Experiment 6: Operational Amplifier II - Pulse Width Modulation

Student Group

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Combination of Integrator and Schmitt Trigger - Oscillator

Background Information

The circuits previously analyzed individually are now connected to form a complete system.
The integrator and the Schmitt trigger together form an oscillator. The output signal of the Schmitt trigger is fed back to the input of the integrator. Therefore, the output signal simultaneously acts as the input signal of the overall system.

Due to this feedback, the circuit generates a periodic signal without requiring an external input signal, apart from the supply voltages of the operational amplifiers.

The Schmitt trigger generates a rectangular signal that is integrated into a triangular signal until one of the switching thresholds is reached. At this point, the output state changes and the process repeats continuously, producing a stable oscillation.

When the circuit is first powered on, the oscillator starts due to small disturbances such as noise, offset voltages of the operational amplifiers, or slight asymmetries in the circuit. These small deviations move the system away from the unstable equilibrium point and initiate the oscillation.

Experimental Tasks

To analyze the behavior of the oscillator (triangle-rectangle generator), the following circuit is used:

Supply voltages (from power supply unit):
UCC = + 3V, UEE = - 3V

Values of the components used:
R1 = 200 kΩ, R1.3 = 10 kΩ, R2 = 20 kΩ, R3 = 27 kΩ, C1 = 10 nF

1. Build the circuit on the MEXLE-board. R1 is a 200 kΩ potentiometer. Set it to a value of 200 kΩ. Perform the following measurements:
    - Connect channel 1 of the oscilloscope to TR and channel 2 to SQ. Switch on the power supply.
    - Now try to generate a minimum and maximum frequency with your circuit by turning the potentiometer R1 to the left and right stops. Perform this experiment with two capacitance values: $C1=10~nF$ and $C1=1~nF$. Enter the measured frequency values in the following table.

2. Sketch the oscilloscope screen image at minimum and maximum frequency for the following capacitance values:

    $C1=10~nF$ and $C1=1~nF$.

    Label the lines with TR and SQ, respectively. Specify the oscilloscope settings you used.

C1 = 10 nF, f = ƒmin

Channel 1: $\frac {Volt}{Div}=$

Channel 2: $\frac {Volt}{Div}=$

Time basis: $\frac {T}{Div}=$

C1 = 10 nF, f = ƒmax

Channel 1: $\frac {Volt}{Div}=$

Channel 2: $\frac {Volt}{Div}=$

Time basis: $\frac {T}{Div}=$

C1 = 1 nF, f = ƒmin

Channel 1: $\frac {Volt}{Div}=$

Channel 2: $\frac {Volt}{Div}=$

Time basis: $\frac {T}{Div}=$

C1 = 1 nF, f = ƒmax

Channel 1: $\frac {Volt}{Div}=$

Channel 2: $\frac {Volt}{Div}=$

Time basis: $\frac {T}{Div}=$

3. Explain how this circuit works in a few sentences.

4. Why is it useful to use R1 as a potentiometer to vary the frequency rather than R2 or R3?

Test Questions