EE-254
Project 6
Due Date: 12/06/2013

Project 6: Oscillator Circuits

Objectives:

Objective was to learn, design, simulate in Micro-Cap, and build and demonstrate an operational amplifier and MOSFET based oscillator circuits.

The specifications given were:

1. Op-Amp based Phase-Shift oscillator with 1kHz frequency.
2. MOSFET based Hartley oscillator with 10kHz frequency.

Phase-Shift Oscillator

Phase shift oscillator was designed and built first. Circuit used was from the textbook[1] (pg. 1078), here shown in figure 1. Calculations were performed for the given frequency of 1kHz. The figure 1 showed the oscillator as it was built in the Micro-Cap software. The software simulation had required the circuit to be nudged into oscillation, thus the pulse source and the diode on the left side. These two components were not used when the circuit was built and tested on the breadboard. Op-Amp used for the circuit was OPA2604 wide-gain bandwidth op-amp.

Figure 1. Phase-shift oscillator circuit

Aleksandar Jankovic
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Preliminary Calcu[illegible]

Preliminary [illegible] to be calculated for the given frequ[illegible]

In project 4 done [illegible]nce with resistor combination of 2k[illegible]acitance value of 32.48nF. For the o[illegible]

Therefore, R_2 valu[illegible] start.

Simulation:

Circuit was [illegible] (above), had already shown the circuit design. Figure 2 showed the oscillations over 1 second period (left) and zoomed in (right). It was noticeable there was some time required for the circuit to start oscillating, but then it became stable. The graph on the right showed the same oscillations zoomed in at 5ms period. The frequency was slightly off, probably due to capacitance being 33nF instead exactly 32.5nF, but it was also hard to measure with the resolution as it was. This was enough to prove the principal operation and good approximation for the circuit to be built on a breadboard.

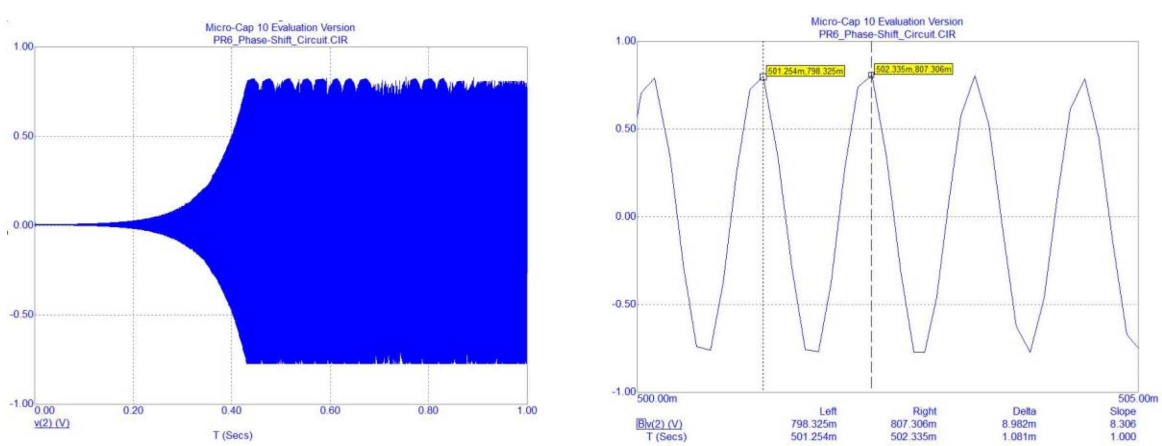

Figure 2. Phase-shift circuit oscillation over 1s period (left) and over 5ms period

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Circuit built and tested

After the simulation was finalized the circuit was built as shown in figure 3. As [redacted] 1.01kHz, which was 1% from the desired 1.00kHz.

