DMX 4410 – Electrical & Pneumatic Machines

Sortation conveyor machine

Mini Project

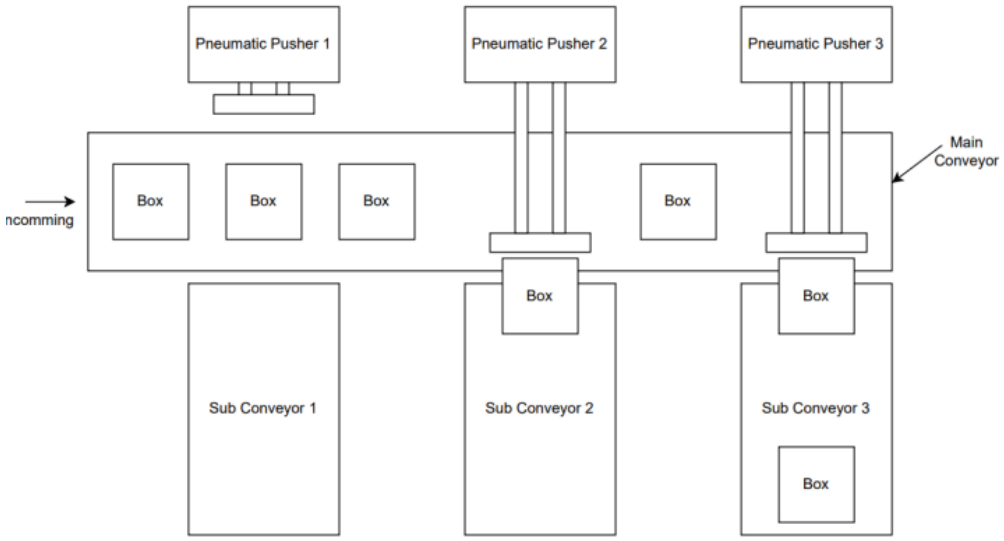
Name: Kenuka Vindinu De Costa

Academic year: 2021/2022

Registration number: 621654910

Date of submission: 22/12/2023

Overall solution as a system



The sortation conveyor system is an automation system designed to efficiently sort boxes based on their heights. The system consists of a main conveyor that transports the boxes and three sub conveyors to receive the sorted boxes from the main conveyor. Three pneumatic pushers move the boxes from the main conveyor to the sub conveyor. Proximity sensors are also used to detect the height and position of the boxes. And a relay-based control system to coordinate and command the operations of the conveyors, pushers, and the sensors. A top view of the sortation conveyor system is shown in the above figure.

The main inputs and outputs of the conveyor system are as follows.

1. Inputs

    - Boxes - (Large, medium, small) are randomly placed by a robotic manipulator.
    - Height information – Captured by three capacitive proximity sensors for each box on the main conveyor.
    - Position of the pusher piston rod - Captured by two magnetic proximity sensors fixed at starting and ending positions of the rod.

- Position of the box in sub conveyor – Captured by optical sensors to determine whether the object has reached its destination.

2. Outputs

    - Main conveyor control – Signals to stop the main conveyor when the box reaches the sorting station.
    - Pneumatic pushers – Pushes the boxes to the sub conveyors according to the received commands.
    - Sub conveyor controls - signals to start the sub conveyors when a box enters the sub conveyor and stop the sub conveyor when the box reaches its destination.

Description of the components selected for the sortation conveyor system.

1. A main conveyor belt - to transport the boxes thorough the conveyor system until it is moved to its necessary sub conveyor.

2. Three sub conveyor belts - To transport the boxes that are sorted to their sub path until their destination.

3. Four 3-phase squirrel cage induction motors for each conveyor - To rotate the conveyor belts so that the boxes can be transported from one location to another. Here the induction motors are connected in the star configuration so that the starting current and the stress on the motor winding can be reduced.

4. Relays - To achieve the necessary controls over the system to sort the boxes according to their sizes.

5. Three capacitive proximity sensors- To detect the height of the boxes traveling on the main conveyor belt and send signals to the controlling unit for it to take the necessary action in sorting the boxes.

6. Three magnetic proximity sensors – To detect the position of the pusher rods and send signal to the controlling unit for it to take the necessary action in sorting the boxes.

7. Three optical sensors – To detect the presence of the box when it reaches its destination so that a signal could be sent to the controlling unit to stop the necessary sub conveyor.

8. Compressor – To supply compressed air to the pneumatic pushes to push the boxes to its sub conveyors.

9. Air service unit – To filter (remove water vapor, dust, and oil particles) and lubricate the compressed air.

10. Selector switch/valve (2-way directional control pneumatic valve) – To allow or stop the flow of compressed air to the system.

11. One way flow control valve – To control the flow rate of air in one direction and allows free flow in other direction. This is used so that we can control the speed of the pneumatic pushers as required.

12. Quick exhaust valve – For rapid exhaust of compressed air from the system so that a quick return of the pneumatic pusher could be obtained. This is obtained by reducing the distance and the resistance for exhaust air to escape.

13. 4-way directional control valve – To operate the double acting cylinder by switching the flow of compressed air.

14. Double acting cylinder with two piston rods – To push the boxes by using compressed air.

Constraints and assumptions.

