

# Automated Controlling Unit

For A Window Cleaning Robot

By Dave Gabriels And Peter Narbaitz

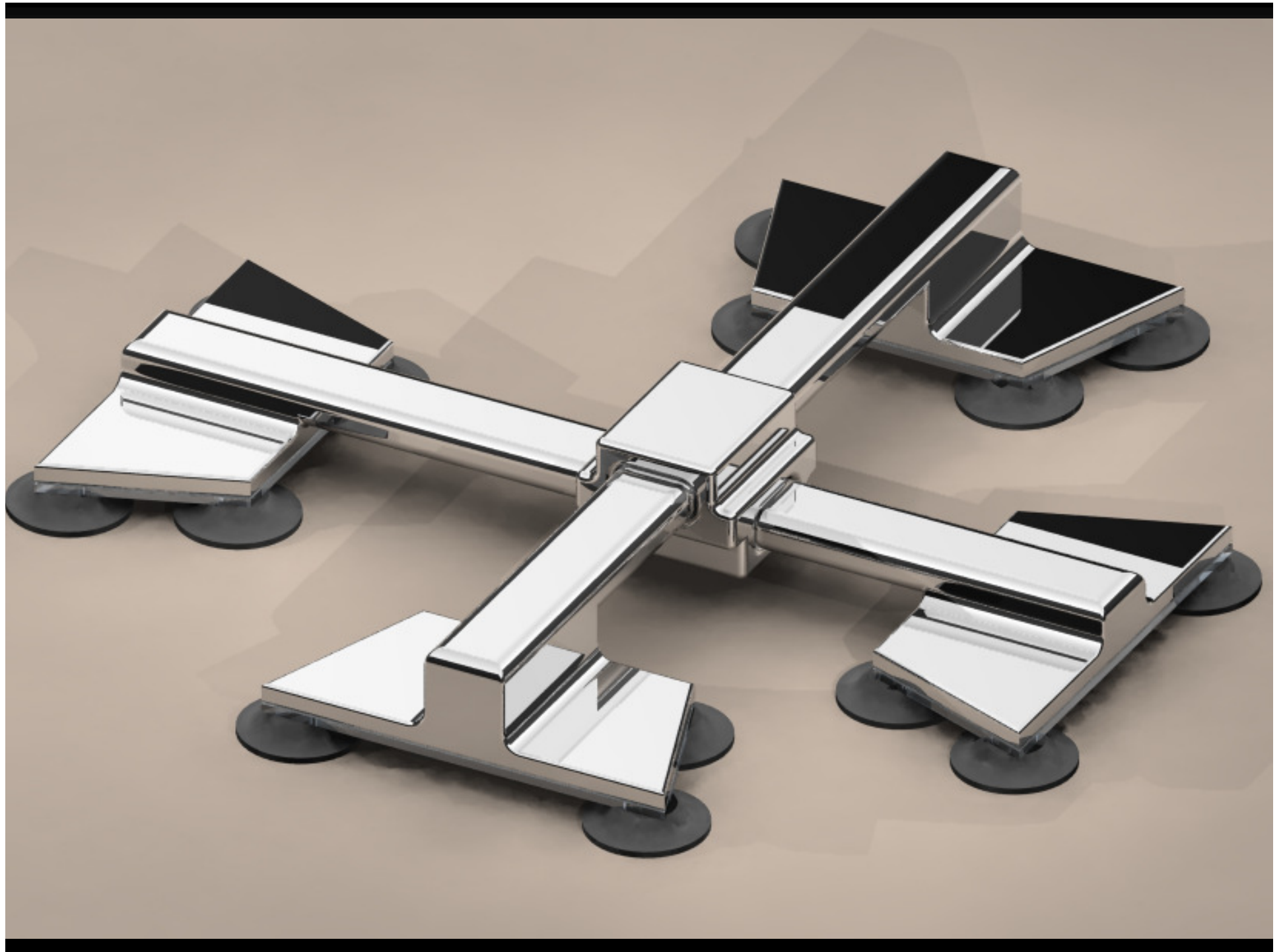
# Original Robot

- ▶ Developed to relieve humans from the hazards of cleaning high-rise building windows

