LabExp-4. Non-linear circuits based on OA

Goals:

1) To strengthen the concepts related to the astable multivibrator and the hysteresis comparator.
2) To Study, assemble and test a circuit based on an astable multivibrator and a comparator with hysteresis, which allows obtaining a variable DC level, which could be used, for example, to control the speed of a DC motor.

Components

Units	Reference	Value
1	AO1	TL081
1	AO2	TL082
1	R1	10 kΩ
1	R2	100 kΩ
1	R3	10 kΩ
1	R4	470 kΩ
1	P1	100 kΩ
1	P2	250kΩ
1	P3	500 kΩ
1	C1	2.7 nF
1	C2	560 nF
1	D1	1N4148
1	D2	1N4148
1	Small screwdriver	N/A

Measurement instrumentation, supply sources and signal generators:

- Digital Oscilloscope and 2 probes
- Function Generator
- Digital Multimeter
- Supply Source

IMPORTANT: Part 0 corresponds to the work to be done by the student before attending the laboratory. It does not have an impact on the grade, but it must be carried out so that the teacher can solve the doubts in a coherent way, since the laboratory experiment session is not intended to solve theoretical doubts.

PART 0. Previous work

0.1 Analyze the circuit in Figure 1 and represent the temporal evolution of the voltage across the capacitor and the output voltage of the OA. Determine theoretically the expression of the period of oscillation of V_{s1} as a function of the value of the components. Consider the ideal diodes for analysis.

0.2 Which potentiometer must be adjusted to vary the duty cycle of the multivibrator output signal (V_{S1})?
Indicate the position of this potentiometer to get an output signal (V_{s1}) with a duty cycle of 50%. Perform the theoretical calculation.

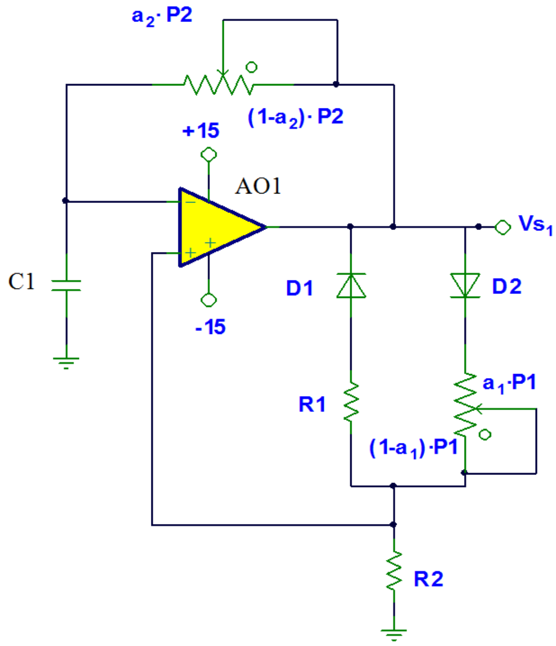

Figure 1. Astable Multivibrator

0.3 What is the maximum theoretical frequency for an output signal (V_{S1}) with a duty cycle of 50%?
What is the theoretical minimum frequency for an output signal (V_{S1}) with a 50% duty cycle?
Indicate the position of this potentiometer to achieve an output signal (V_{S1}) with a duty cycle of 50% and a frequency of 1 kHz.

0.4 Analyze the circuit in Figure 2 assuming that a3 = 0.9 and that ± Vsat = ± 15 V. Represent the transfer function of the circuit in detail. R3 = 10 kΩ, P3 = 500 kΩ.

