1. Experiment Purpose & Foreknowledge

Phase shift oscillators are the oscillators that generate a stable sinusoidal signal at the output. Basically, the circuit has, an amplifier unit like transistor or op-amp along with a feedback network comprising of resistors and capacitors. In RC phase shift oscillator, 180 degree phase shift is generated by the RC network and another 180 degree is generated by the Op-amp, so the resulting wave is inverted by 360 degree, which is a requirement for a sustained sinusoidal output.

A single pole phase shift RC network or ladder circuit which shifts the phase of the input signal equal to or less than 60 degrees. Ideally, the phase shift of the output wave of an RC circuit should be 90 degree, but in practical it is approx. 60 degree, as the capacitor is not ideal. The formula for calculating the phase angle of the RC network is given as:

$$\phi = tan^{-1}(X_C/R)$$

Where, Xc is the reactance of the capacitor and R is the resistor connected in the RC network.

In this experiment, low frequency oscillators will be explained and their circuit applications will be demonstrated. There are 2 circuits in this experiment. They are phase shift oscillator circuit and square wave oscillator circuit. Phase shift oscillator circuit is analysed in experiment 6.1 and square wave oscillator circuit is analysed in experiment 6.2.

2. Experiment 6.1

In Figure 1, a general structure of phase-shift oscillator is given in LTSpice. This phase-shift oscillator is generated using a feedback circuit consisting of an inverting amplifier, resistance and capacitance elements. As it is seen from the Figure 1, feedback circuit is operating as a three-pole high pass filter.

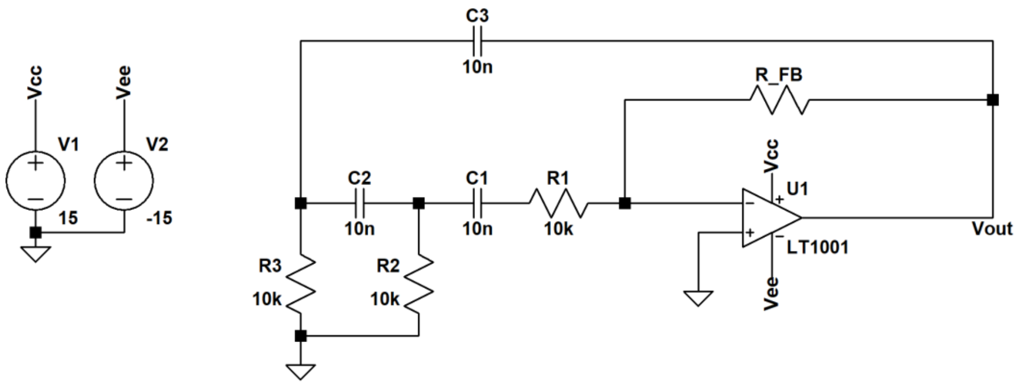

Figure 1

The circuit's modelling equations for the oscillation frequency and oscillation criterion are complicated because each RC stage loads the preceding ones. Since R1 = R2 = R3 = R, and C1 = C2 = C3 = C, with an ideal op-amp, simplified oscillation frequency is;

$$f_{oscillation} = \frac{1}{2\pi RC\sqrt{6}}$$

The feedback resistor required to just sustain oscillation is:

$$R_{feedback} \sim 29R$$

The circuit is made to oscillate using feedback (R_FB) resistance.

a) Adjust R_FB to find minimum R_FB value that achieves a sustained sinusoidal signal at the output node (Vout) with ~15 V peak to peak value.
b) Determine oscillation frequency of your output signal.
c) Compare your simulation results with theoretical calculations. Explain the differences.
d) Adjust R_FB to achieve a sustained sinusoidal signal at the output node (Vout) as early as 300 ms.
e) Adjust R_FB value until clipping occurs at the sinusoidal output.
f) Find R_FB value range where circuit functions correctly.

3. Experiment 6.2

A square-wave oscillator in LTSpice is shown in Figure 2. A Schmitt trigger realized by an operational amplifier is used in the circuit. The operation of this circuit relies on the RC time constant for the charging and discharging of the capacitor. Ideally, oscillation frequency is calculated as;

$$f_{oscillation} = \frac{1}{2R_1C_1 \ln(\frac{2R_3 + R_2}{R_2})}$$

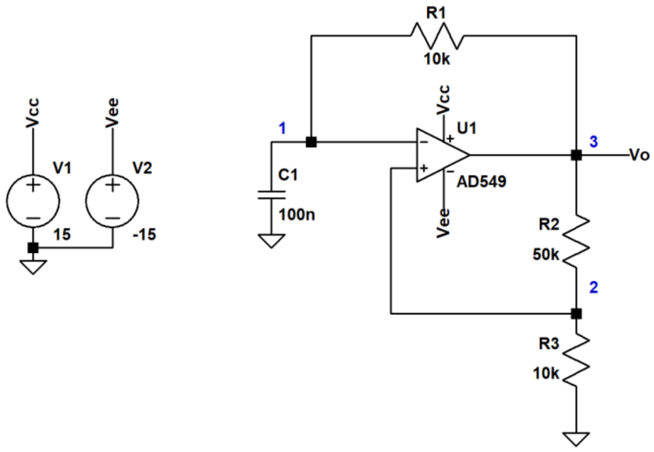

Figure 2

The signal waves are drawn at the nodes 1,2, and 3.

a) Plot these signals and find signal frequencies.
b) Compare output signal frequency with theoretical calculation.
c) Explain circuit behaviour by inspecting these signals.

4. Report

Do not forget to add your cover page to this document.

Place each output/plot/explanation to corresponding section.

4.1. Phase Shift Oscillator

a) Vout Plot and R_FB value.

b) Output signal frequency value calculation by using two reference points on the Vout plot.

c) Comparison of simulation and theoretical values.

d) Vout plot with sinusoidal output sustained at 300 ms.

e) Plot showing no clipping with maximum R_FB value.

f) Usable R_FB range.

4.2. Square-wave oscillator

a) Plot showing signals at 1, 2, and 3 for at least two periods.

b) Comparison of simulation and theoretical values.

c) Explanation of circuit behaviour by using signals at 1, 2, and 3.