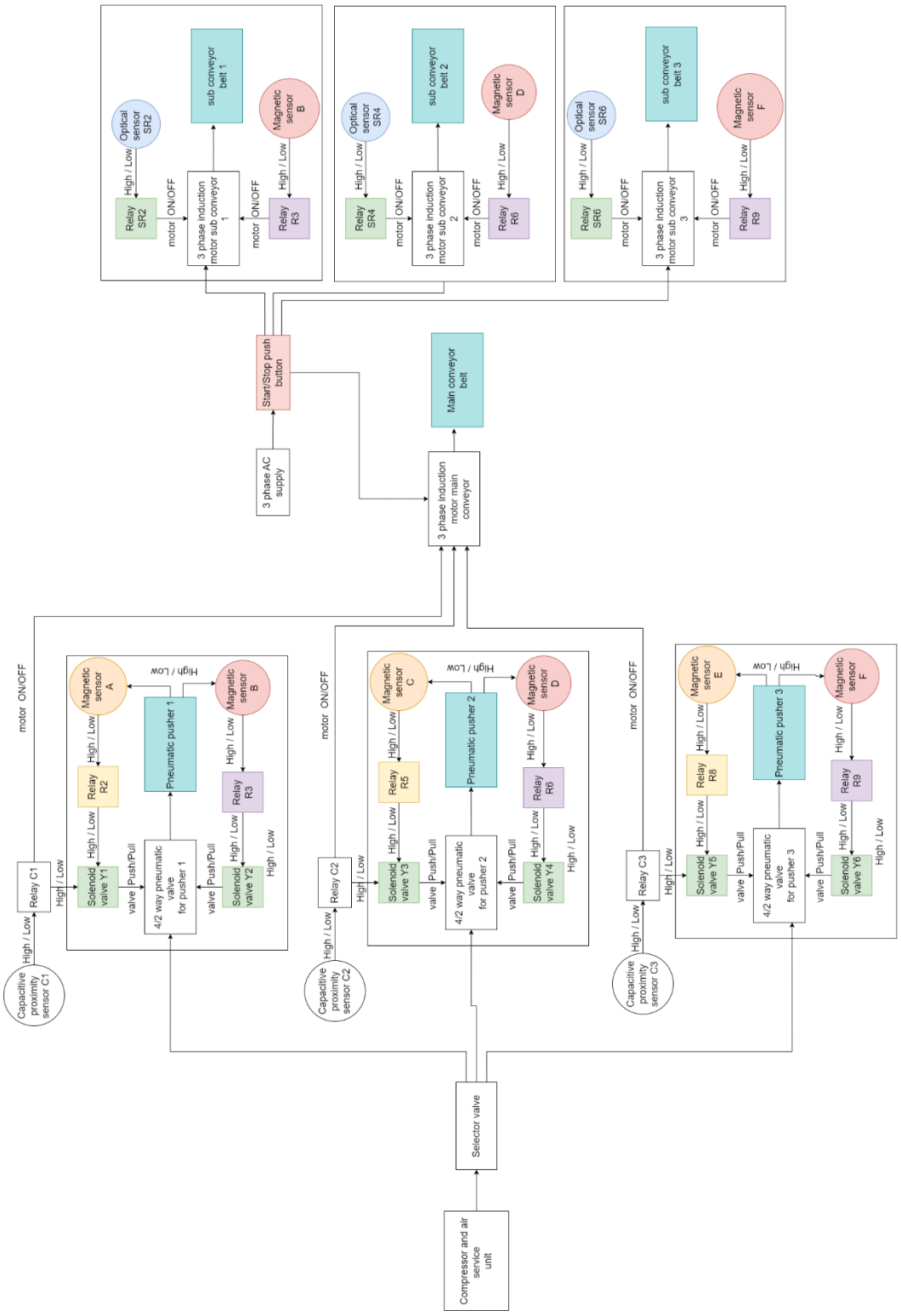
Some of the constraints or restrictions that affect the design, operation or performance of the system are.

- The size, weight and shape of the boxes can be sorted by the system.
- The speed, accuracy, and reliability of the sorting process.
- The cost, availability and compatibility of the valves and the cylinder.
- The sensing range and accuracy of the sensors.

Some of the assumptions when designing the system.

- The boxes are randomly placed on the main conveyor by the robotic manipulator.
- The capacitive sensors can detect the height of the boxes without interference from metal or other materials.
- The pneumatic pusher can move the boxes from the main conveyor to the sub conveyor without damage or slippage.
- The controller can coordinate the operation of the conveyors, the pushers and the sensors without errors or delays.