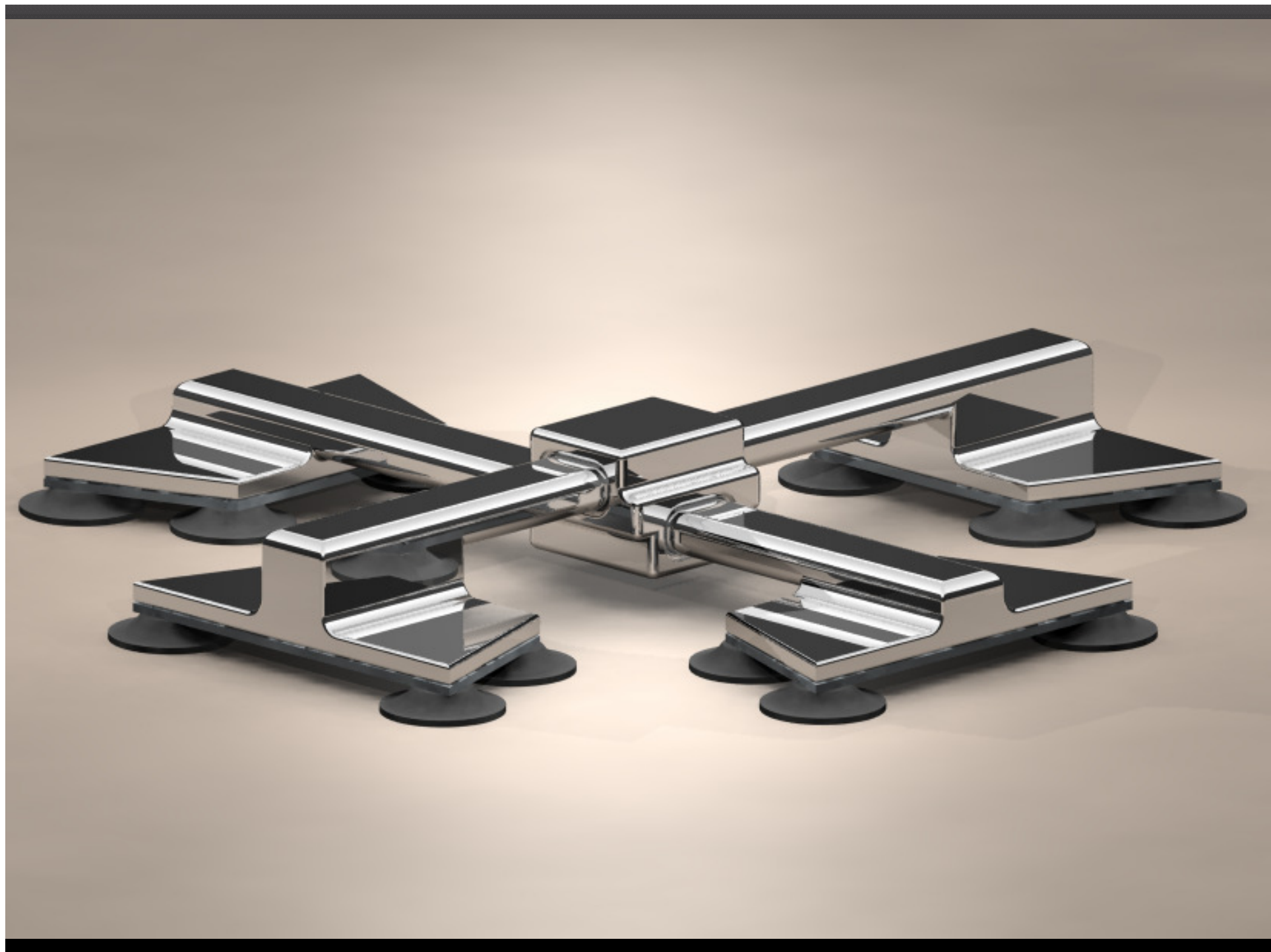


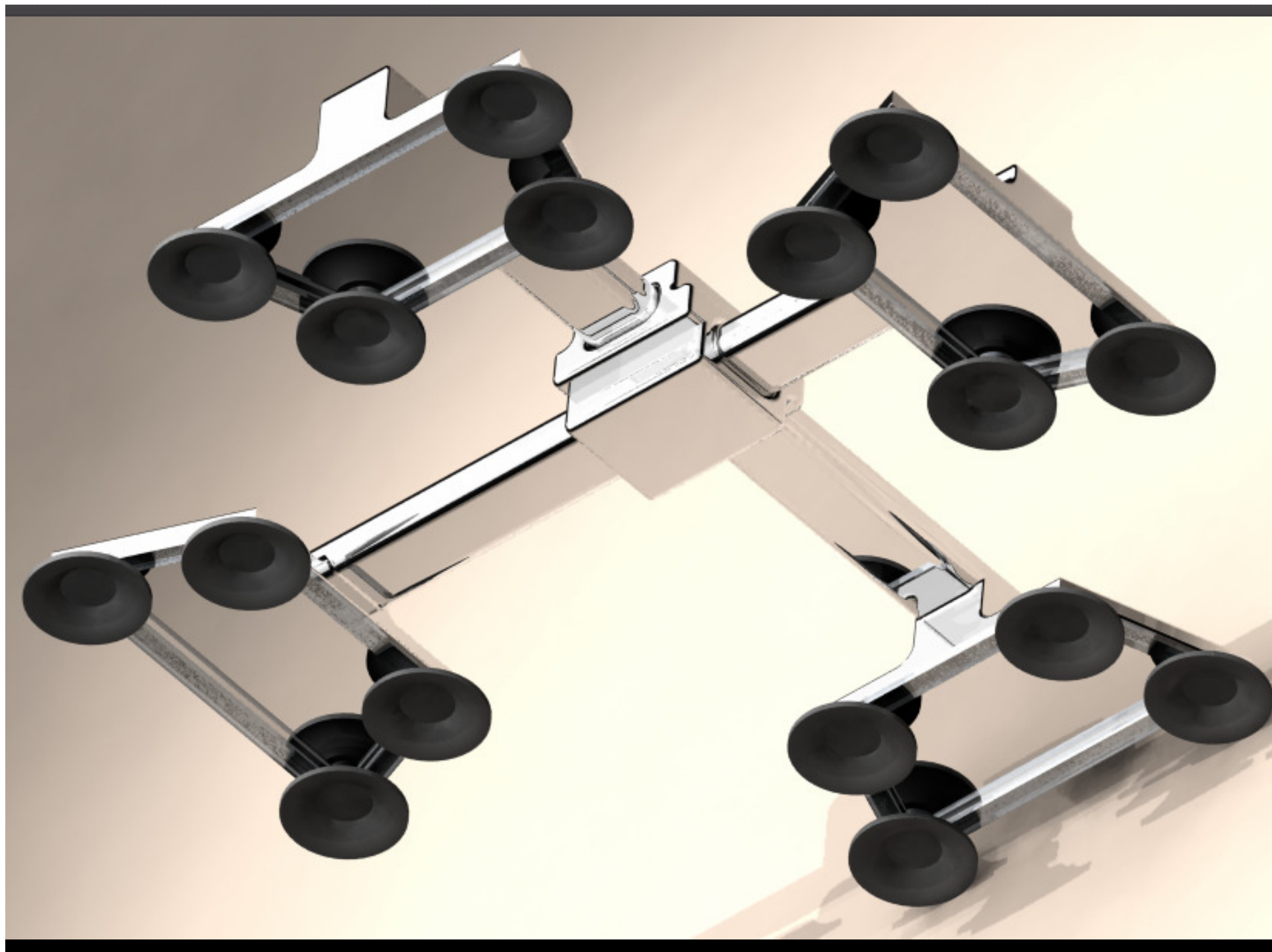
# Original Robot

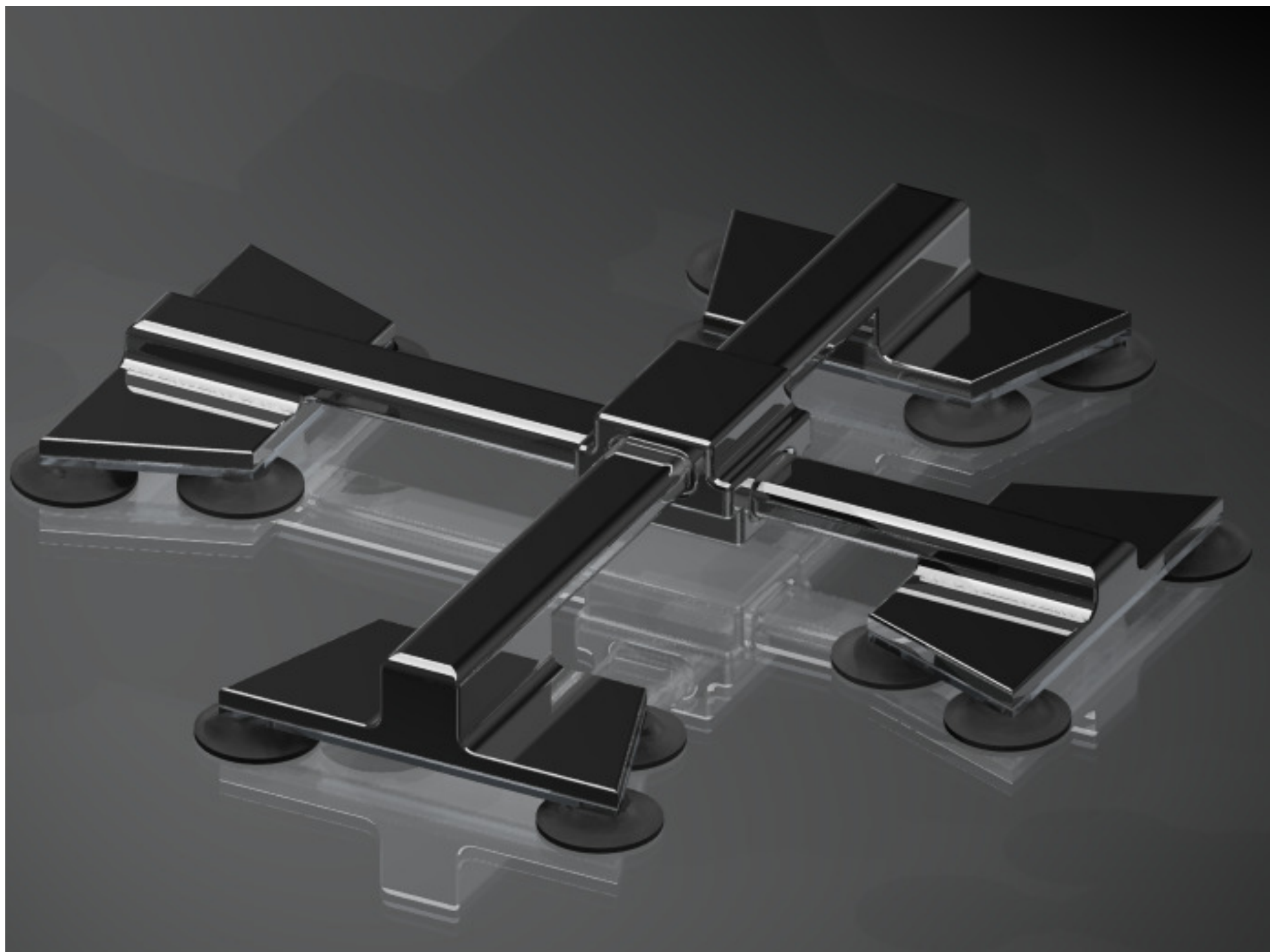
- ▶ Uses 16 vacuum powered suction cups to allow the robot to climb windows
  - ▶ Provides enough suction force to support 15 kg
- ▶ Up and down movements controlled by actuators
  - ▶ By controlling suction and actuators, robot is able to climb window surface
- ▶ Two brushes on either side of horizontal bar are used for cleaning
- ▶ Uses a visual sensor to find its position and destination







