NUEVA GRANADA MILITARY UNIVERSITY

PNEUMATIC CIRCUITS, INTUITIVE AND CASCADE METHODS.

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1. RESUMEN:

Se realiza el montaje de circuitos neumáticos en los cuales se aplican dos diferentes métodos para su desarrollo, de tal manera que se tenga un acercamiento al método intuitivo y en cascada para evitar posibles fallas por interferencias entre los elementos involucrados, también se utilizará el software de FluidSim para realizar las simulaciones correspondientes facilitando observar las características del funcionamiento de las secuencias planteadas.

2. PALABRAS CLAVE:

- Presión
- Aire
- Compresor
- Neumática
- Válvula

3. ABSTRACT:

It's performed the mounting of circuits pneumatic in which is applied two different methods for its development, of such way that is have an approach to the intuitive and cascade methods to avoid possible failures by interference between them elements involved, also is used the software of FluidSim for perform them simulations corresponding facilitating observe them features of the operation of them sequences raised.

4. KEY WORDS:

- Pressure
- Air
- Compressor
- Pneumatics
- Valve

5. INTRODUCTION:

Pneumatics is a technology that manipulates compressed air as an energy transmitting medium to perform movements and obtain the operation of various processes. The techniques consist of increasing the air pressure and through the energy accumulated on the elements of the pneumatic circuit such as cylinders, valves, end of stroke, among others, generate a useful work.

In this case it will be used to develop different sequences and thus achieve an approach to this technique, analyzing the behaviors of the system.

6. OBJECTIVES:

GENERAL OBJECTIVE:

- Perform pneumatic sequences, eliminating interference through the various methods.

SPECIFIC OBJECTIVES:

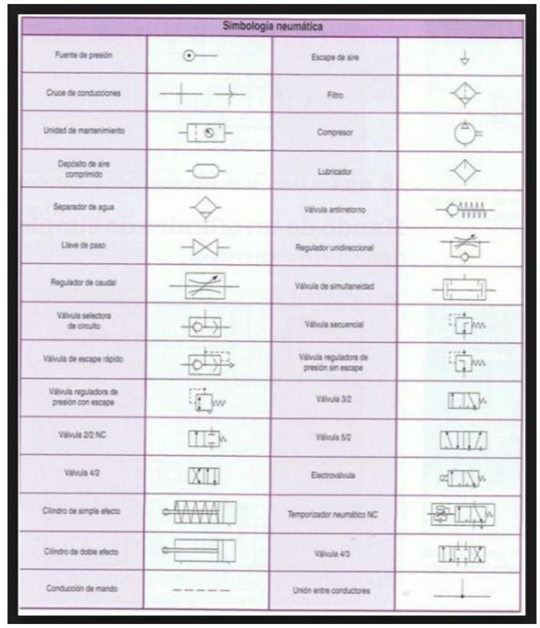
- Recognize the elements to be implemented, such as cylinders, valves, end of stroke among others.
- Develop the simulation in FluidSim and assembly of a pneumatic circuit capable of performing the sequence.
- Implement cascade method and directional valves with folding drive.
- Develop the different simulations and analyze the behavior of the circuits.

7. THEORETICAL FRAMEWORK:

- **Pneumatics:**

“Pneumatics is the technology that uses compressed air as a mode of transmission of the energy necessary to move and operate mechanisms. Air is an elastic material and, therefore, when a force is applied to it, it is compressed, maintains this compression and returns the accumulated energy when it is allowed to expand.

The basic pneumatic circuits are formed by a series of elements that have the function of the creation of compressed air, its distribution and control to carry out a useful work by means of actuators called cylinders.” [3]



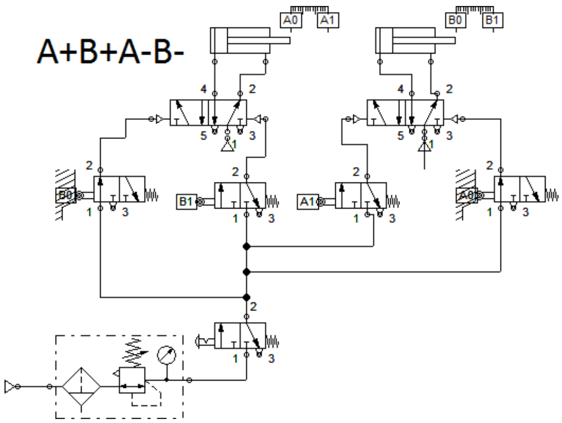
Graph 1. Pneumatic symbology.

8. METHODOLOGY:

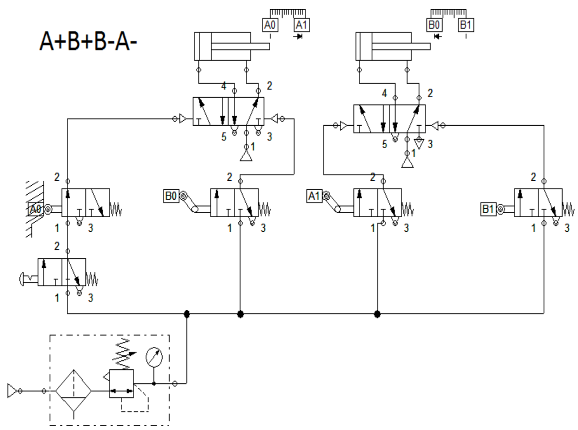
The development of different sequences will be carried out by means of pneumatics.

To perform this control it is necessary to implement an adequate configuration of the different connections to have an optimal sequence.