Block diagram of the sortation conveyor system



Pneumatics and electrical design

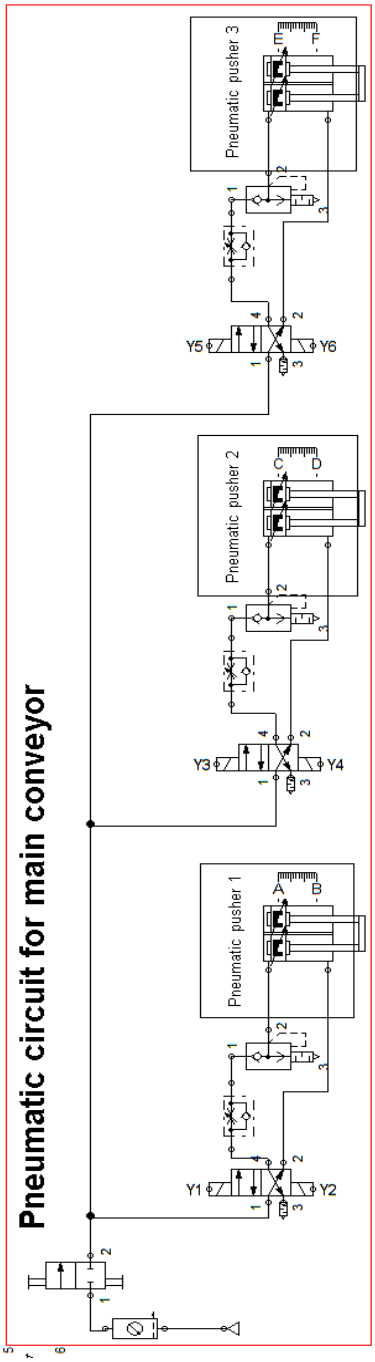


Figure 1 - pneumatic design of the sortation conveyor system

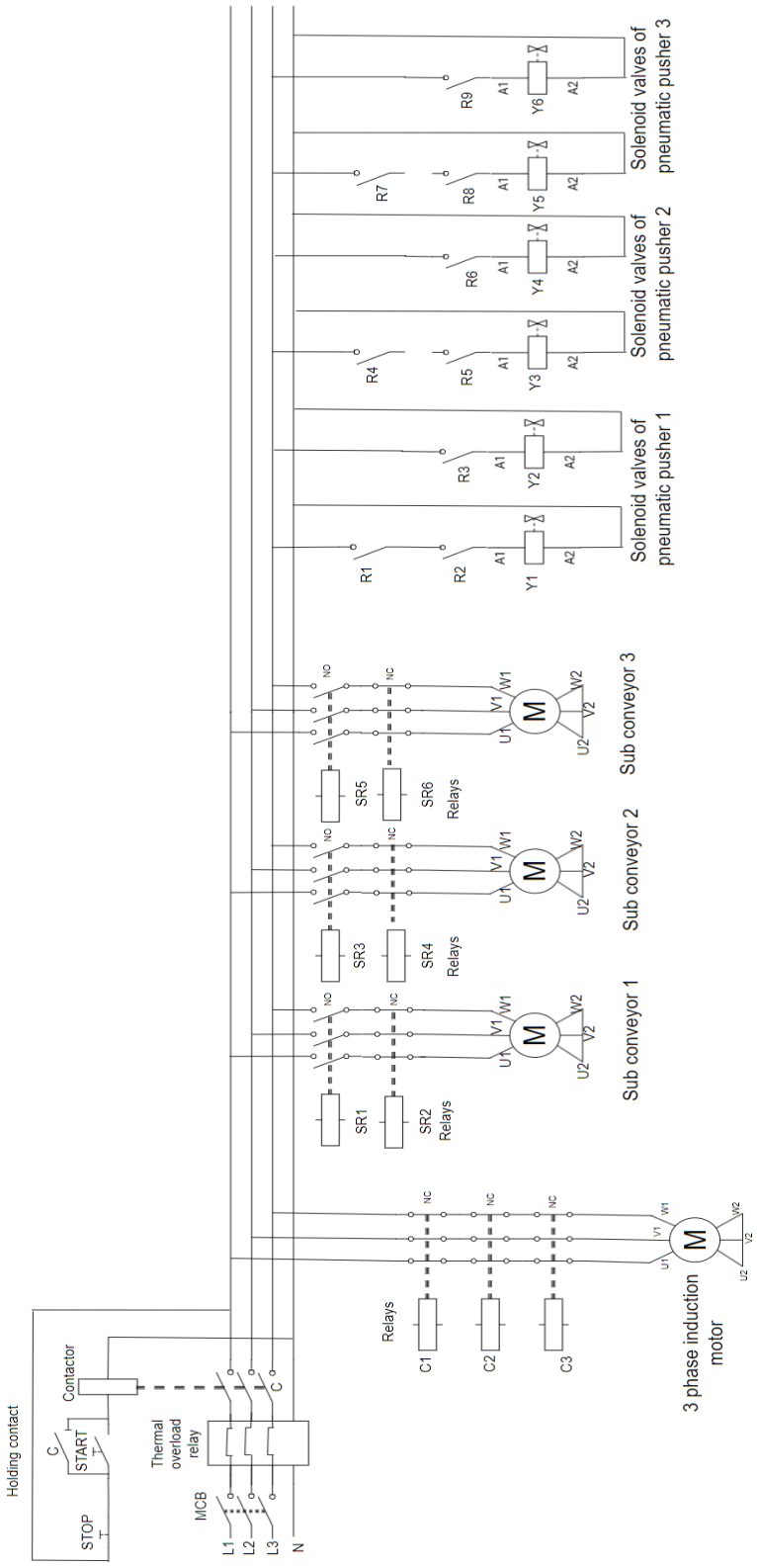


Figure 2 - Electrical design of the sortation conveyor system

Simulation process using FESTO fluid Sim.

