Analog Engineer's Circuit

Relaxation Oscillator Circuit

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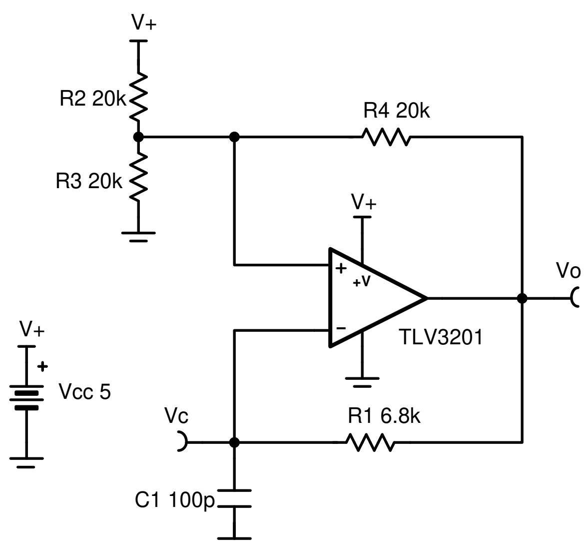
Design Goals

Supply		Oscillator Frequency
V_{cc}	V_{ee}	f
5V	0V	1MHz

Design Description

The oscillator circuit generates a square wave at a selected frequency. This is done by charging and discharging the capacitor, C_1 through the resistor, R_1. The oscillation frequency is determined by the RC time constant of R_1 and C_1, and the threshold levels set by the resistor network of R_2, R_3, and R_4. The maximum frequency of the oscillator is limited by the toggle rate of the comparator and the capacitance load at the output. This oscillator circuit is commonly used as a time reference or a supervisor clock source.



Design Notes

1. Comparator toggle rate and output capacitance are critical considerations when designing a high-speed oscillator.
2. Select C_1 to be large enough to minimize the errors caused by stray capacitance.
3. If using a ceramic capacitor, select a COG or NPO type for best stability over temperature.
4. Select lower value resistors for the R_2, R_3, R_4 resistor network to minimize the effects of stray capacitance.
5. Adjust R_2, R_3, and R_4 to create a duty cycle other than 50%.

Design Steps

1. When $R_2 = R_3 = R_4$, the resistor network sets the oscillator trip points of the non-inverting input at one-third and two-thirds of the supply.

2. When the output is high, the upper trip point is set at two-thirds of the supply to bring the output back low.

$$V_o = V_s\left(\frac{R_3}{(R_2 \| R_4) + R_3}\right) = \frac{2}{3}V_s = 3.33V$$

3. When the output is low, the lower trip point is set at one-third of the supply to bring the output back high.

$$V_o = V_s\left(\frac{R_3 \| R_4}{(R_3 \| R_4) + R_2}\right) = \frac{1}{3}V_s = 1.67V$$

4. The timing of the oscillation is controlled by the charging and discharging rate of the capacitor C_1 through the resistor R_1. This capacitor sets the voltage of the inverting input of the comparator. Calculate the time to discharge the capacitor.

$$V_c = V_i e^{-\frac{t}{R_1C_1}}$$

$$\frac{1.67}{3.33} = e^{-\frac{t}{R_1C_1}}$$

$$t = 0.69R_1C_1$$

5. Calculate the time to charge the capacitor.

$$V_i = V_c\left(1\text{-}e^{-\frac{t}{RC}}\right)$$

$$1.67 = 3.33\left(1\text{-}e^{-\frac{t}{RC}}\right)$$

$$\frac{1.67}{3.33} = e^{-\frac{t}{RC}}$$

$$t = 0.69R_1C_1$$

6. The time for the capacitor to charge or discharge is given by $0.69R_1C_1$. With a target oscillator frequency of 1 MHz, the time to charge or discharge should be 500ns.

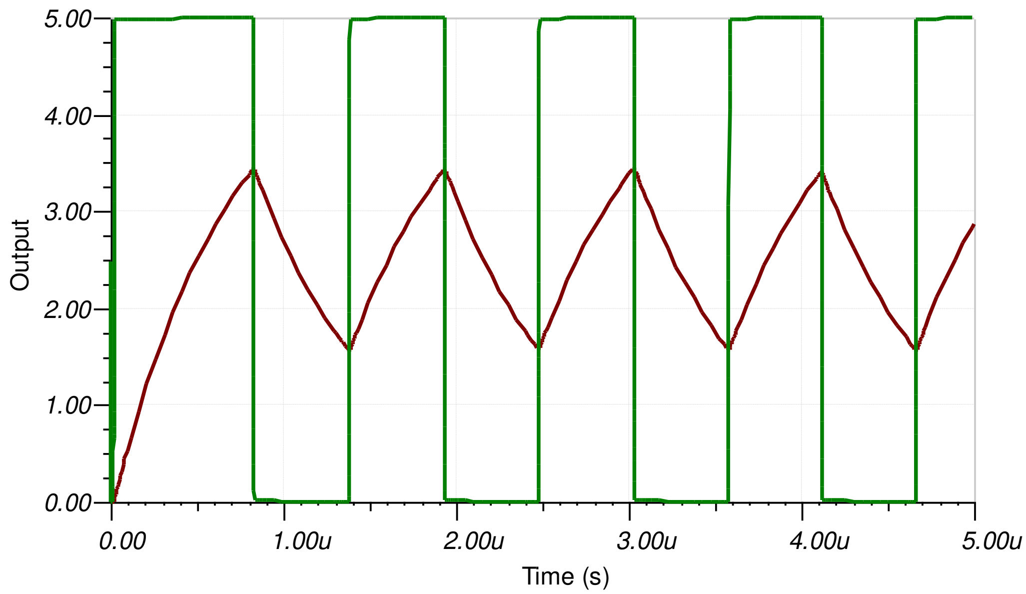
$$0.69R_1C_1 = 500ns$$

$$R_1C_1 = 724ns$$

7. Select C_1 as 100pF and R_1 as 6.8kΩ (the closest real world value).

Design Simulations

Transient Simulation Results



Design References

See circuit spice simulation file, SBOMAO3.

Design Featured Comparator

TLV3201	
V_{ss}	2.7V to 5.5V
V_{inCM}	Rail-to-rail
t_{pd}	40ns
V_{os}	1mV
V_{HYS}	1.2mV
I_q	40µA
Output Type	Push-Pull
#Channels	1
TLV3201	

Design Alternate Comparator

TLV7011	
V_{ss}	1.6V to 5.5V
V_{inCM}	Rail-to-rail
t_{pd}	260ns
V_{os}	0.5V
V_{HYS}	4mV
I_q	5µA
Output Type	Push-Pull
#Channels	1
TLV7011	

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