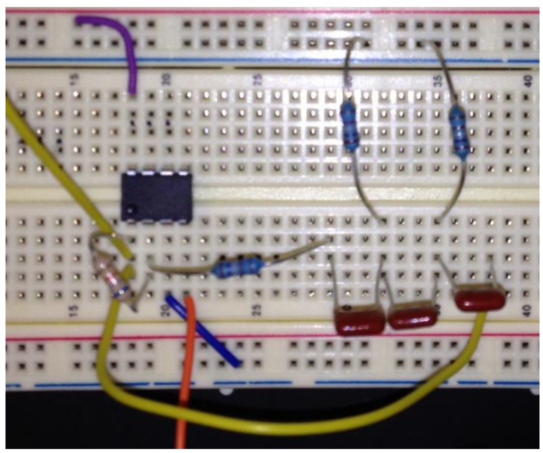

Figure 3. Phase-shift circuit on a breadboard

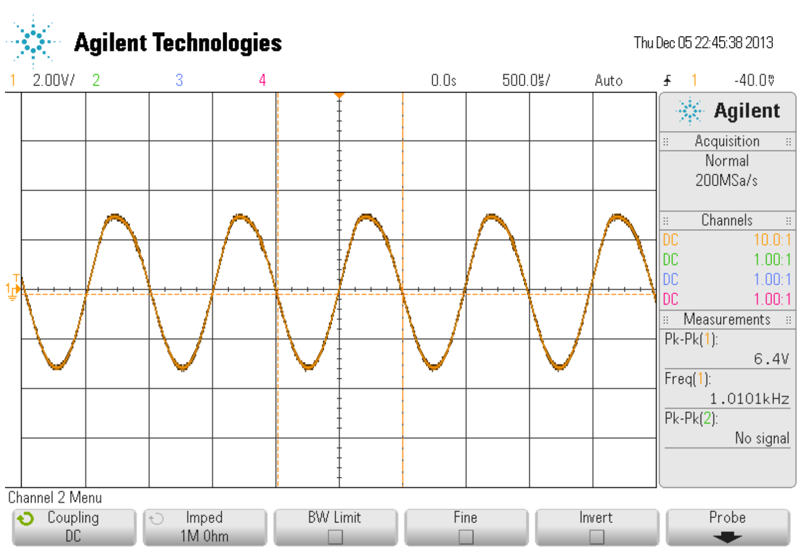

Figure 4. Measured oscillations of the phase-shift circuit

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MOSFET Hartley Oscillator

Hartley oscillator was built and tested next. Circuit below showed the setup used and the AC equivalent of the circuit. The goal was to build an oscillator with 10kHz frequency voltage output.

Figure 5. MOSFET Hartley oscillator circuit (left) and its ac equivalent (right)

Preliminary Calculations:

From the first equat

If the oscillation has started, then $V_o \neq 0$, so the expression in the parenthesis had to be zero. If this expression was separated into real and imaginary parts we get:

$$\frac{1}{R} + g_m \frac{wL_2}{wL_2 + \frac{1}{wC}} = 0 \qquad and \qquad \frac{1}{jwL_1} + \frac{1}{jwL_2 + \frac{1}{jwC}} = 0$$

From these t ations to start and the oscillation fre

Using standa mH, the capacitor was calculated to b

Simulation:

Simulation was done, but not successfully. The oscillations were much lower than 10kHz predicted values. Figure 6 showed the results of the simulation over 10s period. It was obvious the frequency of these oscillations was much lower than 10kHz.

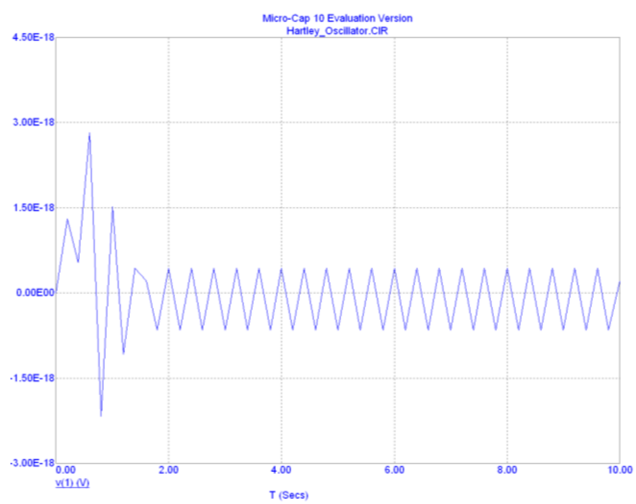

Figure 6. Hartley oscillator simulation results over 10s period

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Circuit built and tested

Hartley circuit was built using IRF3704Z power MOSFET. This was not an ideal choice for this application. The circuit did performed well to a certain extent. Figure 7 showed the output signal measured. Some distortion was obvious from the signal, probably due to MOSFET biasing issues. The Q-point was not exactly were it needed to be. The signal frequency was 10.05khz, which was very close to desired frequency of 10kHz.

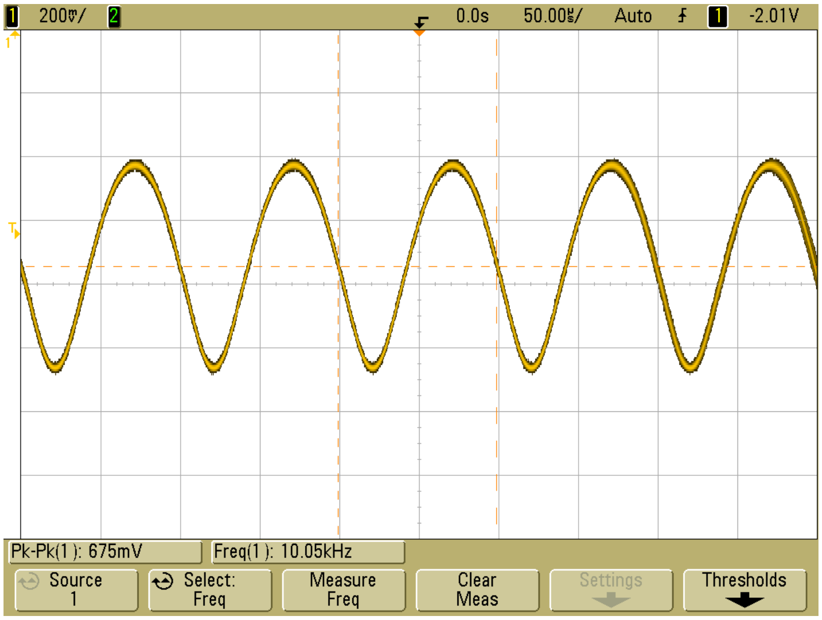

Figure 7. Output signal of the MOSFET Hartley oscillator

Conclusion

The objectives of the project were met. Both, phase-shift oscillator and Hartley oscillator circuits were designed, simulated, built and tested. Phase-shift oscillator performed very well in both simulation and on a breadboard. Hartley oscillator had some performance issues in both, simulation and breadboard testing. However, on a breadboard Hartley oscillator did give satisfactory oscillations at correct frequency, even though the MOSFET used was not optimal for this application.

Reference:

1. Neamen, Donald A. *Microelectronics: Circuit Analysis and Design*. Fourth ed. New York: McGraw Hill, 2010. 1074-84.