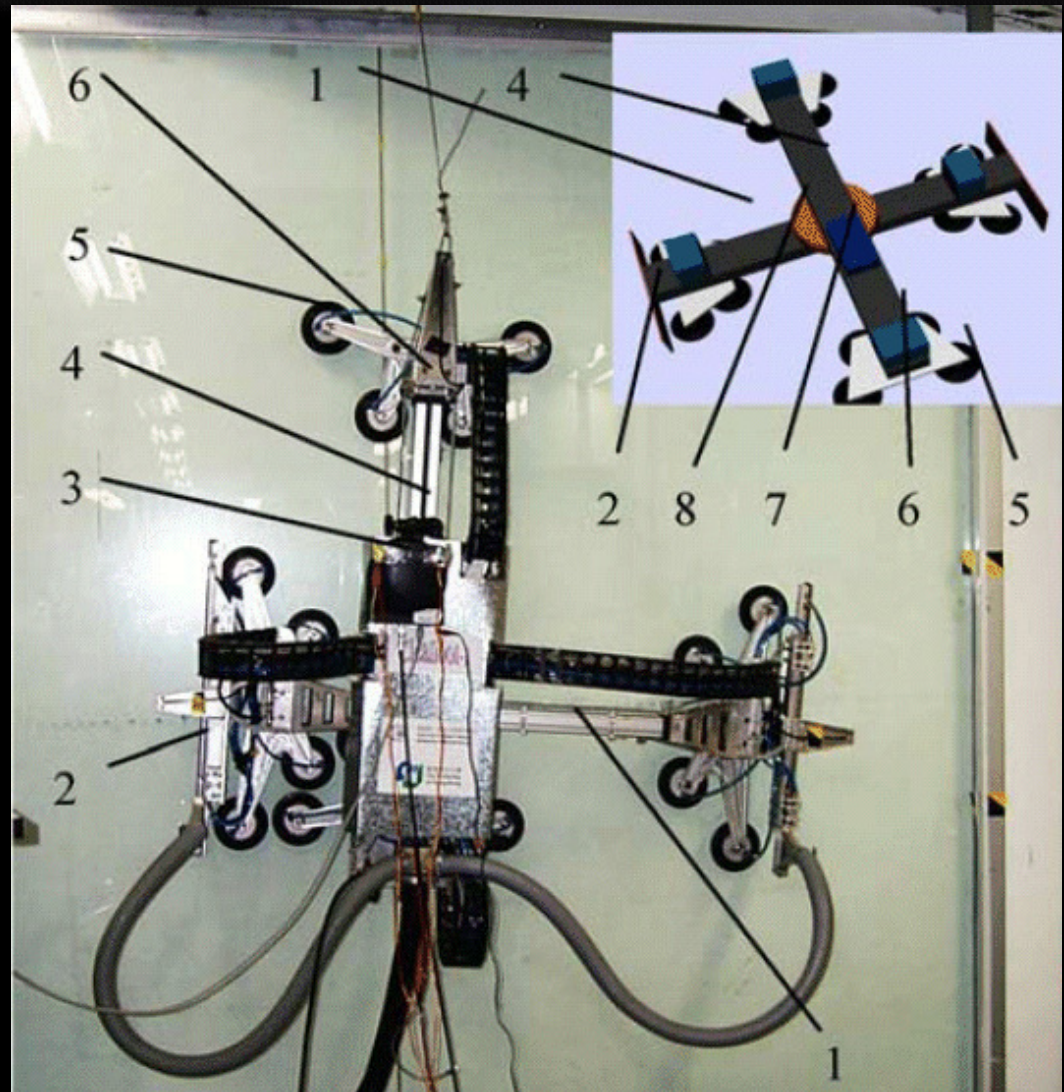






# Working Original Robot

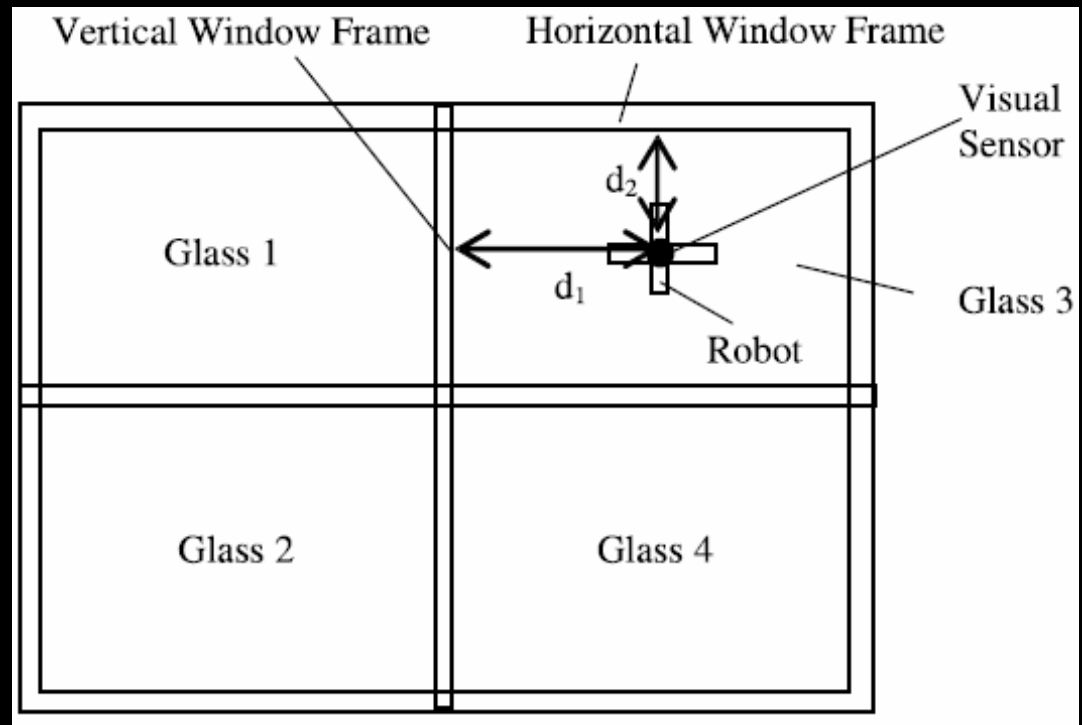
1. Horizontal (X-) Cylinder
2. Brush
3. Visual Sensor
4. Vertical (Y-) Cylinder
5. Suction Cup
6. Z- Cylinder
7. Slave CPU
8. Rotation Cylinder