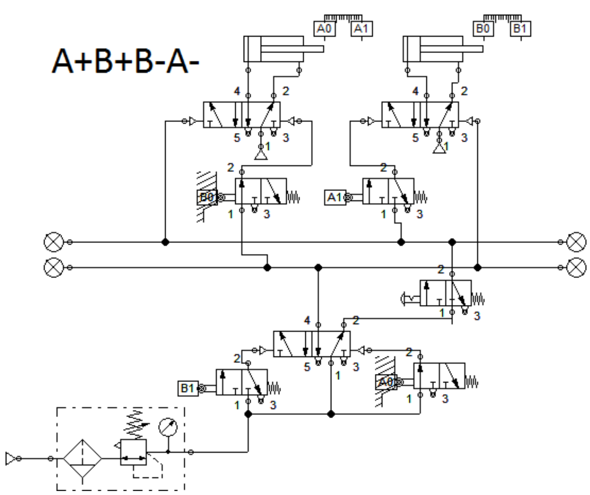
The structure to be implemented for development will be as follows:



Graph 2. Sequence A+B+A-B-



Graph 3. Sequence A+B+B-A-



Graph 4. Sequence (Cascade) A+B+ B-A-

9. MATERIALS:

To carry out the practice, the following materials are used:

- FluidSim Festo Simulation software.
- Pneumatic actuated vales 5/2.
- Double acting cylinders.
- Pneumatic maintenance unit.
- Mechanically actuated valves.
- Dealers

10. PROCESS:

- Perform simulations to determine the correct configuration.
- Determine the components needed to develop the sequence.
- Perform the design and assembly of a pneumatic circuit that performs the following sequence:

$$A^+B^+A^-B^-$$

- Perform the design, simulation and assembly of a pneumatic circuit that performs the following pneumatic sequence:

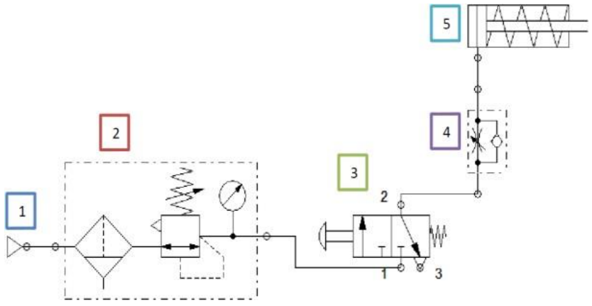
$$A^+B^+B^-A^-$$

a. Use directional valves with flip-up actuation to eliminate interference problems.
b. Use the cascade method to eliminate interference issues that occur.

- Analyze the operation of five pneumatic circuits, in which the operation of the maintenance unit, a cylinder and conditional and directional valves is implemented.

11. SIMULATIONS:

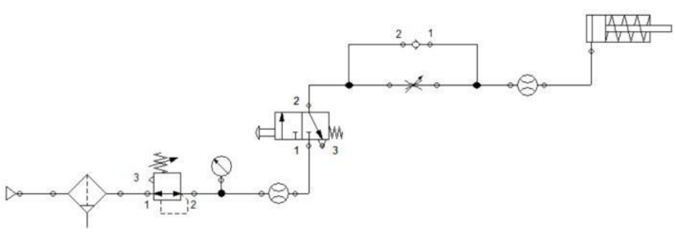
- First circuit:



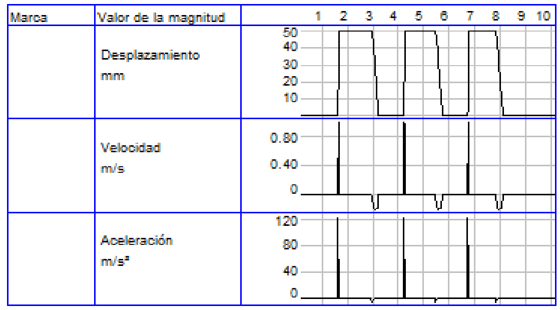
Graph 5. First circuit.

When performing the respective simulation, the following components were used:

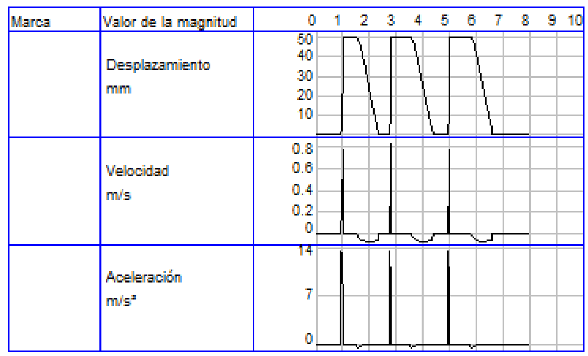
- A Compressed Air Source.
- A maintenance unit, consisting of a filter or manual purge of condensates (which allows the manual evacuation of water) and a pressure regulating valve with pressure gauge.
- A 3/2 valve manually operated by spring return pushbutton.
- A non-return choke valve (which allows the passage of a certain amount of air and does not allow the return of air).
- A single-effect cylinder with spring return.


Graph 6. First circuit simulation.

When simulating the circuit it is observed that if the valve is actuated, nothing happens. So we proceed to increase the value of the pressure; when using a pressure of 0.5 MPa or higher, the cylinder makes the displacement, as can be seen in the figure.

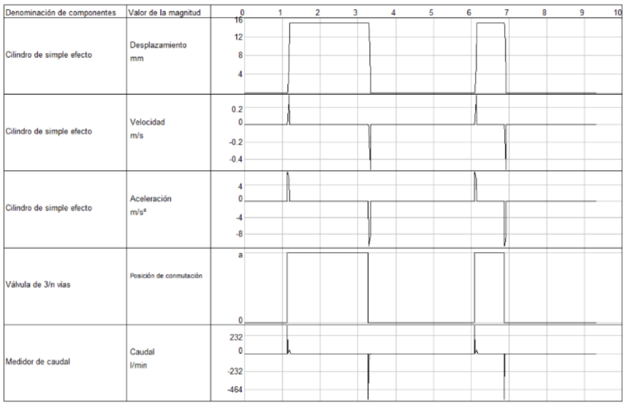


Graph 7. Diagram of first circuit without load.

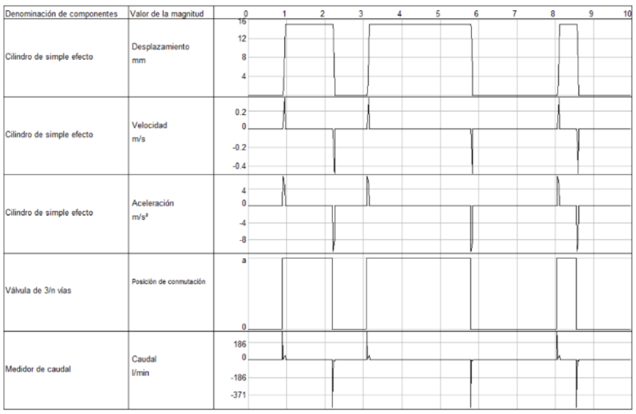


Graph 8. *Diagram of first circuit with a 10kg load*.

