Chapter 5
SPICE SOFTWARE’S APPLIED TO THE WEIN-BRIDGE OSCILLATOR AND RC COUPLED AMPLIFIER
5.1 WEIN-BRIDGE OSCILLATOR:

Many electronic devices require a source of energy at specific frequency which may range from few Hz to several MHz. This is achieved by an electronic device called an oscillator. Oscillators are extensively used in electronic equipments for example, in radio and television receivers, oscillators used to generate high frequency wave (called carrier wave) in tuning stage. Audio frequency and radio frequency signals are required for the repair of radio, television and other electronic equipments. Oscillators are widely used in radar, electronic computers and other electronic devices.

Oscillators can produce sinusoidal or non-sinusoidal waves. Here we should take into account that oscillations are produced without any external signal source. The only input power to an oscillator is the dc power supply. In case of sinusoidal oscillator it may be mentioned here that although an alternator produces sinusoidal oscillations of 50Hz. It cannot be called an oscillator. Firstly, an alternator is a mechanical device having rotating parts where as an oscillator is a non-rotating electronic device. Secondly an alternator converts mechanical energy in to a.c. energy while an oscillator converts dc energy in to ac energy. Thirdly an alternator cannot produce high frequency oscillations whereas an oscillator can produce oscillations ranging from few Hz to several MHz.

Although oscillations can be produced by mechanical devices (e.g. alternator), but electronic oscillators have the following advantages:

An oscillator is a non rotating device. Consequently, there is little wear and tear and hence longer life. Due to the absence of moving parts, the operation of oscillator is quite silent. An oscillator can produce waves from small (20Hz) to extremely high frequencies (>100 MHz). The frequency of oscillations can be easily changed when desired. It has good frequency stability i.e. frequency once set remains constant for considerable period of time. It has very high efficiency.
There are different types of oscillators: Tuned oscillator, Colpitt’s oscillator, Phase shift oscillator, Hartley oscillator, Wien bridge oscillator, Crystal oscillator etc. In this work we study the Wien bridge oscillator using operational amplifier.

The Wien-bridge oscillator is a unique circuit because it generates an oscillatory output signal without having a sinusoidal input source. Instead, it uses capacitors with initial voltages to create the output. This circuit can be especially useful if connected to a voltage follower to de-couple the load from the source.

As you can see, the Wien-bridge oscillator uses two RC networks connected to the positive terminal to form a frequency selective feedback network. It also amplifies the signal with the two negative feedback resistors.

Uses two RC networks connected to the positive terminal to form a frequency selective feedback network Causes Oscillations to Occur.

As it is known the oscillators of bridge Wein, they are used for the production of amplifier of low frequencies, in which is created positive and negative feedback. A simplified circuit of bridge Wein we see in the fig. 1. The positive feedback it fixes the frequency of oscillations. In the simpler case where are used same resistances and capacitors, the frequency of oscillation is: \( F = \frac{1}{2\pi RC} \). The gain of unit is fixed from network the negative feedback and is calculated by the relation: \( A = \frac{R_2 + R_1}{R_2} \). To are maintained the oscillations and together is not distortion the output signal, the gain of stage should be little bigger than the demotion that it creates network the positive feedback. In the case where are used same prices of resistances and capacitors in the sector of positive feedback, the gain should be roughly [1-3].
Figure 5.1 wein bridge oscillator [Reference: 13].

With $R_4 = 3.3 \, k\Omega$, $C = 0.05 \, \mu F$, use a 741 Op-Amp IC to construct the following Wien-bridge oscillator on a general-purpose IC board.

So that you can adjust $R_1 / R_2 = 2$, choose $R_2 = 5 \, k\Omega$ and let $R_1$ consist of a 10 $k\Omega$. From results of the analysis, determine the oscillation frequency and the minimum value of $R_1$ necessary to sustain oscillation. In this part, we will compare the output of Wein bridge oscillator by transient simulations with Pspice, B² Spice, Top Spice, Tina and Circuit Maker. Begin by drawing Wein bridge oscillator circuit in different spice software. Take the value of $R_2 = 5 \, K$. In the simulations, provide an initial signal that has a frequency component at the oscillation frequency from which the oscillations in the simulations can grow by applying a small (perhaps 1mV in amplitude) narrow (perhaps 10$\mu$s in duration) pulse. This short pulse has a broad frequency spectrum and thus will almost surely contain the frequency from which oscillations can build up. Run a transient simulation and display both the
voltage pulse (zoom as necessary to gain a clear view) and its Fourier spectrum to make sure that the pulse has spectral components near the frequency of oscillation you calculated from analysis. To ensure that PSpice sees the narrow pulse, set the maximum step size in the transient simulation profile to 10μs or less. Include screen shots.

