UNIVERSITY OF SANTO TOMAS
Faculty of Engineering
ELECTRONICS ENGINEERING DEPARTMENT
First Term, AY 2021 – 2022

EE2315 Lab: Industrial Electronics

Experiment 4: Unijunction Transistor (UJT) Relaxation Oscillator Part 2

Intended Learning Outcomes

1. Be able to determine the frequency of oscillation of a relaxation oscillator.
2. Be able to determine the effect of a change in supply voltage, timing components, and temperature on the frequency of oscillation in a UJT relaxation oscillator

Discussion

Applications of UJT include non-sinusoidal oscillators, sawtooth generators, phase control, and timing circuits. Figure 4.1 shows a UJT relaxation oscillator as an example of one application. The operation is as follows. When dc power is applied, the capacitor C charges exponentially through until it reaches the peak-point voltage V_P. At this point, the PN junction becomes forward biased, and the emitter characteristic goes into the negative resistance region. The capacitor then quickly discharges through the forward-biased junction and R_2. When the capacitor voltage decreases to the valley-point voltage the UJT turns off, the capacitor begins to charge again, and the cycle will repeat.

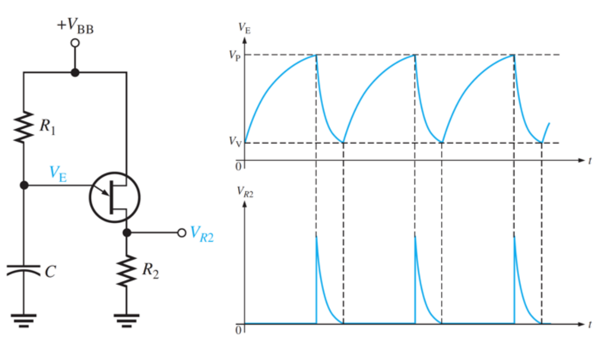

Fig. 4.1 UJT oscillator circuit and the corresponding waveforms of V_E and V_{R_2}

Materials

LTSpice Simulator

Experiment Proper

Part A.

1. Construct the circuit shown in Fig. 4.2.

2. Set-up a **10ms** transient analysis using the .tran command. To ensure that the initial voltage across the capacitor is zero, include the directive:

   .IC V(<name of emitter node>)=0

   (e.g. **.IC V(emitter)=0**)
3. Run the simulation and plot V_E.
4. Measure and record V_V, and V_P.
5. Measure and record t_{ON} by placing two cursors in between V_V and V_P.
6. Measure and record t_{OFF} by placing two cursors in between V_P and V_V.
7. Compute for the oscillation period, T, by adding the measured t_{ON} and t_{OFF}, compute for the frequency of oscillation, and record the computed values on Table 4.1.
8. Compute for the theoretical oscillation period, T, using the following and record it on Table 4.1:

$$T = R_E C_E \ln\left(\frac{V_{BB} - V_V}{V_{BB} - V_P}\right);$$

9. Compute for the theoretical frequency of oscillation and record it on table 4.1.

Guide Question: **What may be the cause of deviation in the measured and calculated oscillation frequency?**

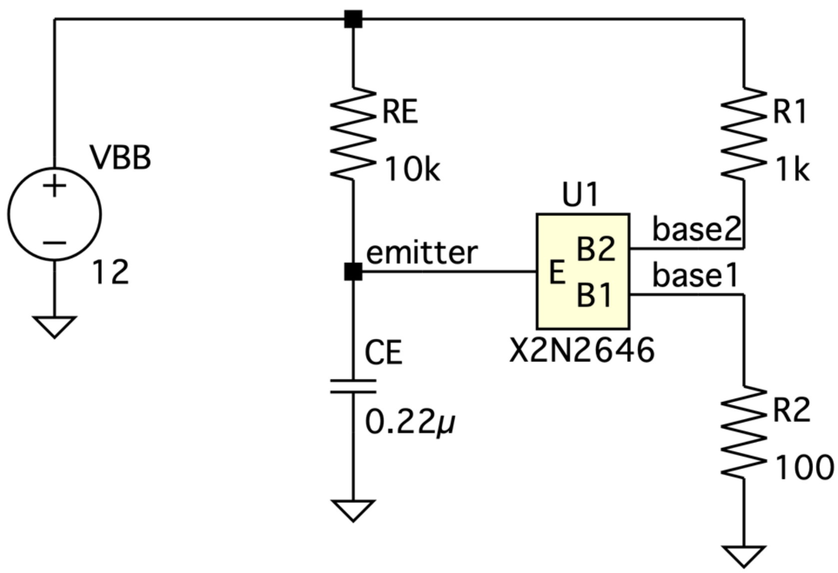

Fig. 4.2 The UJT relaxation oscillator circuit

Part B.