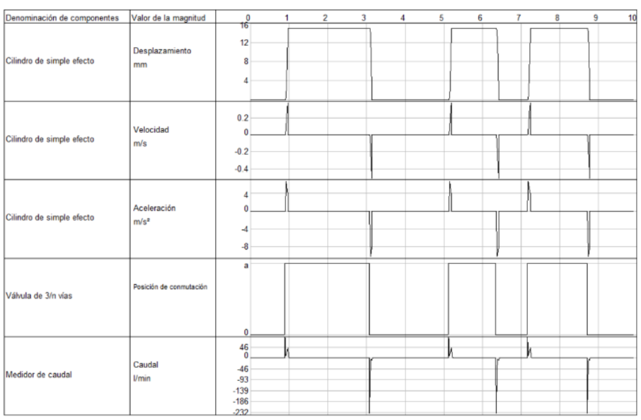
With respect to the graph in Figure 7, it is observed how the behavior is compared to the graph in Figure 6 when an external load is coupled. As for the speed, it can be said that its value remains constant despite whether the load increases or decreases. However, the acceleration decreases considerably according to the amount of cargo supplied; as the load increases, the acceleration decreases in a significant way. As it can also be seen that the force when the cylinder has no load it is zero.



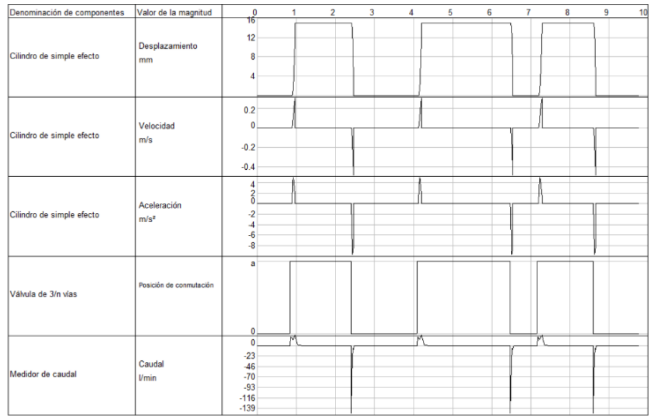
Graph 9. First circuit with valve open 100%



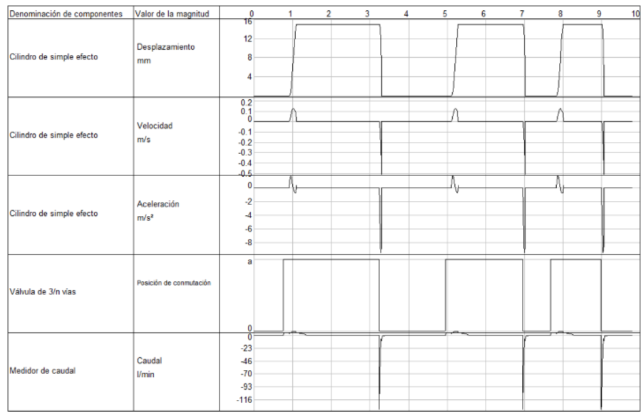
Graph 10. First circuit with valve open 50%



Graph 11. First circuit with valve open 10%



Graph 12. First circuit with valve open 20%

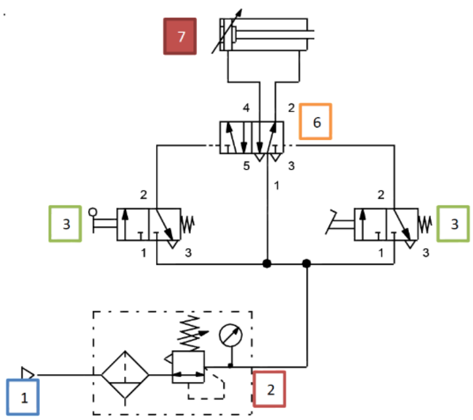


Graph 13. First circuit with valve open 0.5%

As can be seen in the different graphs, by varying the degree of opening of the choke valve, it is observed that the cylinder increases or decreases its exit velocity of the stem proportionally to the degree of opening. As the advance and recoil of the cylinder is carried out, it can be evidenced that when the advance occurs it is observed that the flow is limited by a unidirectional choke valve, so it is observed how the displacement as a function of time presents a lower slope than that of the recoil, it can also be visualized that at the moment in which the displacement of the cylinder begins it presents a peak of acceleration that increases the speed at that very moment of time. During the rest of the transition what is presented in the behavior of the displacement the acceleration becomes zero, so the decrease in speed that is observed is due to the directional choke valve, because when limiting the flow rate the speed is also affected by being directly proportional. For recoil something similar happens but with a displacement in much less time due to the spring that the cylinder has.

Second circuit:

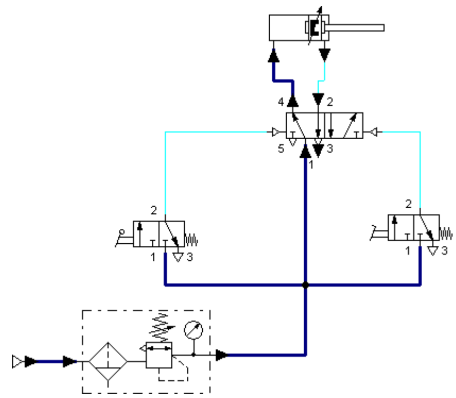
This circuit must be assembled in the laboratory:



Graph 14. Second circuit.

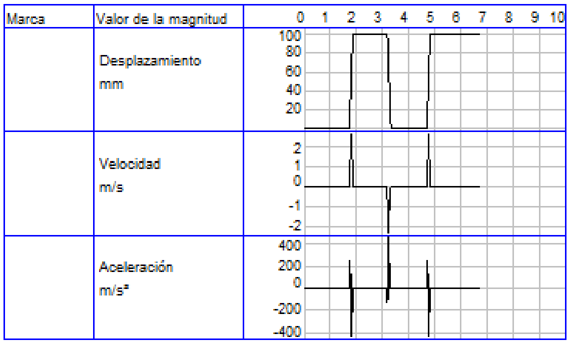
When performing the respective simulation, the following components were used:

- A double-acting cylinder with damping.
- A source of compressed air.
- Pneumatic maintenance unit.
- One manually operated 3/2 valve by spring return lever.
- One manually operated 3/2 valve per spring return pedal.
- One pneumatically operated 5/2 valve.

