Project: OP-AMP RELAXATION OSCILLATOR

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Analysis

Derived the period of oscillation, This is the Time taken by the oscillator to complete one complete cycle from $-V_{sat}$ to $+V_{sat}$. Got an expression in terms of R3, C1 and beta, as derived below.

$$-V_{sat} = Ae^{-\infty/T} + B \qquad \text{(e^-(inf) = 0)}$$

$$-V_{sat} = B$$

$$\beta\, V_{sat} = Ae^{to/T} + B \qquad \text{(At time t = 0)}$$

$$\beta\, V_{sat} = Ae^{0} + B$$

$$\beta\, V_{sat} = A + B$$

$$\beta\, V_{sat} = A - V_{sat}$$

$$V_{sat}\,(\beta + 1) = A$$

Solve for B using $-V_{sat} = B$ and then simplified it until you can get to A

Substituting A and B, into $-\beta\, V_{sat} = Ae^{-t_{switch}/T} + B$ and then solve for t_{switch} which led to the period of oscillation equation.

$$-\beta\, V_{sat} = Ae^{-t_{switch}/T} + B$$

$$-\beta\, V_{sat} = V_{sat}\,(\beta + 1)e^{\frac{-t_{switch}}{T}} - V_{sat}$$

$$-\beta\, V_{sat} = (\beta + 1)e^{\frac{-t_{switch}}{T}} - 1$$

$$\ln\left(\frac{-\beta + 1}{\beta + 1}\right) = ln(e^{\frac{-t_{switch}}{T}})$$

$$-\mathrm{T}\ln(-\beta + 1) - \ln(\beta + 1) = t_{switch}$$

$$Period\ of\ oscillation = -2\,T\,\ln\left(\frac{-\beta + 1}{\beta + 1}\right)$$

$$Period\ of\ oscillation = -2\,R_3C_1\,\ln\left(\frac{-\beta + 1}{\beta + 1}\right)$$

Testing

Chose values of β, $R3$, and $C1$ so that the period of oscillation is at least 5 seconds and at most 10 seconds. For ease of calculation, we chose beta = ½, and used 10uF capacitor to keep the resistance in an optimal range. Then calculated the range of R3 and finally used R3 = 300K ohm to measure the period of oscillation.

When period of oscillation = 5 secs

$R_3 = ?$

$C_1 = 10\ \mu F$

$\beta = 1/2$

$$Period\ of\ osciallation = -2\, R_3 C_1 \ln\left(\frac{-\beta + 1}{\beta + 1}\right)$$

$$5 = -2\, R_3 10\ \ln\left(\frac{-1/2 + 1}{1/2 + 1}\right)$$

$$R_3 = 227560\Omega$$

When period of oscillation = 10 secs

$R_3 = ?$

$C_1 = 10\ \mu F$

$\beta = 1/2$

$$Period\ of\ osciallation = -2\, R_3 C_1 \ln\left(\frac{-\beta + 1}{\beta + 1}\right)$$

$$10 = -2\, R_3 10\ \ln\left(\frac{-1/2 + 1}{1/2 + 1}\right)$$

$$R_3 = 455120\Omega$$

Therefore 227560 Ω < R3 < 455120 Ω and the R3 value was chosen to be 300000 Ω as it satisfies the conditions.

Then we chose the following values for Resistance, Capacitance and beta, to compute the Time of Oscillation and got T = 6.519 sec (as shown below).

$R_3 = 300000\Omega$

$C_1 = 10\ \mu F$

$\beta = 1/2$

$$Predicted\ period\ of\ osciallation = -2\, R_3 C_1 \ln\left(\frac{-\beta + 1}{\beta + 1}\right)$$

$$Predicted\ period\ of\ osciallation = -2\ (300000)10\ \ln\left(\frac{-1/2 + 1}{1/2 + 1}\right)$$

$$Predicted\ period\ of\ osciallation = 6.519\ sec$$

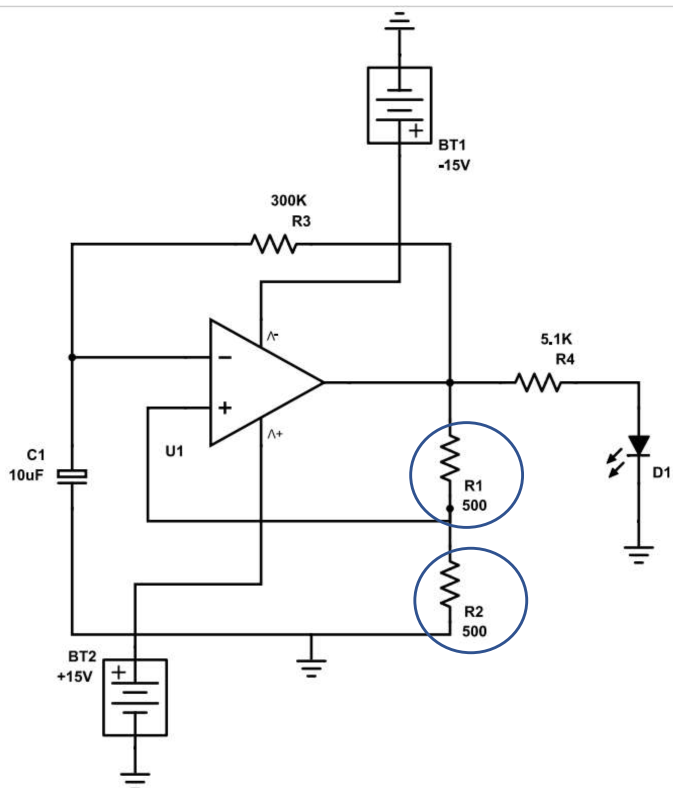

Figure 1: Circuit diagram of the circuit

Figure 1 shows the circuit diagram of the circuit with all the components.