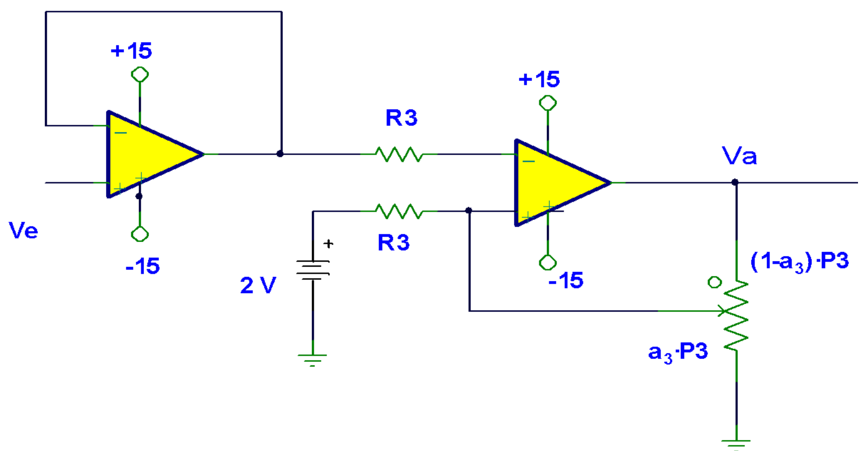

Figure 2. Comparator with hysteresis

0.5 The circuits of Figures 1 and 2 are connected as shown in Figure 3. If a V_{S1} is programmed with a duty cycle of 50% and a frequency of 1 kHz and a3 = 0.9, represent as a function of time the input signal (V_e) to subsystem 2 and the comparator output signal (V_a). How can the duty cycle of V_a be regulated?

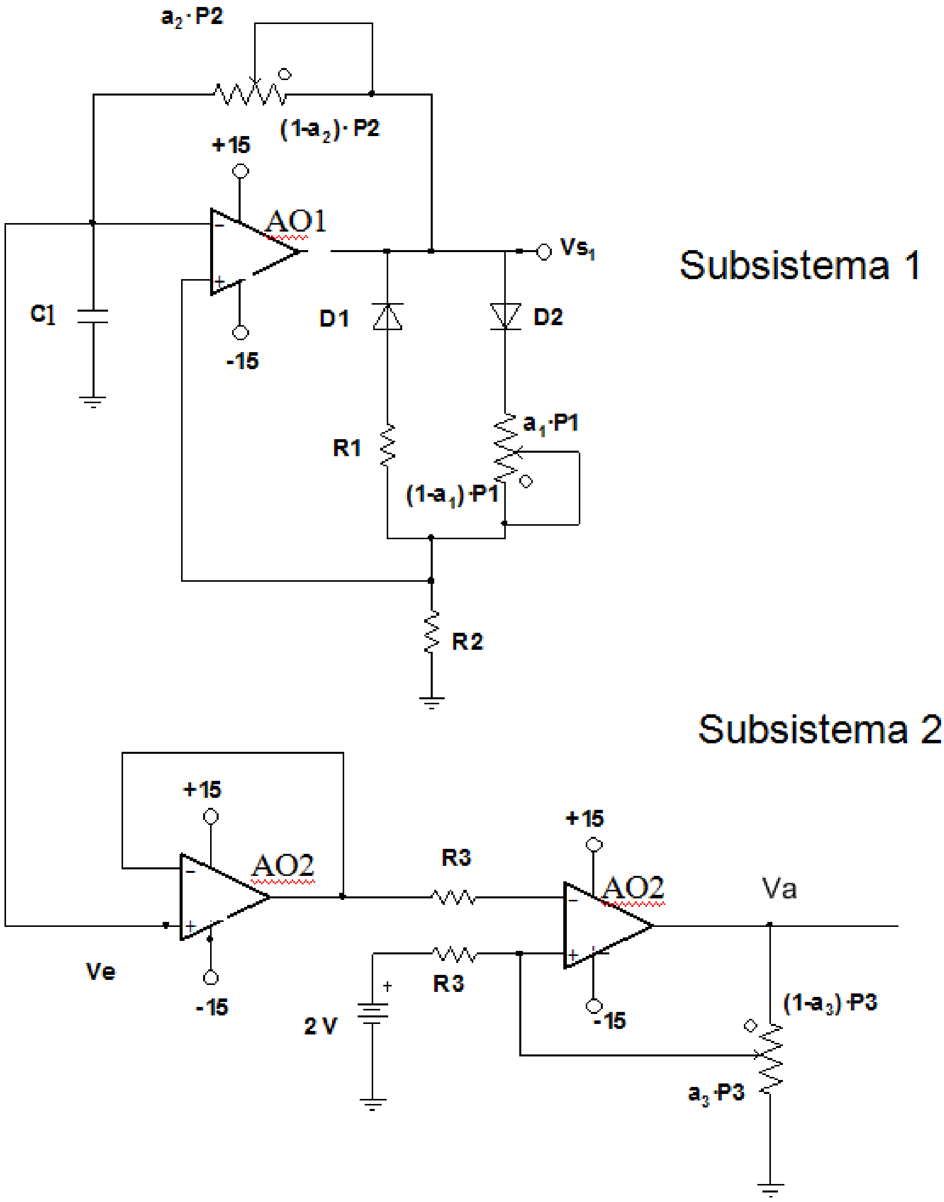

Figure 3. Multivibrator + comparator

0.6 If capacitor C2 is connected together with resistor R4 to the output of the comparator (V_a) as indicated in Figure 4, a DC regulator would be obtained. Justify it. How could the DC level of the signal be varied? (R4= 470 kΩ, C2 = 560 nF)