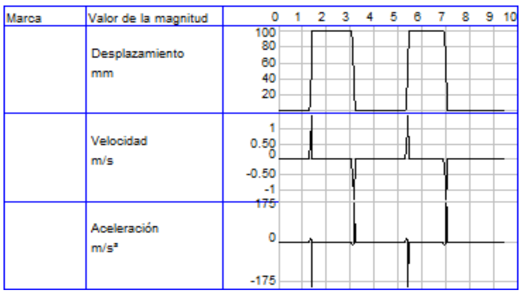


Graph 15. Second circuit simulation.

When performing the simulation for the second circuit, the cylinder is stopped, because the incoming pressure is in the plugs and does not perform any action. By lever actuating the valve, it conducts the air to the valve 5/2 and shifts it to the right, causing it to adopt this position, taking pressure from the lower line and which causes the stem to come out. When the lever is lowered, the valve continues in its current position and continues to execute the previous action. When the valve is operated by pedal, the 5/2 valve returns to the initial position, where the pressure is connected to the plug and the air present goes through the exhaust route, causing the stem to recede to its initial position. Since this valve maintains its position if no actuation is applied on either side, when releasing the pedal drive, it maintains its position.



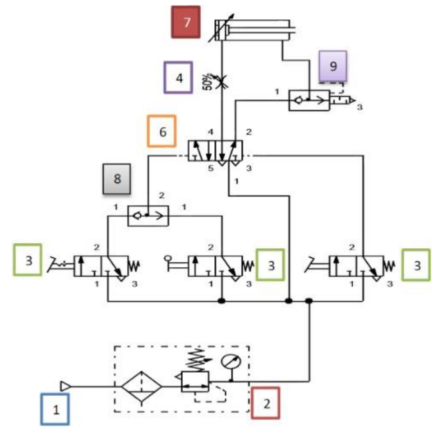
Graph 16. Diagram of second circuit without load.



Graph 17. Diagram of second circuit with a 10kg load.

Comparing the 2 graphs of the second circuit shows something similar to the previous circuit, with the difference of a rounding in the graphs when reaching the initial and final positions, due to the damping of the stem. Unlike the previous one, the speed of this decreases in a smaller proportion according to the load placed. This behavior is repeated in acceleration; decreases very little from the initial value without load. It is also observed in the graphs that the acceleration of its advance is equal to the recoil value, because it has two pressure pathways where neither has flow restriction. Thus reaching speed and acceleration values higher than those observed in the simulation of the first circuit at the same time.

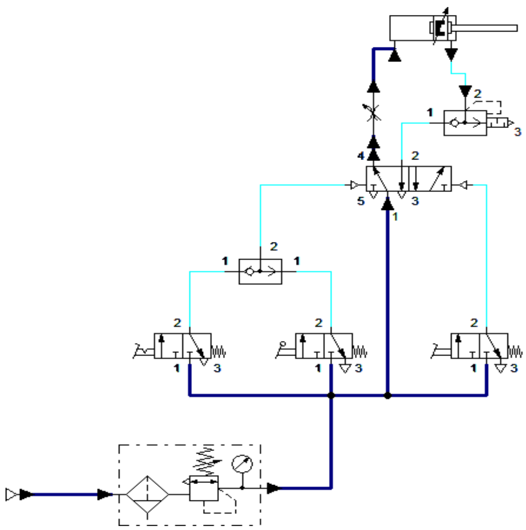
Third circuit:



Graph 18. Third circuit.

When performing the respective simulation, the following components were used:

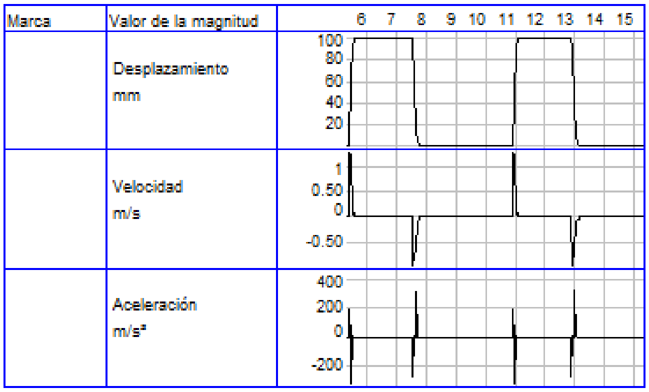
- A source of compressed air.
- A pneumatic maintenance unit.
- A manually operated 3/2 valve by spring return interlocking.
- One manually operated 3/2 valve by spring return lever.
- A choke valve with a 50% pitch.
- A double-acting cylinder with damping.
- One manually operated 3/2 valve per spring return pedal.
- One pneumatically operated 5/2 valve.
- Selector valve.
- A fast anti-return exhaust valve.



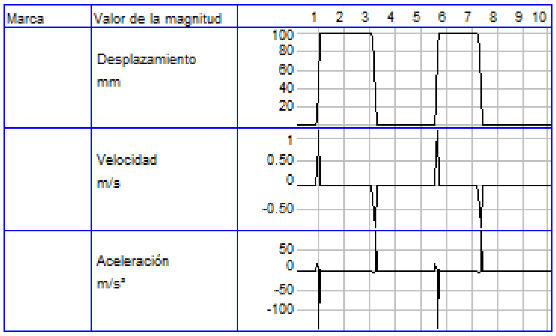
Graph 19. Third circuit simulation.

With regard to the simulation of the third circuit at the beginning of the simulation, it does not change any position. When the valve is operated with lever actuation or interlocking, the pressure goes to the selector valve, which when receiving a signal from any of the previous 2, activates and moves the valve 5/2 to the right. In this position the valve actuates the progress of the stem, but with a pressure lower than that which arrives, due to the choke valve. When the pedal valve is actuated, the 5/2 valve moves to the starting position, where air is directed through the quick purge valve and actuates the stem in reverse. However, it has some delay from when the pedal valve is pressed until the stem backs up, because the quick exhaust valve needs a while to push the plug to let air through. When activated, the recoil of the stem is faster, since the exhaust valve evacuates the air in a more agile way than through the exhaust route.