# Visual Sensor

- ▶ The visual sensor consists of a video camera with 2 laser diodes fixed to it
- ▶ With the data given by these three instruments we can triangulate the robot's position within the window frame



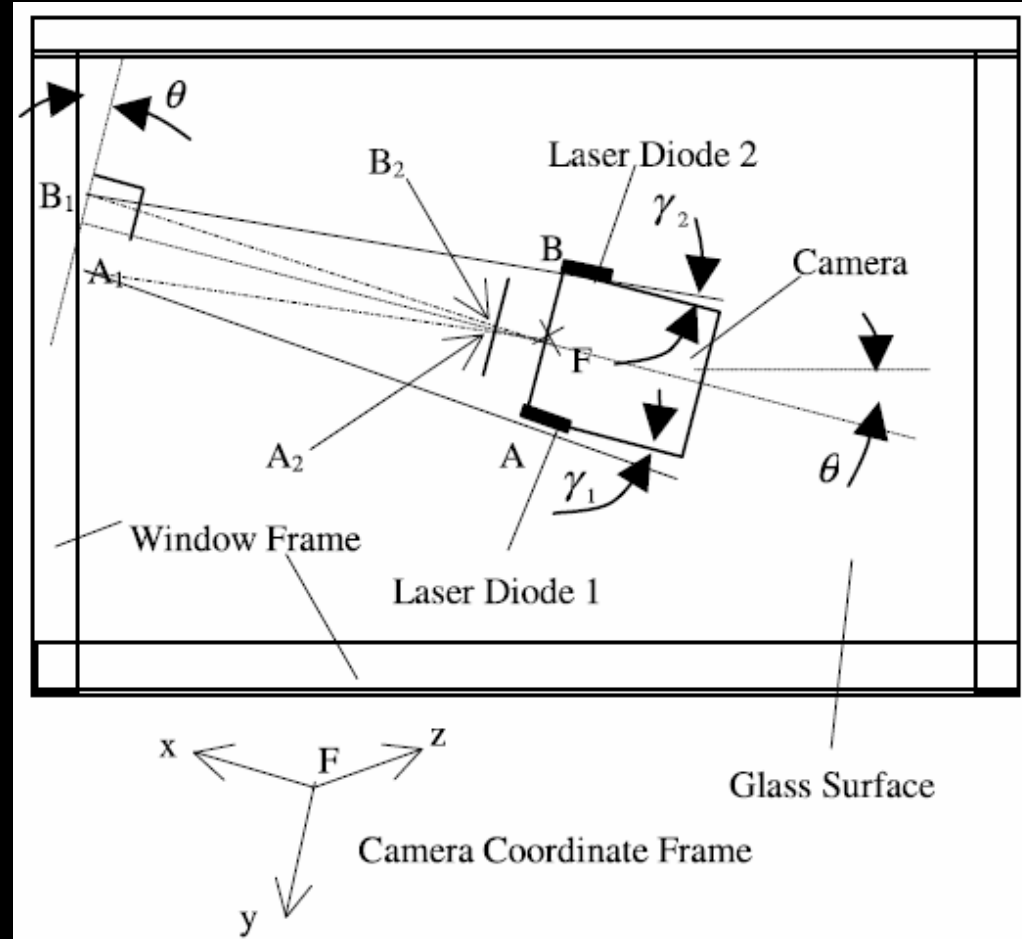
# Orientation Measurement

- ▶ With our knowledge of the geometry of the lasers, the robot is able to determine its position on the window
- ▶ These are the main formulas that are used

$$x_{A1} = \frac{f(y_L - x_L \operatorname{tg} \gamma_1)}{d_x(u_0 - u_L) - f \operatorname{tg} \gamma_1}$$