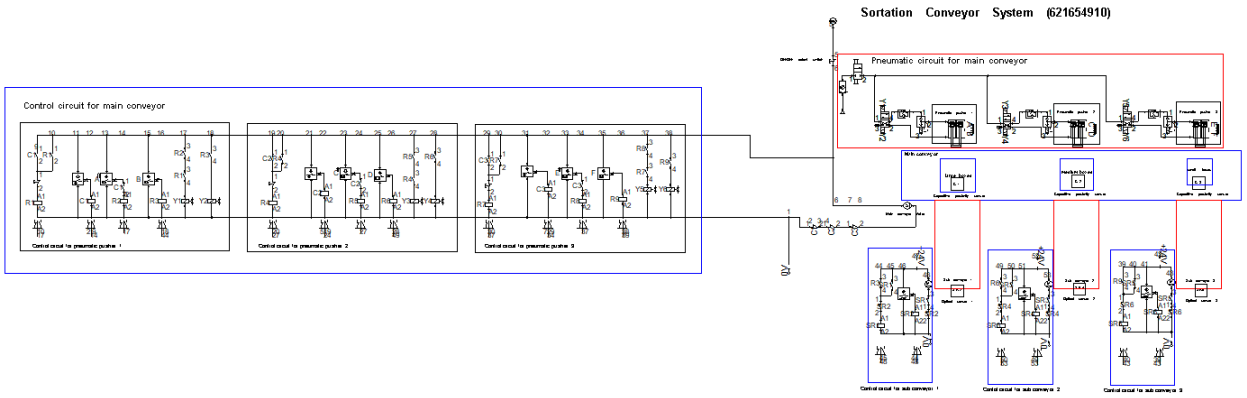


Figure 3- sortation conveyor system FESTO fluid sim design

- When the conveyor system is turned on using the ON/OFF detent switch the main conveyor motor starts to run, thus the conveyor belt moves and then the boxes start to move on the conveyor belt. (See figure 3 and 4).

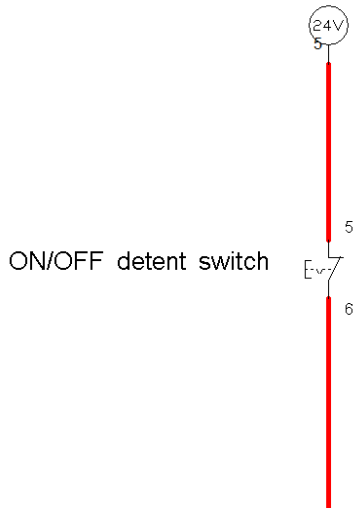


Figure 4 - ON/OFF detent switch

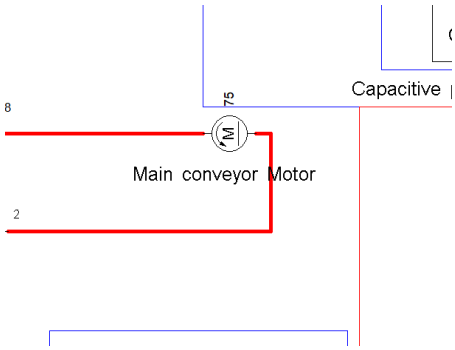


Figure 5- main conveyor motor

- And when the flow control valve is pushed the air pressure is allowed to flow from the air service unit and the pressurized air goes through the 4/2-way electro pneumatic valves output 2 and fills inside the double acting cylinders in a way that it pushes the piston and keeps it contracted (see figure 5).

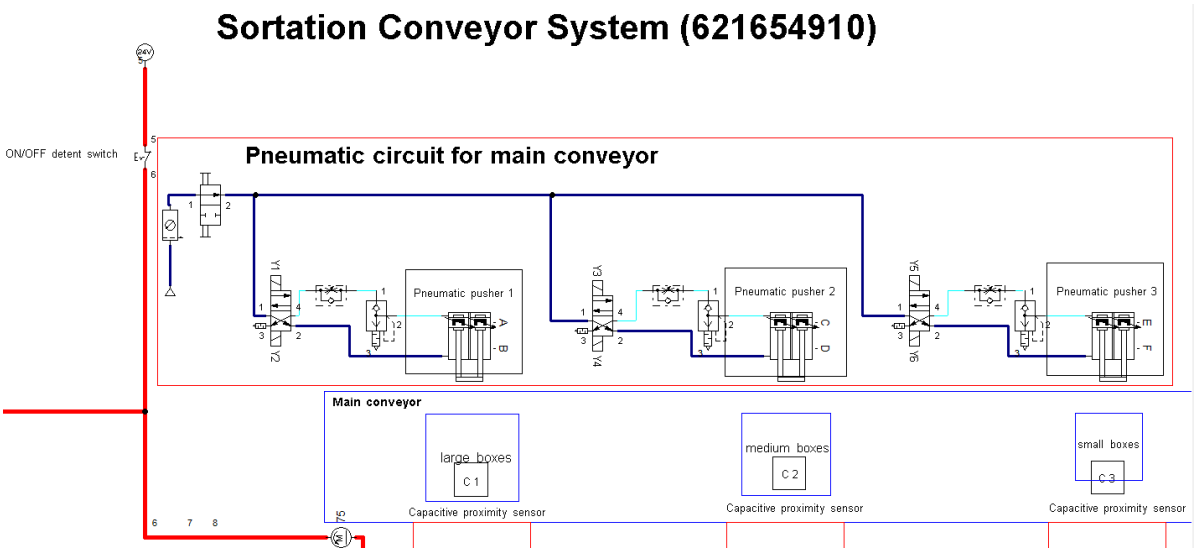


Figure 6 - Simulation of the air passing through the output port 2 of the 4/2-way valve and filling inside the double acting cylinder keeping the piston contracted.

- Consider a situation when a large box is conveying on the main conveyor belt (see figure 6).