Figure 2 shows the circuit operating with the LED blinking.

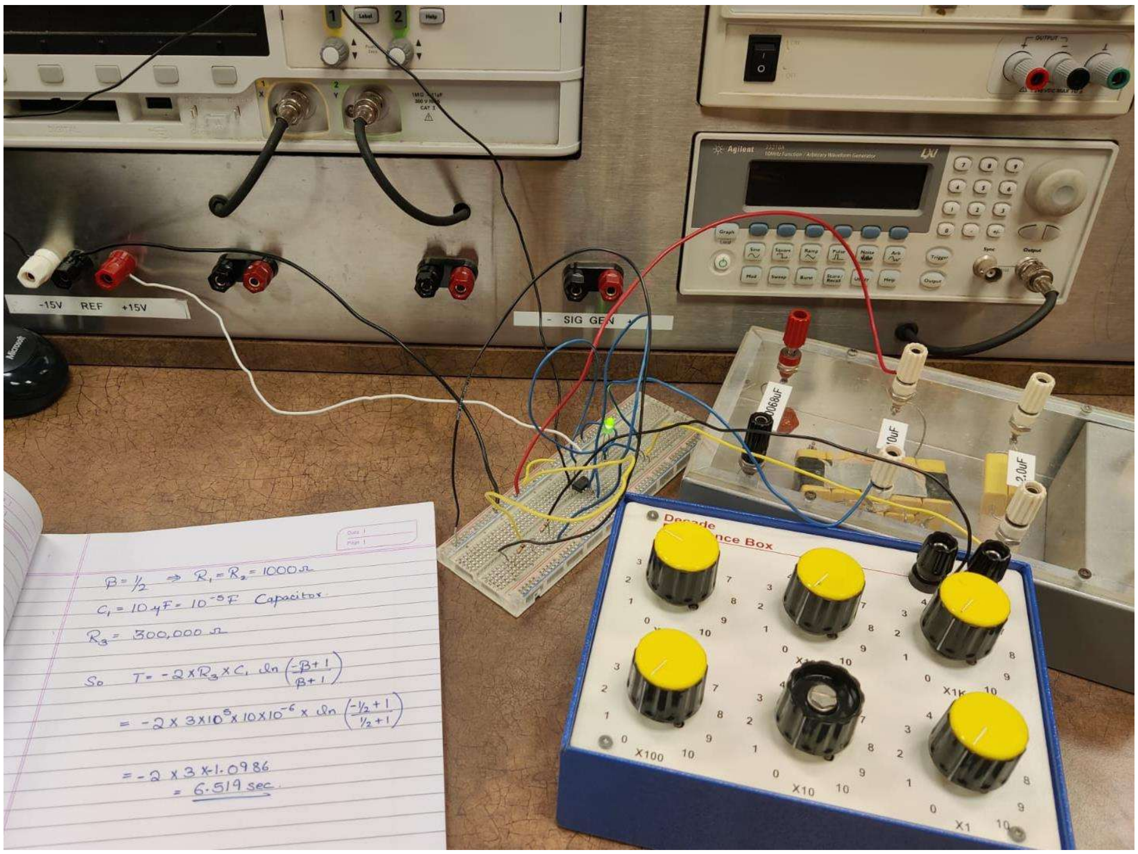

Figure 2: The OP-Amp Relaxation Oscillator operating

Measured the time it takes to the LED to blink ON and OFF ten times. Divided the result by ten to compute the period of oscillation of the circuit.

Table 1 shows the results obtained after measuring the time it takes the LED to blink ON and OFF ten times and it was also determined that the average oscillation period is 7.1 seconds.

Table 1: Time measured of LED

Trial	Time taken for 10 blinks (seconds)	Period of oscillation (seconds)
1.	75 sec	7.5 sec
2.	73 sec	7.3 sec
3.	65 sec	6.5 sec

[1]

Discussion

We see that there is a difference of 0.5 second between the experimental and the calculated value. This difference might be because, an op-amp constituents of active filters which affects the time constant, and further changing the period of oscillation.

The ultimate accuracy of Time Period depends on the tolerances of R and C. If ±5% parts are used in production, a variance of about ±10% is possible. Also, at higher frequencies, the op amp circuit will produce a moderate phase shift of its own. With extreme values in the positive feedback network, it is also possible that some shift of the output frequency may occur due to the capacitive and resistive loading effects of the op amp. One of the other reasons there is a difference in the experimental and calculated value due to the tolerance of resistors. The tolerance of a resistor indicates the percent of error in the resistor's resistance or how much more or less you can expect a resistor's actual measured resistance to be from its original stated resistance. It is usually the last color band on the resistor [1].

References

[1] "Resistor Color Codes," [Online]. Available: https://learn.parallax.com/support/reference/resistor-color-codes#:~:text=The%20first%20stripe%20is%20yellow,of%20the%20first%20two%20digits.. [Accessed 11 February 2022].