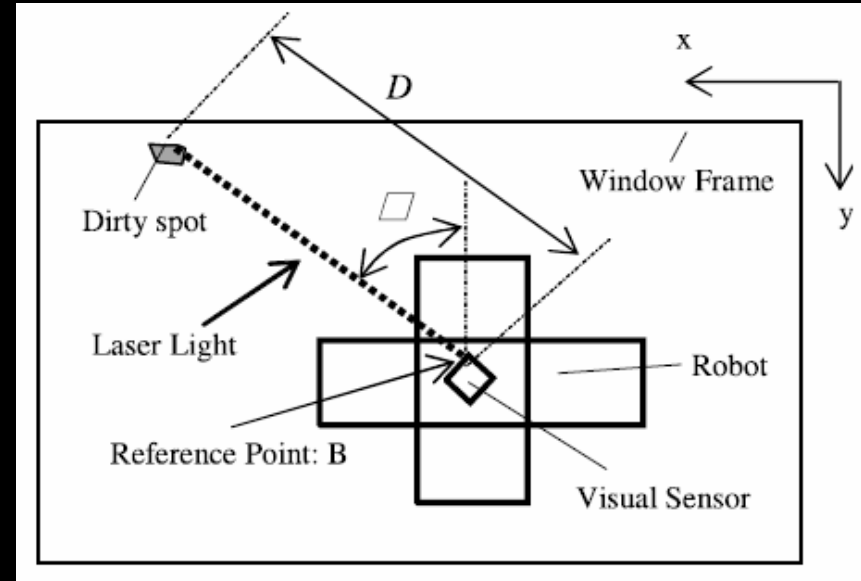
$$y_{A1} = \frac{d_x(u_0 - u_L)(y_L - x_L \operatorname{tg} \gamma_1)}{d_x(u_0 - u_L) - f \operatorname{tg} \gamma_1}$$

$$\theta = \operatorname{arctg} \left( \frac{x_{B1} - x_{A1}}{y_{B1} - y_{A1}} \right)$$



# Locating The Dirty Spot

- ▶ Dirty spots on the window are located visually by an operator looking through the robots camera
- ▶ The robot will then automatically travel to these spots and clean them



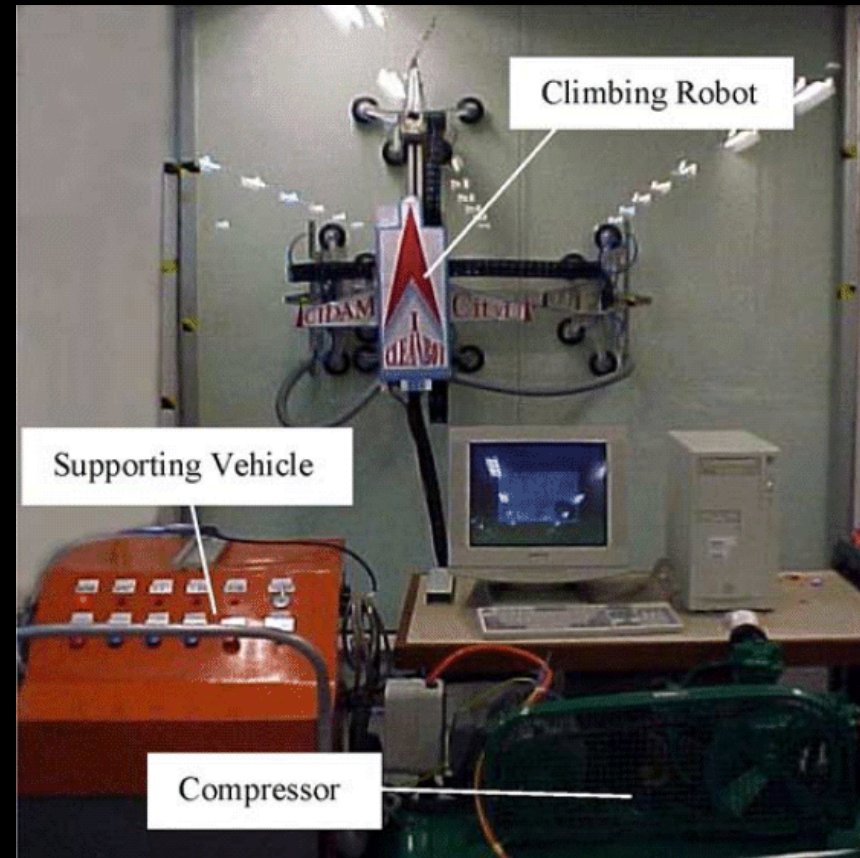
# Movement of Robot

- ▶ [Movement Demo](#)
- ▶ Able to rotate  $1.6^{\circ}$  per step
- ▶ Able to step over small window ledges using Z-axis actuator



# Robot and Support System

- ▶ The robot has the following tubes running back to the ground
  - ▶ Vacuum tubes
  - ▶ A cleaning fluid tube
  - ▶ A sewage tube