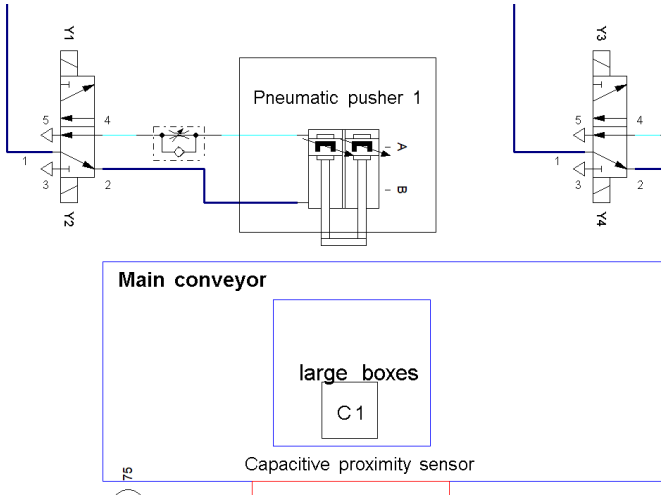


Figure 6 - A situation when a large box is on the conveyor.

- Then the capacitive proximity sensor **C1** will detect the presence of a large box and an active high signal will be generated by the sensor which will then activate the relay **C1** in path 11(see figure 7).

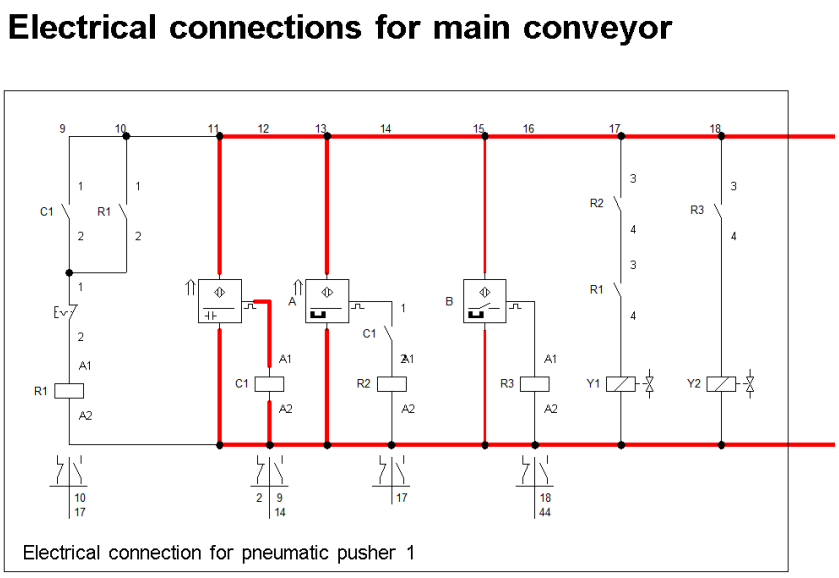


Figure 7 - Simulation of the activation of the proximity sensor C1 and relay C1 in path 11.

- Then the normally open out of the C1 relay will activate the relay R1 in path 9. Also, another normally open out of the C1 relay in path 13 will activate the path of the magnetic proximity sensor A which is connected to the initial or contracted position of the double acting cylinder piston. Note that since the magnetic proximity sensor is fixed to the initial position of the double acting cylinder the sensor would always be active high. With the normally open out of the C1 relay in path13 activates the path the relay R2 also gets activated (see figure 8).

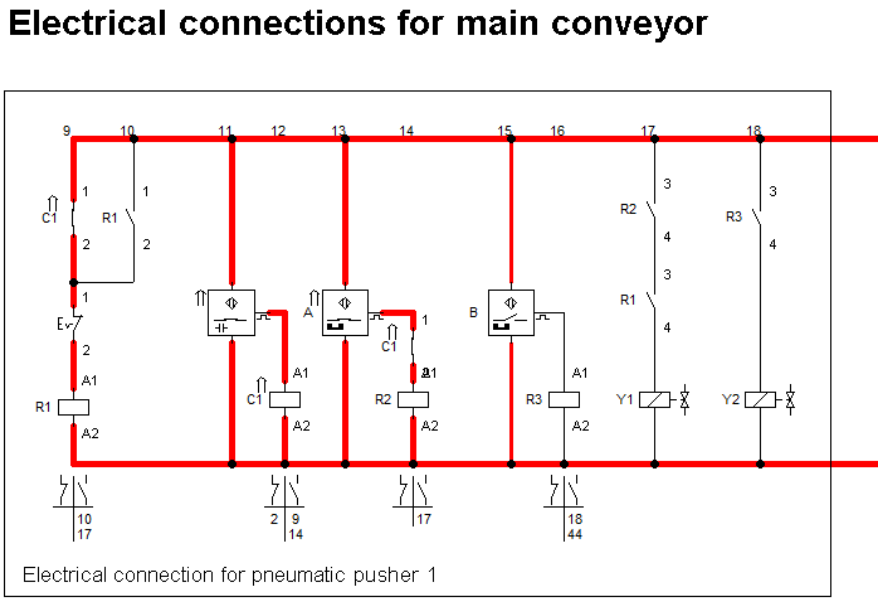


Figure 8 - Simulation process of activation of relays C1 and R2 with the activation of the magnetic proximity sensor at position A

- With this the path 17 will get activated when the normally opened outs of the relay R1 and R2 get activated. Thus, the solenoid valve Y1 gets high pushing the 4/2-way pneumatic valve allowing air to flow through the output port 4 (see figure 9 & 10).