If the interlock valve is activated and the valve is pressed by pedal, the valve 5/2 maintains its current position, because there is pressure on both sides, it remains stable. One way to ensure that when the interlock valve is activated and the pedal valve is activated, the 5/2 valve changes, is with differential pressure

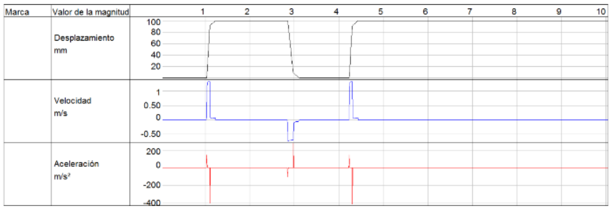


Graph 20. Diagram of third circuit without load.

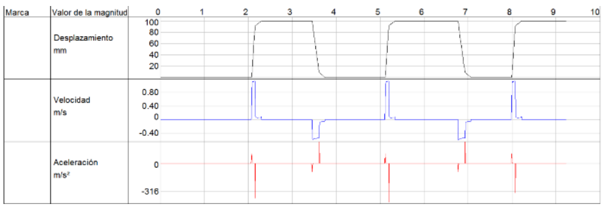


Graph 21. Diagram of third circuit with a 10kg load

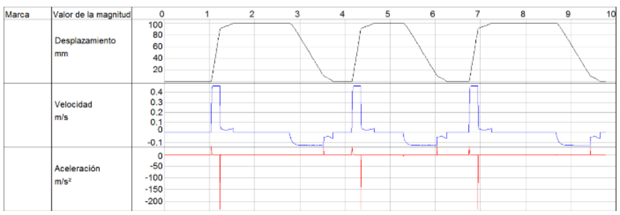
As can be seen in the unloaded, the graphs are similar, however, the displacement is made more slowly in this case, because the choke valve limits the passage of pressure to the cylinder. When comparing with the graph with load the same thing happens as with previous cases, unlike that it can withstand a lower load due to the pressure restriction in the cylinder and the speed of recoil of the cylinder is higher, thanks to the quick exhaust valve.



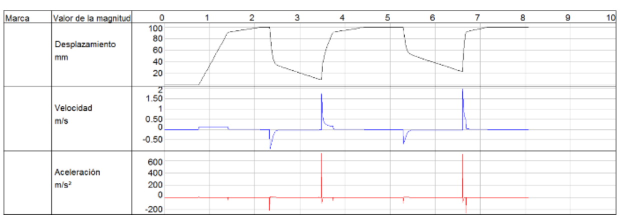
Graph 22. Third circuit with valve open 100%



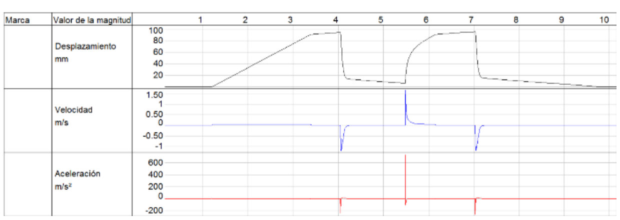
Graph 23. Third circuit with valve open 50%



Graph 24. Third circuit with valve open 10%.

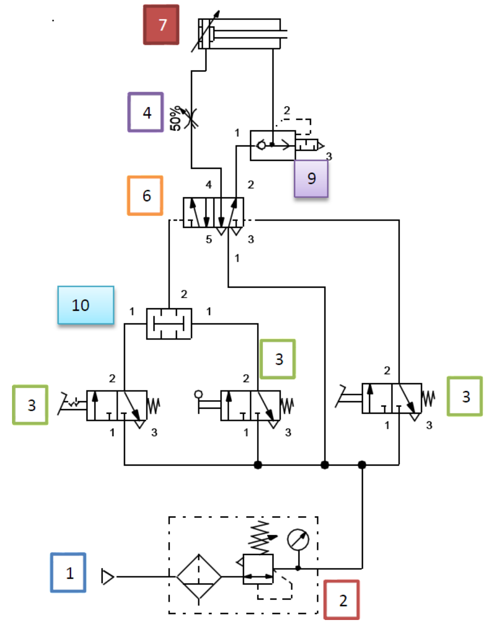


Graph 25. Third circuit with valve open 2%



Graph 26. Third circuit with valve open 0.5%.

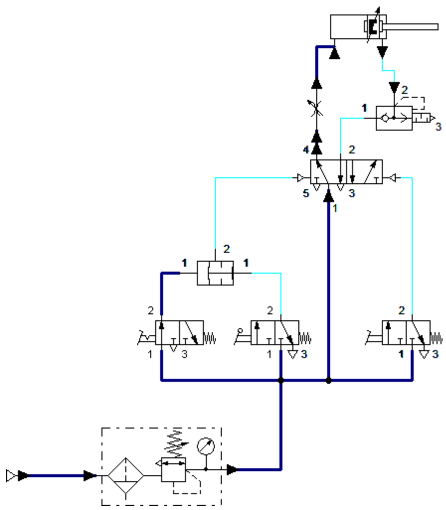
Fourth circuit:



Graph 27. Fourth circuit

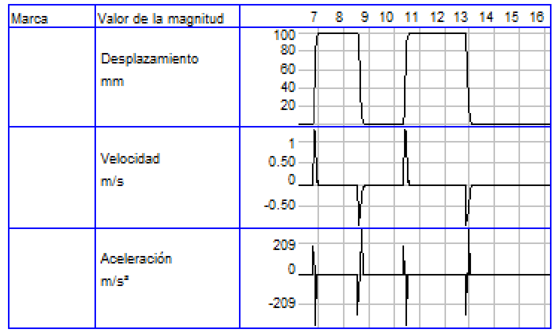
When performing the respective simulation, the following components were used:

- A source of compressed air.
- A pneumatic maintenance unit.
- A manually operated 3/2 valve by spring return interlocking.
- One manually operated 3/2 valve by spring return lever.
- One manually operated 3/2 valve per spring return pedal.
- One pneumatically operated 5/2 valve.
- A dual pressure valve.
- Una válvula de escape rápido antirretorno.
- A fast anti-return exhaust valve.
- A double-acting cylinder with damping

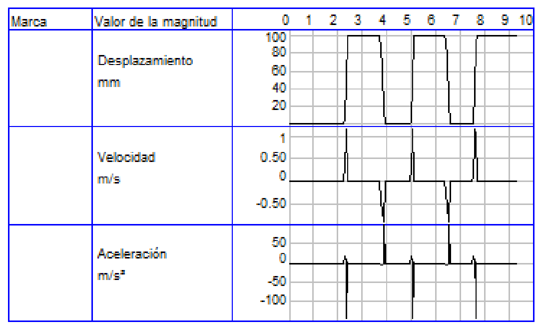


Graph 28. Fourth circuit simulation.