Zoom in to display a few cycles of the oscillator output at full amplitude and verify that the waveform appears approximately sinusoidal. Include screenshot. Use the cursors to measure the period of the oscillations and from it calculate the frequency of oscillation and compare it with the value

\[ f = \frac{1}{2\pi RC} \]

5.2 Figures of Wein Bridge oscillator output in different software’s:

![Figure 5.2 Output potential of Wein bridge oscillator using Pspice](image)
Figure 5.3 Output current of Wein bridge oscillator using PSpice [Reference: 6]

- In this software the wave starts at 2 µs.
- The potential at this time is 0.696 mV.
- The maximum potential at positive amplitude is 1.969 mV.
- The minimum potential at negative amplitude is – 1.854 mV.
- Current is out of phase with output potential.
- The maximum current at positive amplitude is 140 nA.
- The minimum current at negative amplitude is – 150 nA
Figure 5.4 Output potential and current of Wein bridge oscillator using Top Spice [Reference: 7].

- In this software the wave starts at 5.4μs.
- The potential at this time is -0.117 mV.
- The maximum potential at positive amplitude is 0.0024 mV.
- The minimum potential at negative amplitude is – 0.279 mV.
- Current is out of phase with output potential.
- The maximum current at positive amplitude is 38 nA.
- The minimum current at negative amplitude is – 35 nA.
In this software the wave starts at 0 µs.

The potential at this time is 0 mV.

The maximum potential at positive amplitude is 12 mV.

The minimum potential at negative amplitude is – 5 mV.

Current is out of phase with output potential.

The maximum current at positive amplitude is 1.68 µA.

The minimum current at negative amplitude is – 1.68 µA.
Figure 5.7 Output potential of Wein bridge oscillator using TINA [Reference: 9].

- In this software the wave starts at 23 µs.
- The potential at this time is 1.79 mV.
- The maximum potential at positive amplitude is 2.94 mV.
- The minimum potential at negative amplitude is – 2.43 mV.

Figure 5.8 Output potential of Wein bridge oscillator using Circuit Maker [Reference: 10].
In this software the wave starts at 2 μs.
The potential at this time is 0.042 mV.
The maximum potential at positive amplitude is 0.042 mV.
The minimum potential at negative amplitude is 0.042 mV.

Table 5.1 Data for simulated Wein bridge oscillator circuit using Pspice, Top Spice, B2 Spice, Tina and Circuit Maker.

<table>
<thead>
<tr>
<th>Software</th>
<th>Start Time</th>
<th>Start Potential</th>
<th>Positive Potential</th>
<th>Negative Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pspice</td>
<td>2</td>
<td>0.696</td>
<td>1.969</td>
<td>-1.854</td>
</tr>
<tr>
<td>TopSpice</td>
<td>5.4</td>
<td>-0.117</td>
<td>0.0024</td>
<td>-0.279</td>
</tr>
<tr>
<td>B2 Spice</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>-5</td>
</tr>
<tr>
<td>Tina</td>
<td>23</td>
<td>1.79</td>
<td>2.94</td>
<td>2.43</td>
</tr>
<tr>
<td>Circuit m.</td>
<td>2</td>
<td>0.042</td>
<td>0.042</td>
<td>0.042</td>
</tr>
</tbody>
</table>

5.3 Comparison of Wine bridge oscillator output in different software’s:

Figure 5.9 Shows start time for Wein bridge oscillator in different software’s
Figure 5.10 Shows starting potential of Wein bridge oscillator in different software’s

Figure 5.11 Shows minimum and maximum potential of Wein bridge oscillator in different software’s
5.4 RC COUPLED AMPLIFIER:

We know that a properly biased transistor rises the strength of the weak signal and thus acts as an amplifier. Almost all electronic devices must include means for amplifying electrical signals. For instance, radio receivers amplify very weak signals—sometimes a few millionth of a volt antenna until they are strong enough to fill a room with sound. The transducer used in medical and scientific investigations generates signals in the microvolt (µV) and mill volt (mV) range. The signals must be amplified as per our requirement thousand and millions times before they will strong enough to operate indicating instruments. Therefore electronic amplifiers are a constant and important ingredient of electronic systems. It may be emphasized here that a practical amplifier is always a multistage amplifier i.e. it has a number of stage of amplification. However, it is profitable to consider the multistage amplifier in terms of single stages that are connected together.

When only one transistor with associated circuitry is used for amplifying a weak signal, the circuit is known as a single stage amplifier.

A single stage transistor amplifier has one transistor, bias circuit and other auxiliary components. Although a practical amplifier consists of number of stages, yet such complex circuit can be conveniently split up in to separate single stages. By analyzing carefully only a single stage and using this single stage repeatedly, we can effectively analyses the complex circuit. It follows, therefore, that single stage amplifier analysis is of great value in a practical analysis circuits.

The amplifiers which amplify a specific frequency or narrow band of frequencies are called tuned amplifiers. These are mostly used for the amplification of high or radio frequencies. It is because the radio frequencies are generally single and the tuned circuits permit their selection and efficient amplification [1].

The unturned cascade amplifiers may be of different types depending upon the nature of coupling elements used in between successive stages. Two important types of unturned cascaded amplifiers are: 1) RC coupled amplifiers and 2)
transformer coupled amplifiers. In the case of RC coupled amplifier, each stage uses a resistor as the load impedance and a capacitor as a coupling element. Unturned transformer coupled amplifier on the other hand uses a transformer (unturned) for coupling the output of one stage to the input of next stage.