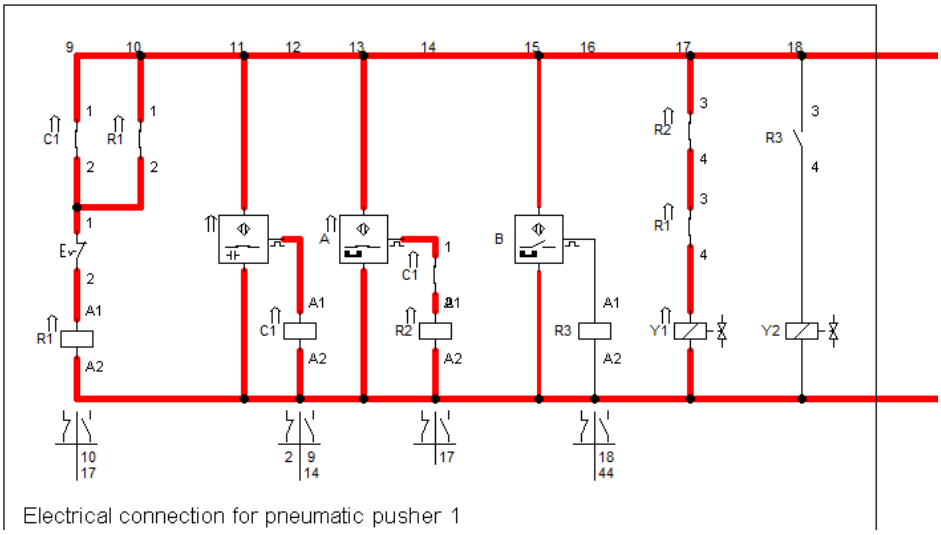


Figure 9 - simulation of the activation of relay 2 and relay 1

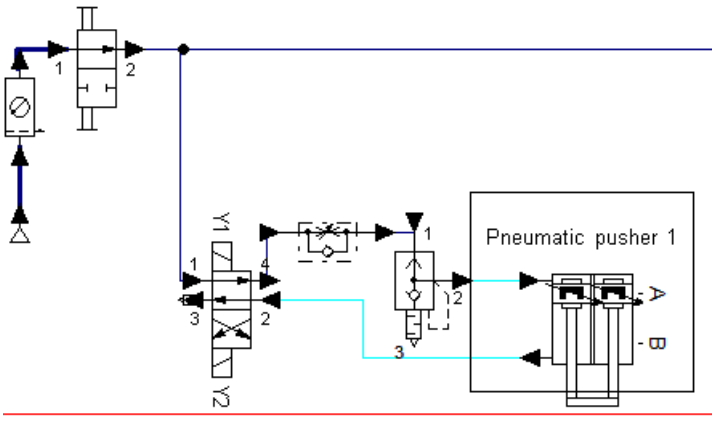


Figure 10 - simulation of the air flowing through the output port 4.

- Also, since the normally closed out of the relay C1 get opened the motor will stop thus the main conveyor will be stopped until the large boxes get pushed to the sub conveyor (see figure 11).

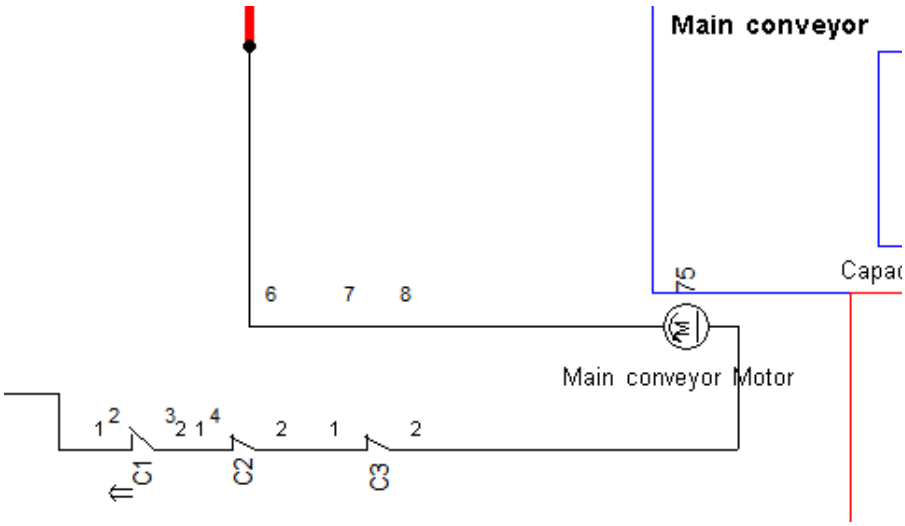


Figure 11- Simulation of the main conveyor motor getting stopped due to normally closed out of the relay C1 being opened.

- Then the pressurized air will push the pistons forward thus pushing the large box to its sub conveyor (see figure 12).