When the valve is activated by interlocking or lever, the pressure reaches the concurrency valve, but does not activate it. As the name implies, for this valve to be activated, the interlocking valve must be activated and the lever that operates the other valve must be activated. When this occurs, the valve allows the passage and displaces the valve 5/2, being connected to the pressure of the lower line and activates the cylinder, taking into account that, when activating the quick exhaust valve, it takes a while to push the plug. If the valve is activated by pedal, otherwise the previous one, it will always return to its initial position even if the interlocking valve is activated, because the 2 conditions are not met to leave the simultaneity one active.

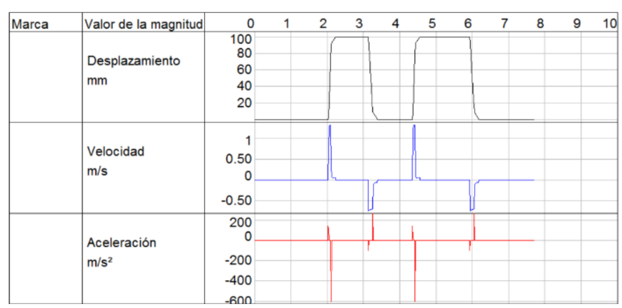


Graph 29. Diagram of fourth circuit without load.

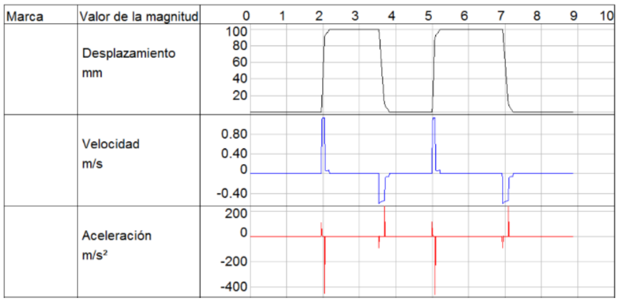


Graph 30. Diagram of fourth circuit with a 10kg load.

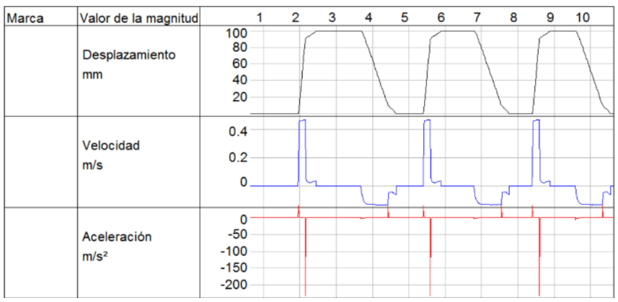
Like the previous case, the 2 graphs show a reduction in the acceleration of displacement thanks to the reduction of pressure that reaches the cylinder. When coupling load, as in the previous cases, the displacement from start to finish is slower, and its speed again remains constant.



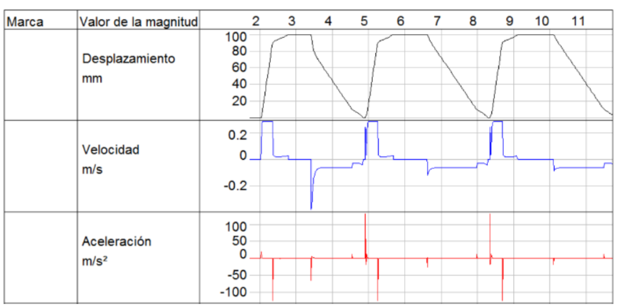
Graph 31. Fourth circuit with valve open 100%



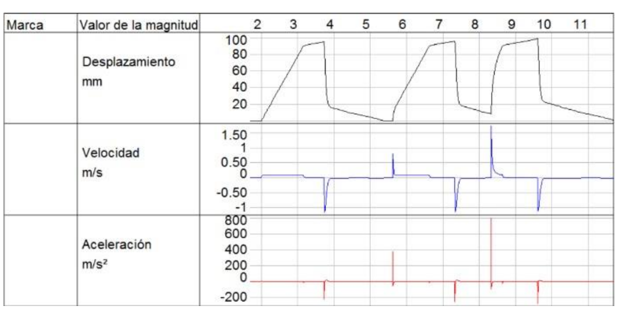
Graph 32. Fourth circuit with valve open 50%



Graph 33. Fourth circuit with valve open 10%.

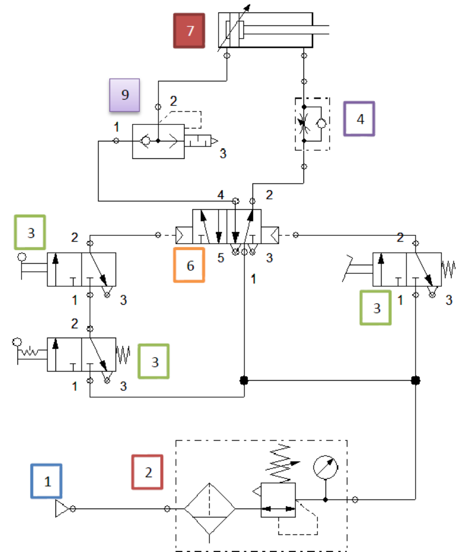


Graph 34. Fourth circuit with valve open 5%.



Graph 35. Fourth circuit with valve open 1%.

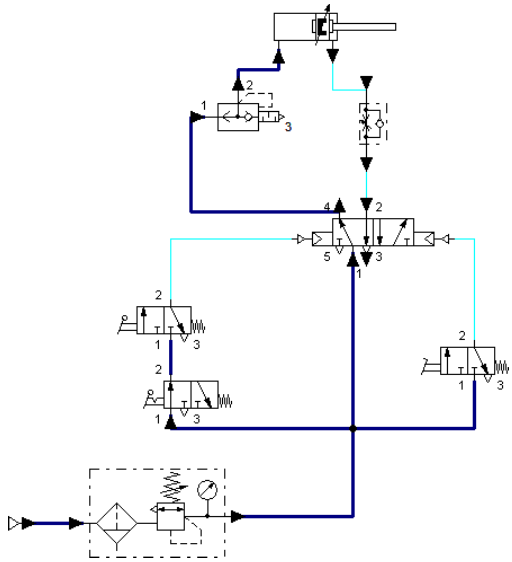
Fifth circuit:



Graph 36. Fifth circuit.

