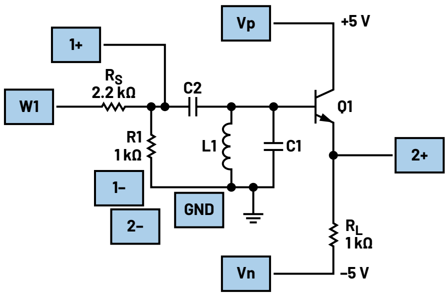


Figure 2. An emitter follower tuned amplifier.

The green squares indicate where to connect the ADALM2000 module AWG, scope channels, and power supplies. Be sure to turn on the power supplies only after you double check your wiring.

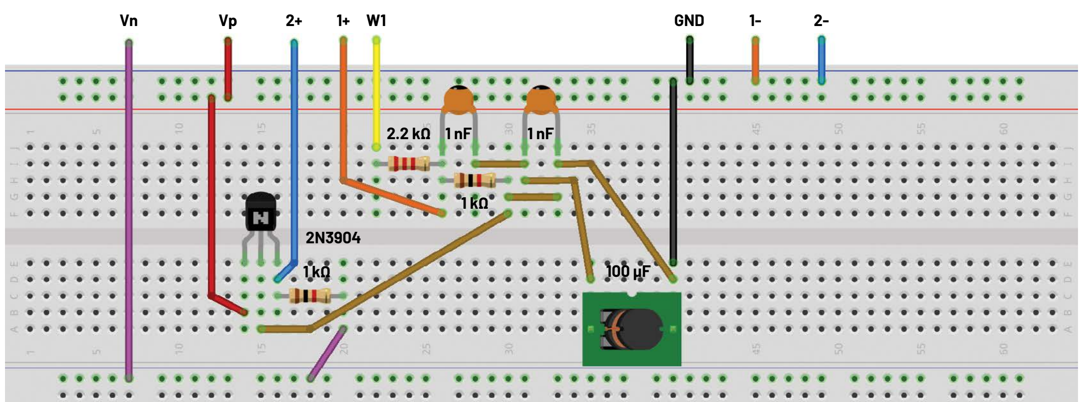


Figure 3. An emitter follower tuned amplifier breadboard circuit.

Hardware Setup

Open the power supply control window to turn on and off the +5 V and –5 V power supplies. Open the network analyzer software instrument from the main Scopy window. Configure the sweep to start at 10 kHz and stop at 10 MHz. Set the amplitude to 200 mV and the offset to 0 V. Under the Bode scale, set the maximum magnitude at 40 dB and minimum magnitude at –40 dB. Set the phase top to 180° and bottom to –180°. Under the scope channels, click on use Channel 1 as reference. Set the number of steps to 500.

Procedure

Turn on the power supplies and run a single frequency sweep. You should see amplitude and phase vs. frequency plots that look similar to your simulation results. Once you have determined that the maximum gain of the amplifier occurs near 350 kHz, you can then reduce the frequency sweep range to start at 100 kHz and stop at 1 MHz.

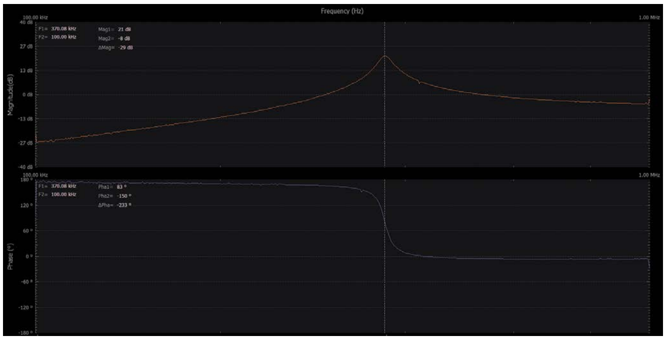


Figure 4. An emitter follower tuned amplifier plot.

Tuned Amplifier with Quadrature Outputs

If we add a second conventional emitter follower stage as a nontuned parallel path, we will have an amplifier with two outputs that will have exactly a 90° phase difference between them, at the resonant frequency. By adding a resistor in parallel with the resonant tank, L1, C1, we can lower the gain at resonance to unity (0 dB) such that the gain from the input to the emitter of Q1 will be the same as the nontuned gain unity gain of the conventional emitter follower stage, Q2.

Additional Materials

- One 2N3904 NPN transistor
- Two 470 Ω resistors
- One 1 kΩ resistor

Directions

Modify the circuit on your solderless breadboard to add the second emitter follower stage, Q2, as shown in Figure 5. Be sure to turn off the power supplies and stop the AWG before making any changes to your circuit.

The exact value for R1, such that the gain is reduced to unity, may vary from the 470 Ω suggested in the figure. You can experiment with different values to obtain the proper amount of gain to match the amplitude seen at the emitter of Q2.