In this work we have study the single stage RC coupled amplifier using different software’s. In RC coupled amplifier is a small signal unturned cascaded amplifier in which a resistor is used as a load impedance while a capacitor is used as the integer-stage coupling element. These amplifiers are widely used as audio amplifiers and also used as video amplifiers.

The figure 5.12 shows the single stage RC coupled CE amplifier. The capacitor Cout acts as the blocking capacitor. The capacitor disallows the dc component of the output voltage to the output. The emitter resistance Re and the resistance R₁, R₂ are used to establish the bias capacitor Ce bypass the ac components of emitter current and thus prevent the loss of amplification due to negative feedback. The capacitor Ce is chosen so large that it acts as ac short circuit across Re and the effect of this bypass capacitor on the low frequency characteristics may be neglected [4].

After simulation we have measure the values of peak to peak input voltage (Vᵢ) and peak to peak output voltage (Vₒ) in different a software. We calculate the input voltage amplitude and output voltage amplitudes [5].

Input Voltage Amplitude = Vᵢ / 2.

Output voltage amplitude = Vₒ / 2
Transient Analysis:

In Transient Analysis, we perform the simulation of the circuit and analyze the output voltage with respect to time. For this maximum simulation time and the time limit are set in the corresponding parameters window. Then simulation is performed with ‘Display Waveform’ option enabled. The output of the amplifier is viewed in the Waveform viewer. The user also has the provision to simulate with print and plot outputs [11].

Figure 5.12 RC coupled amplifier
5.5 Figures of RC coupled amplifier output in different software’s:

**Figure 5.13** Input signal amplitude to RC coupled amplifier in PSpice

**Figure 5.14** Output signal amplitude of RC coupled amplifier using PSpice
The maximum potential at positive amplitude of input signal is 0.995 mV.

The minimum potential at negative amplitude of input signal is -0.995 mV.

The maximum potential at positive amplitude of output signal is 11.674 mV.

The minimum potential at negative amplitude of output signal is -10.561 mV.

Figure 5.15 Input, output signal amplitude and current at output of RC coupled amplifier using Top Spice.

- The maximum potential at positive amplitude of input signal is 0.991 mV.
- The minimum potential at negative amplitude of input signal is -0.991 mV.
- The maximum potential at positive amplitude of output signal is 11.071 mV.
- The minimum potential at negative amplitude of output signal is -10.942 mV.
The maximum potential at positive amplitude of input signal is 1 mV.
The minimum potential at negative amplitude of input signal is -1 mV.
The maximum potential at positive amplitude of output signal is 9.882 mV.
The minimum potential at negative amplitude of output signal is -10.53 mV.
The maximum potential at positive amplitude of input signal is 1.99 mV.
The minimum potential at negative amplitude of input signal is -0.012 mV.
The maximum potential at positive amplitude of output signal is 10.63 mV.
The minimum potential at negative amplitude of output signal is -10.53 mV.
Figure 5.19 Input signal amplitude to RC coupled amplifier in Circuit Maker

Figure 5.20 Output signal amplitude of RC coupled amplifier using Circuit Maker

- The maximum potential at positive amplitude of input signal is 1 mV.
- The minimum potential at negative amplitude of input signal is -1 mV.
- The maximum potential at positive amplitude of output signal is 10.67 mV.
- The minimum potential at negative amplitude of output signal is -10.67 mV.
Table 5.2 Shows data for simulated RC coupled amplifier circuit using Pspice, TopSpice, B2 Spice, TINA and Circuit Maker [Reference: 12].

<table>
<thead>
<tr>
<th>Software</th>
<th>Maximum Amplitude</th>
<th>Minimum Amplitude</th>
<th>Maximum Amplitude</th>
<th>Minimum Amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pspice</td>
<td>0.995</td>
<td>-0.995</td>
<td>11.674</td>
<td>-10.561</td>
</tr>
<tr>
<td>Top Spice</td>
<td>0.991</td>
<td>-0.991</td>
<td>11.071</td>
<td>-10.942</td>
</tr>
<tr>
<td>B2 Spice</td>
<td>1</td>
<td>-1</td>
<td>9.882</td>
<td>-9.82</td>
</tr>
<tr>
<td>Tina</td>
<td>1.99</td>
<td>0.012</td>
<td>10.63</td>
<td>-10.53</td>
</tr>
<tr>
<td>Circuit m.</td>
<td>1</td>
<td>-1</td>
<td>10.67</td>
<td>-10.67</td>
</tr>
</tbody>
</table>

5.6 Comparison of RC coupled amplifier circuit output in different software’s:

![Input signal Amplitude](image_url)

Figure 5.21 Input signal amplitude of RC coupled amplifier in different software’s
Figure 5.22 Output signal amplitude of RC coupled amplifier in different software’s
REFERENCE:

8. B2 Spice A/D 5.2.3, Beige Bag Software www.beigebage.com info@beigebage.com
9. TINA™ for Windows, The Complete Electronics Lab version 6.00.008SFS.
10. CircuitMaker V6.2C Protel Technology, Inc. 5252N Edgewood Dr Ste175 Provo UT84604 USA.