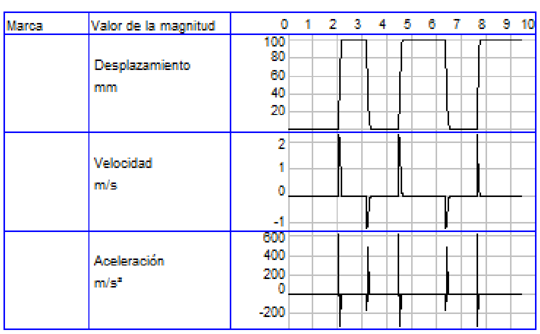
When performing the respective simulation, the following components were used:

- A source of compressed air.
- A pneumatic maintenance unit.
- A manually operated 3/2 valve by spring return interlocking.
- One manually operated 3/2 valve by spring return lever.
- One manually operated 3/2 valve per spring return pedal.
- A 5/2 piloted pneumatic drive valve.
- A fast anti-return exhaust valve.
- An anti-return choke valve.
- A double-acting cylinder with damping.

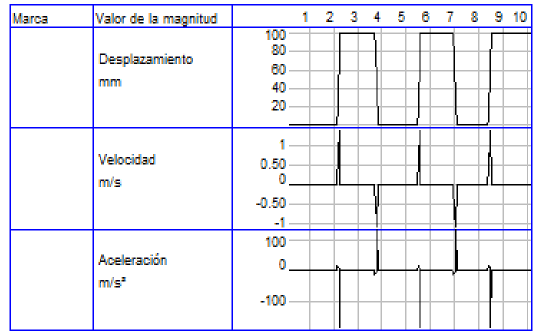


Graph 37. Fifth circuit simulation.

The simulation of the fifth circuit works by activating the interlock valve, causing pressure to pass to the lever valve. When the lever is activated, it shifts the valve 5/2 and the pressure passes to the quick escape valve; when pressure reaches the valve, it takes a while while pushing the plug and then the stem moves forward. When the pedal valve is activated, it shifts the valve 5/2 to the starting position and the pressure flows to the choke valve, where the range of the valve indicates how fast the stem will recede..

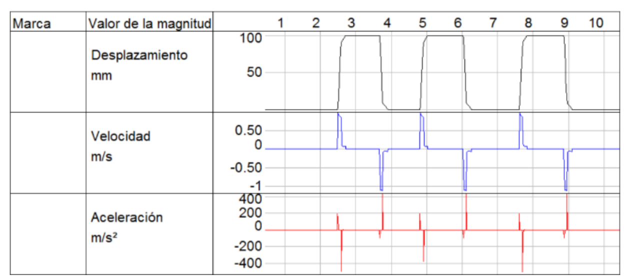


Graph 38. Diagram of fifth circuit without load

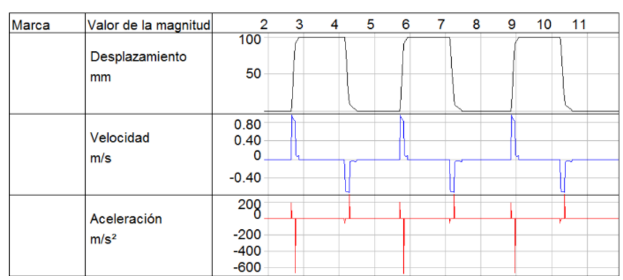


Graph 39. Diagram of fifth circuit with a 10kg load

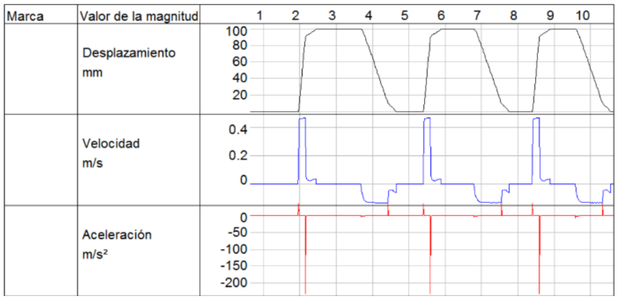
Like the previous cases, in the graphs it is seen how when switching the 2 switches to change position to the valve 5/2, there is a delay in the quick exhaust valve and when pressing the pedal valve, the recoil speed is directly proportional to the degree of opening of the valve. As in all previous cases, the displacement takes longer when coupled with an external load, and both speed and acceleration decrease.



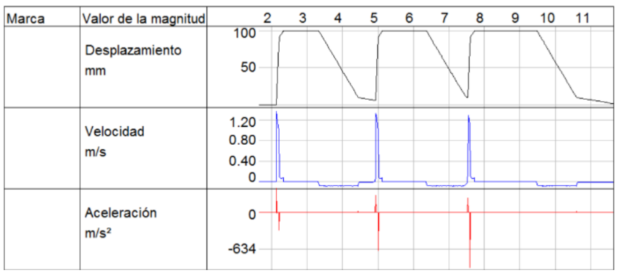
Graph 40. Fifth circuit with valve open 100%



Graph 41. Fifth circuit with valve open 40%



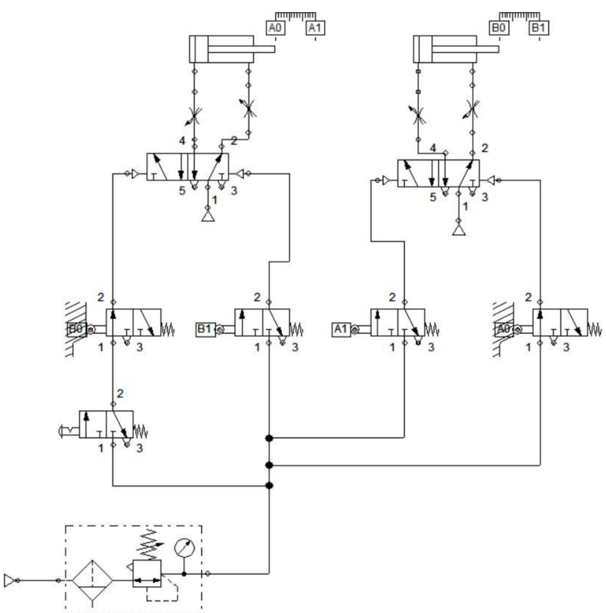
Graph 42. Fifth circuit with valve open 15%



Graph 43. Fifth circuit with valve open 2%

PNEUMATIC ASSEMBLIES:

First assembly:



Graph 44. First assembly.