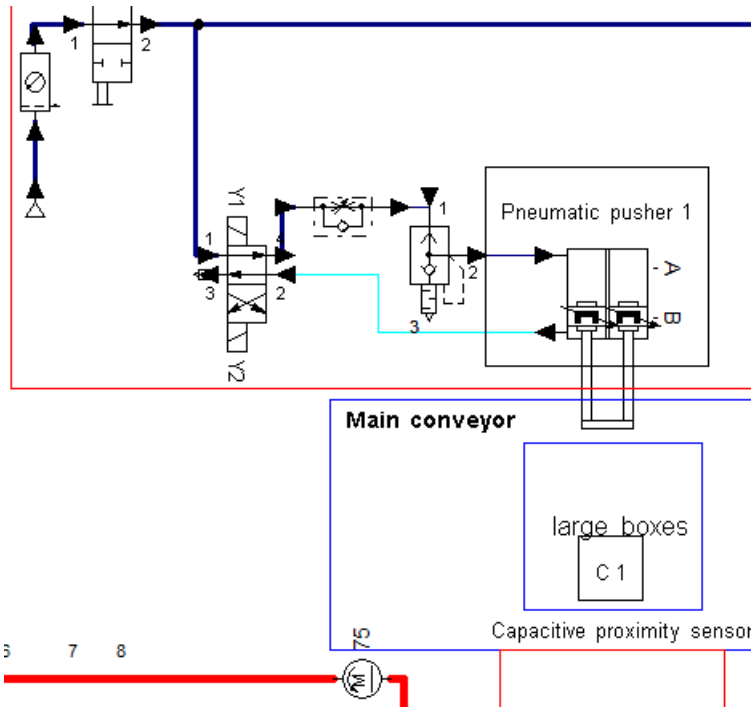


Figure 12- simulation of the pneumatic cylinder being pushed by the air pressure.

- Now when the piston moves to its maximum position, that is B, the magnetic proximity sensor fixed to the end of the cylinder will get active high and activates the relay R3 in path 15. Thus, the normally open output of the R3 relay will close activating path 18 (see figure 13 & 14).

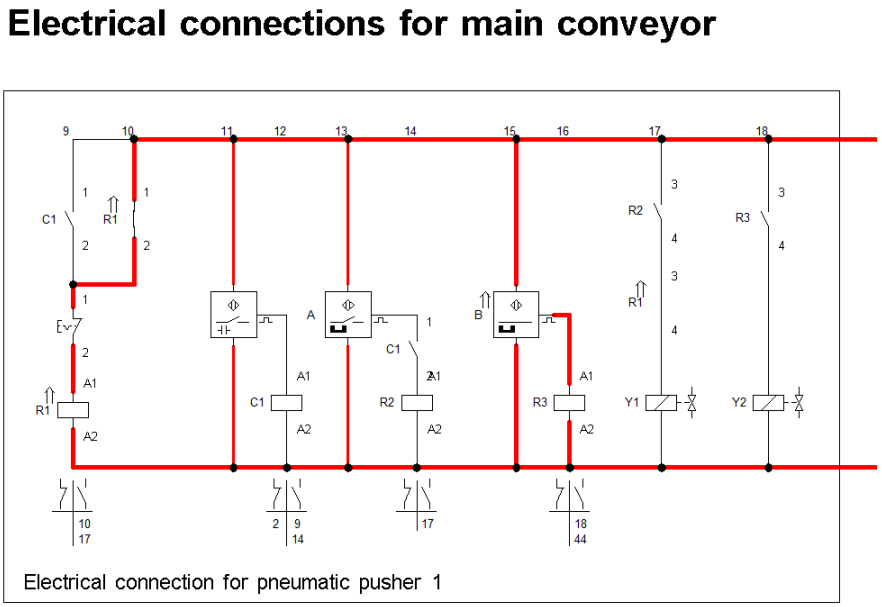


Figure 13 - simulation of the activation of the magnetic proximity sensor at B and the relay R3

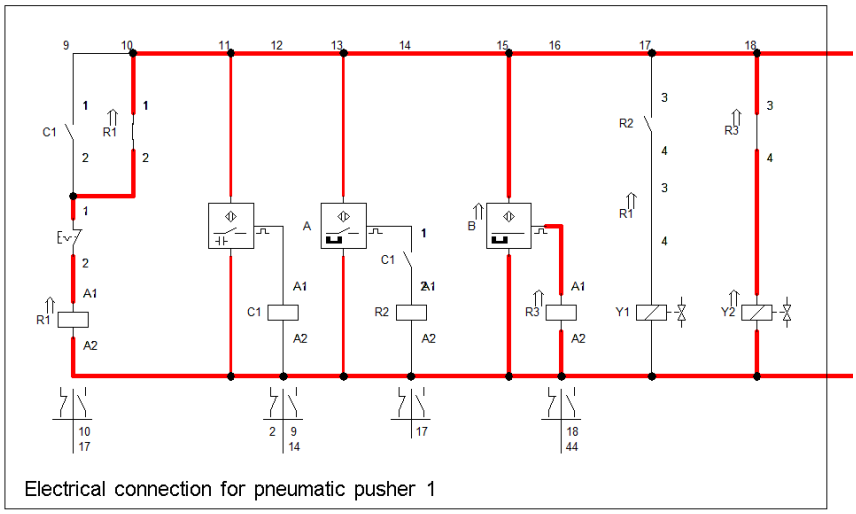


Figure 14 - simulation of the activation of solenoid valve Y3 due to the closing of normally open out of relay R3.

- Then the solenoid valve Y2 gets activated and then pushes the 4/2-way valve to its initial position allowing the air to flow through the output 2 and pushing the cylinder piston to its initial position in a quick backward motion because of the quick exhaust valve.