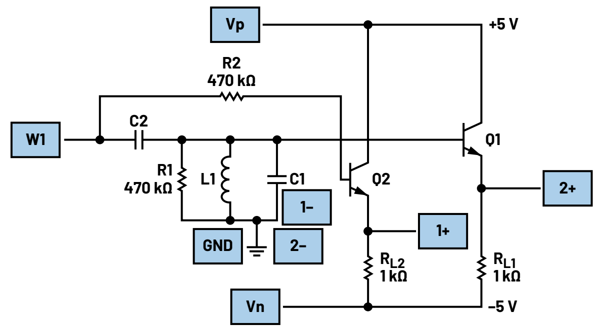


Figure 5. An amplifier with quadrature outputs.

The blue squares indicate where to connect the ADALM2000 module AWG, scope channels, and power supplies. Be sure to turn on the power supplies only after you double check your wiring.

Hardware Setup

Build the breadboard circuit presented in Figure 6.

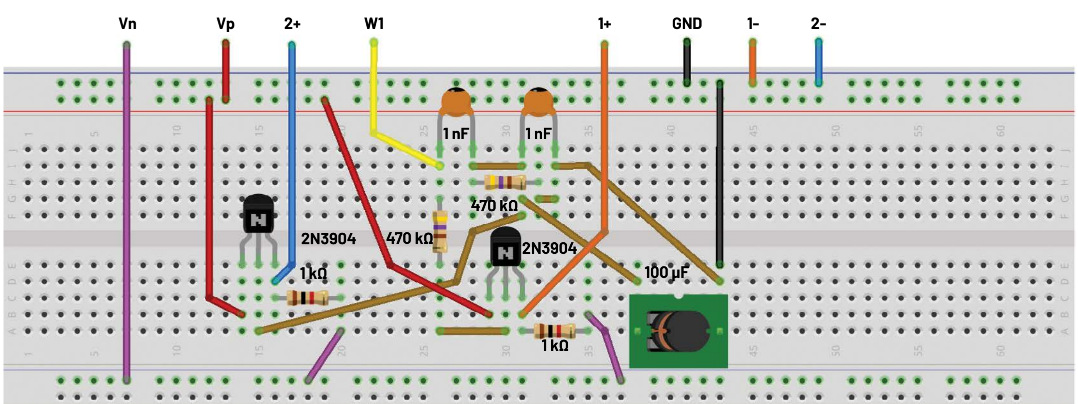


Figure 6. An amplifier with quadrature outputs breadboard circuit.

Procedure

Set the AWG amplitude in the network analyzer to 2 V because we have reduced the gain by adding R1. Turn on the power supplies and run a single frequency sweep. You should see amplitude and phase vs. frequency plots that look very similar to your simulation results.

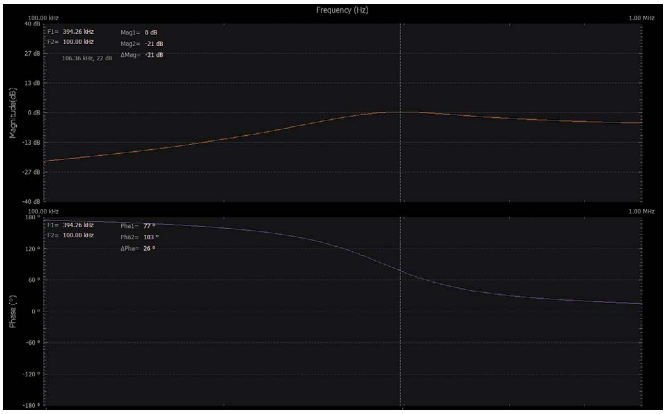


Figure 7. An amplifier with quadrature outputs plot.

Using the scope and function generator software instruments (in the time domain), set the AWG frequency to the resonant frequency with the amplitude set to 2 V. Observe the relative amplitude and phase of the two outputs.

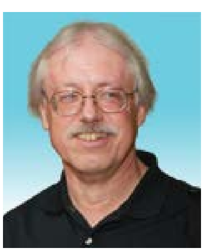
Question

Can you name several applications for the emitter follower tuned amplifier circuits and the amplifier with quadrature output circuits?

You can find the answers at the StudentZone blog.

About the Author

Antoniu Miclaus is a system applications engineer at Analog Devices, where he works on ADI academic programs, as well as embedded software for Circuits from the Lab®, QA automation, and process management. He started working at ADI in February 2017 in Cluj-Napoca, Romania. He currently holds an M.Sc. degree in software engineering from the Babes-Bolyai University and a B.Eng. degree in electronics and telecommunications from the Technical University of Cluj-Napoca.



About the Author

Doug Mercer received his B.S.E.E. degree from Rensselaer Polytechnic Institute (RPI) in 1977. Since joining Analog Devices in 1977, he has contributed directly or indirectly to more than 30 data converter products and holds 13 patents. He was appointed to the position of ADI Fellow in 1995. In 2009, he transitioned from full-time work and has continued consulting at ADI as a fellow emeritus contributing to the Active Learning Program. In 2016, he was named engineer in residence within the ECSE department at RPI.