The sequence has no interference, so the valve actuations will be by the valves of limit switch. The sequence is as follows:

$$A^{+}B^{+}A^{-}B^{-}$$

A^{+} is activated by the limit switch of B in reverse. Phase B^{+} is activated by the limit switch of A in advance. A^{-} is activated by the limit switch of B in advance, and the phase of B^{-} is activated by the limit switch of A in reverse.

Second assembly:

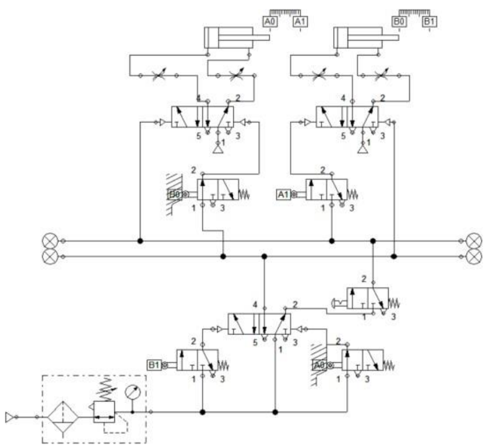
This sequence has interference. The sequence is:

$$A^{+}B^{+}B^{-}A^{-}$$

The cylinder valve A for forward is activated by the limit switch of A in reverse, and the drive for recoil is controlled by the limit switch of B in reverse. The two limit switch will be activated at the same time so that the valve of cylinder A will not change states.

If the above problem is solved, there would still be interference in the valve of cylinder B. The forward drive is controlled by the limit switch of A in advance, and the recoil is triggered with the limit switch of B in advance. Again, the two stroke ends are activated at the same time, so the valve of cylinder B will not change states.

A solution method is called the cascade method, and its name is due to the use of cascade 5/2 valves to change the phases while making the feed independent of the drives. By making the drives independent, there will no longer be two drives that are activated at the same time, because the end of the stroke changes state, but they will not have pressure.



Graph 45. Second assembly using cascade method.

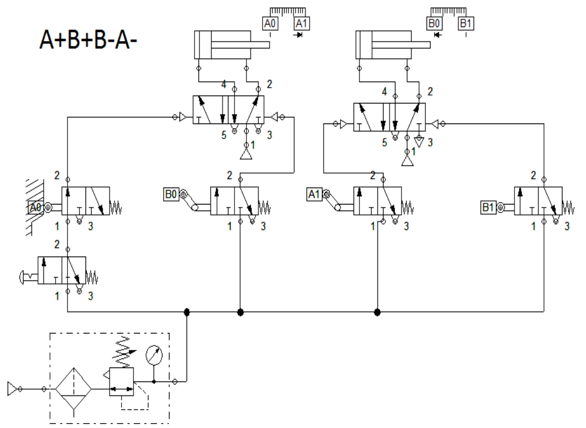
The method consists of separating the sequence into groups, and the divisions are made in the part of the sequence where the interferences are, and will always be in the interferences when there are two different phases in a row, but of the same cylinder. For this case the division of the sequence would be as follows:

$$A^{+}B^{+}/B^{-}A^{-}/$$

Each group will be controlled by a pressure line. The pressure lines will alternate between them receiving pressure by 5/2 valves placed in cascade. The drives of the starting phases of the groups will be connected directly to the group line, ensuring that as soon as the pressure line receives air, the first phase of the group begins. The internal phases will be activated by the corresponding limit switch of the previous phase, but the power or pressure they receive will be connected to the pressure line. The 5/2 valves that alternate the groups will change states by the limit switch of the last phases, so depending on the number of pressure lines that are used, that same number minus 1 will be needed.

For the sequence, the A^{+} phase starts the first group, so the actuation of the A valve in advance will be connected to the pressure line of the first group. Then B^{+} is the internal phase of the first group, so it will be activated by the corresponding limit switch, the limit switch of A in advance. B^{+} is the final phase of the first group, so its limit switch will trigger the next group, that is, the limit switch of B in advance will change state to the valve 5/2 that alternates the groups. The second group has the same analysis as the first.

Another possible method is the use of valves with folding limit switches. It consists of a limit switch that is triggered for a moment because it is placed a little further away from the end of the stem course. But when running it can be activated twice: in advance and in reverses. For this, the drives have a mechanical structure that allows activation in only one direction.



Graph 46. Second assembly using cascade method.

To know which of the drives at the limit switch have to be foldable, you have to analyze which of the drives occurs first. For the cylinder valve A, the limit switch is activated first, so that will be a folding drive. For the cylinder B valve, the limit switch is activated first is that of the cylinder A in advance. The limit switch are connected in the same way as if there were no interference, each limit switch corresponding to the actuation of the phases.

12. ANALYSIS OF RESULTS:

It can be evidenced in the implemented assemblies how various drawbacks can occur when you have contiguous groups with repeated letters in which these interruptions can be eliminated through the methods used such as the waterfall or folding end of the race. In the case of folding, these inconveniences are eliminated because they are only activated for an instant in a direction of movement of the stem, being input or output-

13. CONCLUSIONS:

If the sequence presents a large number of groups, it is not appropriate to use the step-by-step or cascade method to perform this sequence because a high number of components would be required to perform it, which would imply an increase in both costs and efficiency of the system.

Pneumatic actuators have an important application within industrial automation, due to their speed and strength. Pneumatic systems allow to generate solutions with a moderate expense and with a much greater use than other systems in various applications.

For each application, it must be analyzed and decided what type of actuator is the most appropriate to implement according to consumption, efficiency, costs and other factors of great importance to the company.

The organization in the pneumatic dashboard will allow a better visualization of what is being done and will allow to find more easily errors that have been had in the connections.

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