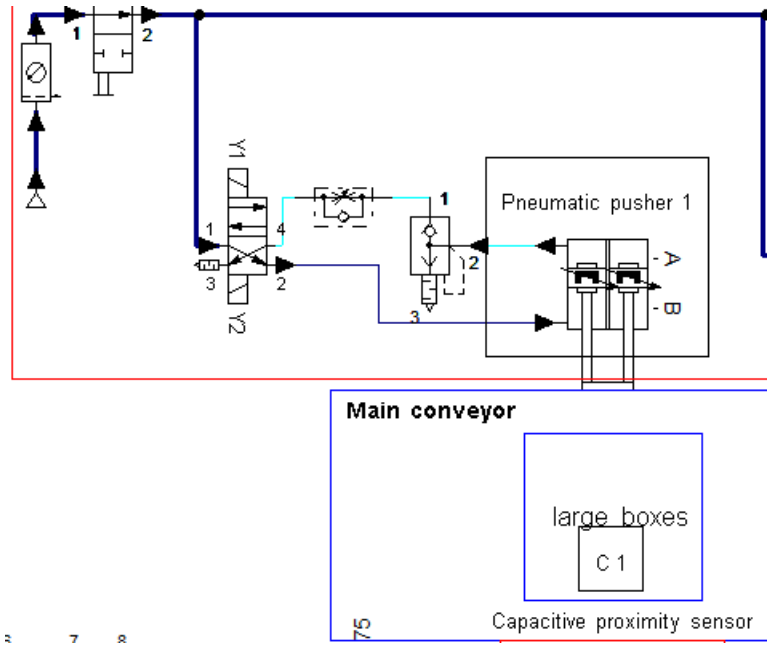
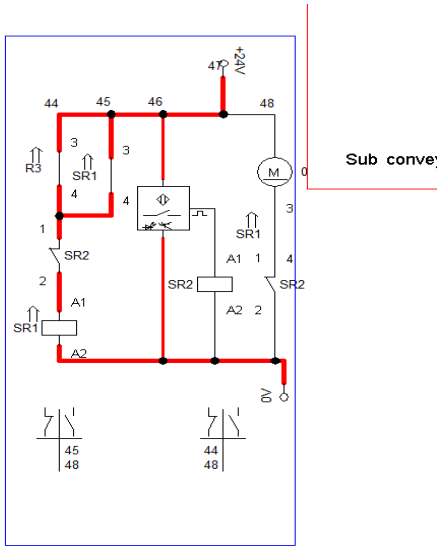
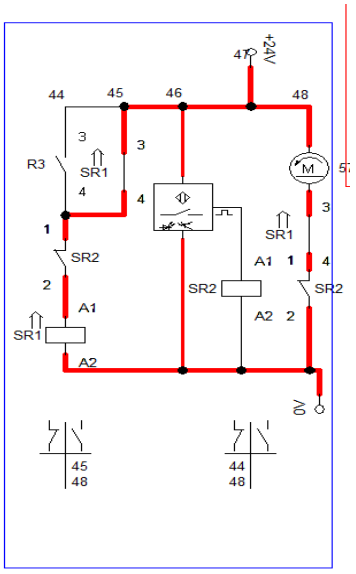


Figure 15- simulation of the pneumatic cylinder being pushed to its initial position by the air pressure.

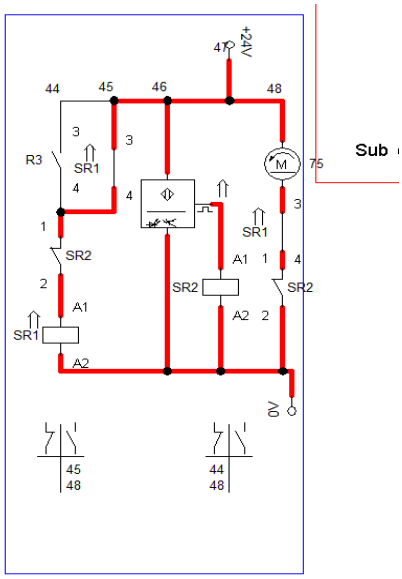
- Meanwhile, since the normally open output of the relay R3 gets activated in the sub conveyor 1 the path 44 will get activated allowing the relay SR1 to be high thus the sub conveyor motor will get on allowing the large box to conveyor through its sub conveyor path until it comes to its destination.



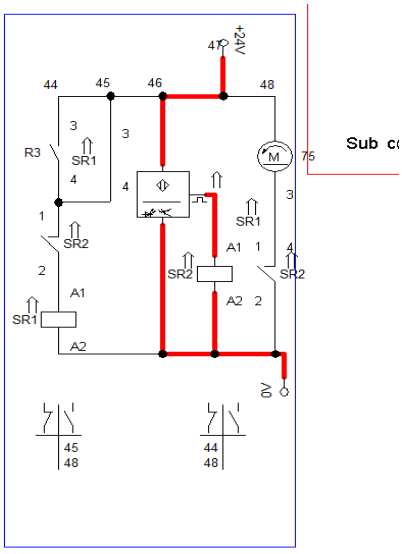
Electrical connection for sub conveyor 1



- Once the large box reaches its destination the optical sensor connected at the end of the sub conveyor will get active high thus activating the relay SR2. Then the normally closed out of the SR2 will be opened and the sub conveyor motor will get off and the sub conveyor will be stopped when the box reaches its destination.



Electrical connection for sub conveyor 1



Electrical connection for sub conveyor 1

- This same process will continue for the other sized boxes allowing a fully automated sortation Conveyor System.