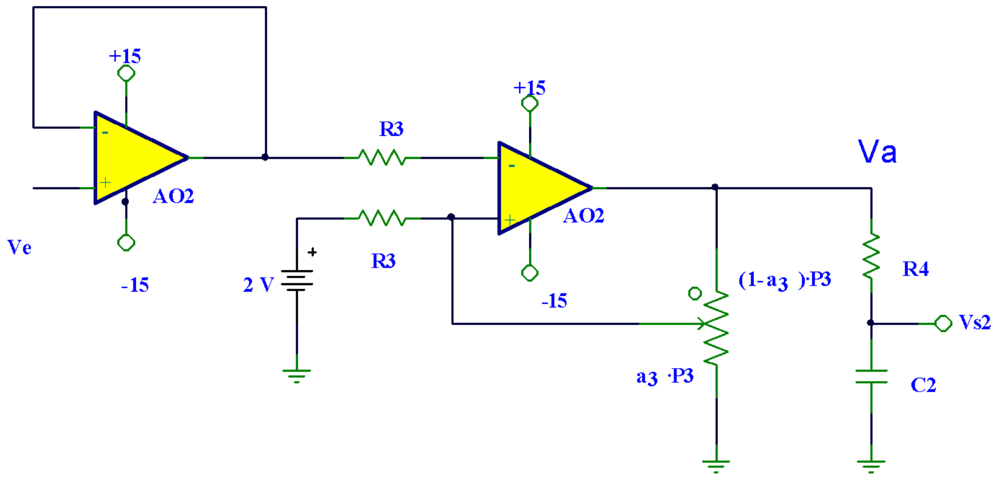

Figure 4. DC regulator

PART 1. Equipment and components setting

1. Use the digital multimeter to measure all resistances. Write down the value next to each component to avoid confusion during assembly.

2. Check the operation of the oscilloscope and voltage probes. To do this, connect each probe to one of the oscilloscope channels (1 and 2). Uses the square auxiliary signal generated by the oscilloscope itself to do the check. Remember that the probes can have fixed attenuation (×10) or adjustable (×1, ×10), and that consequently it is necessary to indicate to the oscilloscope which is the attenuation for each channel.

3. Check the function generator operation. To do this, for example, program a sinusoidal signal with 1 kHz frequency and 1 V amplitude (peak). Extract the signal from the generator using the BNC-crocodile cable. Display the signal on channel 1 of the oscilloscope. DO NOT connect the crocodile directly to the oscilloscope probe, as you can damage the probe tip. Use an intermediate wire.

4. Check the operation of the power supply. To do this, measure with the multimeter the direct voltage generated at the symmetrical output of ±15 V (that is, between +15 and the reference point, and between -15 and the reference point).

PART 2. Astable Multivibrator

5. Assemble the circuit of Figure 1 and obtain an output signal V_{s1} with a duty cycle of 50% and a frequency of 1 kHz. Represent in full detail the temporal evolution of the signal V_{s1} and the voltage at the terminals of the capacitor C1.

A1 (assessable). Measure the maximum and minimum frequencies of the signals that we can obtain with a duty cycle of 50%. Compare with the values obtained in section 0.3 of the previous work and explain the reasons for the discrepancies, if any.

PART 3. Comparator with histeresis

6. Assemble the circuit of Figure 2 and connect it to the circuit of Figure 1 as shown in Figure 3. From the input voltage V_e set in part 1, regulate the potentiometer P3 to obtain a cycle of signal work V_a of about 50%.

7. Display on the oscilloscope the input signal (V_e) to subsystem 2 and the comparator output signal (V_a).

8. Represent the hysteresis cycle associated with the transfer function (V_a versus V_e) on the oscilloscope. To do this, use the XY mode of the oscilloscope, where V_a is Y (channel 2) and V_e is X (channel 1). Before viewing it, center the ground signals on each channel.

A2 (assessable). Paste the oscilloscope results here. Compare with the values obtained in section 0.4 of the previous work and explain the reasons for the discrepancies, if any.

PART 4. DC Regulator

9. Without disconnecting subsystem 1, connect the circuit formed by C2 and R4 to the comparator output as shown in Figure 4. On the oscilloscope, display the signal V_a and the output V_{s2}.

A3 (assessable). Describe what the output signal V_{s2} looks like and how it can be regulated.