1. Change the supply voltage (VBB) of the circuit to 10V and re-run the transient simulation.
2. **Using different plot panes**, plot V_E, V_{B1}, and V_{B2}.
3. Measure and record the oscillation period and frequency on Table 4.2.
4. Repeat steps 1 to 3 for VBB=15V.

Guide Question: **What is the effect of the supply voltage in the oscillation frequency?**

Part C

1. After finishing part B, revert the supply voltage back VBB to 12V.
2. Change R_E to 100kΩ and re-run the transient simulation (change the final time if necessary).
3. **Using different plot panes**, plot V_E, V_{B1}, and V_{B2}.
4. Measure and record both the oscillation period and frequency on Table 4.3.
5. Repeat steps 2 to 4 using the components indicated in Table 4.3.

Guide Question: **What is the effect of R_E and C_E to the oscillation frequency?**

Part D:

1. After finishing part C, revert R_E and C_E back to $10k\Omega$ and 0.22µF, respectively.
2. Change the temperature to $0°C$ and re-run the transient simulation. Use the command:
   .temp <desired temperature>
3. **Using different plot panes**, plot V_E, V_{B1}, and V_{B2}.
4. Measure and record both the oscillation period and frequency on Table 4.4.
5. Repeat steps 2 to 4 using the temperature indicated in Table 4.4.
6. Using Excel (or MATLAB®), plot the measured frequency versus the temperature.
7. Compute and record the temperature coefficient (the unit of TC is in ppm or parts per million) of the oscillation frequency using the formula:

$$TC = \frac{2 \cdot (f_{max} - f_{min})}{(f_{max} + f_{min}) \cdot (T_{max} - T_{min})} \times 10^6$$

Comment on the temperature coefficient of the oscillator. (Hint: Search for the TC of other types of oscillator and compare it to the calculated TC)

· End of Experiment 4 ·

Experiment Number 4 Group Report

Group No.: ____________________

Group Members: ________________

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Part A:

Plot of Part A Simulations (Step 3):

<Insert Plot Here>

Table 4.1

	Measured	Calculated
Oscillation Period		
Oscillation Frequency		

Answer to the Guide Question:

<Insert Answer Here>

Part B:

Plot of Part B Simulations (Step 2):

When $V_{BB} = 10V$:

<Insert Plot Here>

When $V_{BB} = 15V$:

<Insert Plot Here>

Table 4.2

	Time Period	Frequency
V1 = 10V		
V1 = 15V		

Answer to the Guide Question:

<Insert Answer Here>

Part C:

Plot of Part C Simulations (Step 3):

Case 1:

<Insert Plot Here>

Case 2:

<Insert Plot Here>

Case 3:

<Insert Plot Here>

Table 4.3

	RE	CE	Oscillation Period	Oscillation Frequency
Case 1	100KΩ	0.22uF		
Case 2	1MΩ	0.22uF		
Case 3	10KΩ	0.05uF		

Answer to the Guide Question:

<Insert Answer Here>

Part D:
Plot of Part D Simulations (Step 3):

Temperature = 0°

<Insert Plot Here>

Temperature = 25°

<Insert Plot Here>

Temperature = 50°

<Insert Plot Here>

Temperature = 70°

<Insert Plot Here>

Temperature = 100°

<Insert Plot Here>

Table 4.4

Temperature	Oscillation Period	Oscillation Frequency
$0°C$		
$25°C$		
$50°C$		
$75°C$		
$100°C$		
Temperature Coefficient		

Plot of Frequency versus Temperature:

<Insert Plot Here>

Comment:

<Insert Comment Here>

Conclusion:

<Inset Conclusion Here>