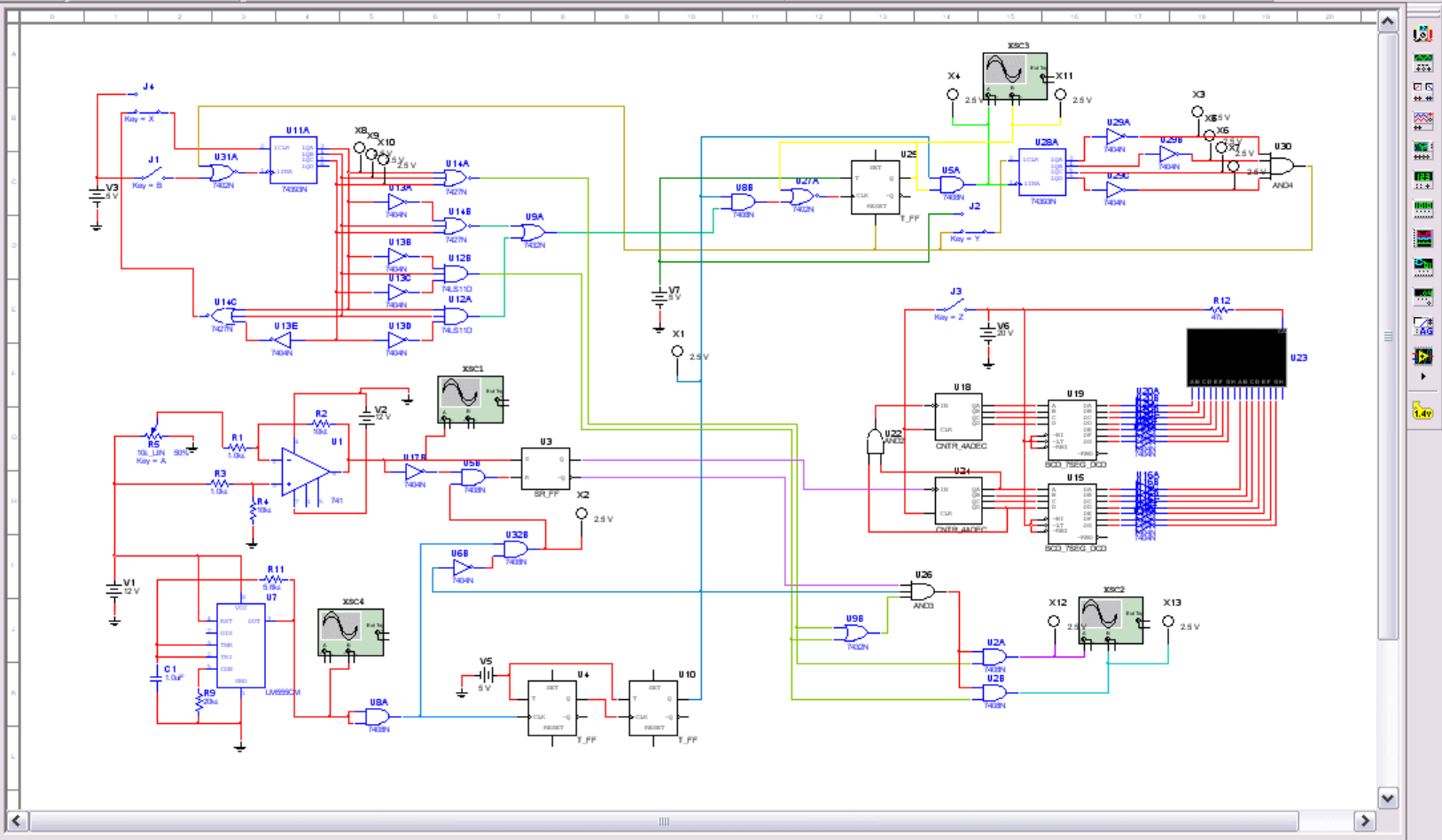
# Project Focus

- ▶ To improve the design by developing an automated controlling unit for robot which would eliminate the need of an operator
  - ▶ Create a circuit to control the movement of the robot into a scanning pattern
  - ▶ Create sub-circuits to scan glass surface and time robot actions

Working Colaberation With Vert Counter - Multisim - [Working Colaberation With Vert Counter]

File Edit View Place Simulate Transfer Tools Reports Options Window Help

Working Colabration With Vert Coun  
Working Colabration With Vert C

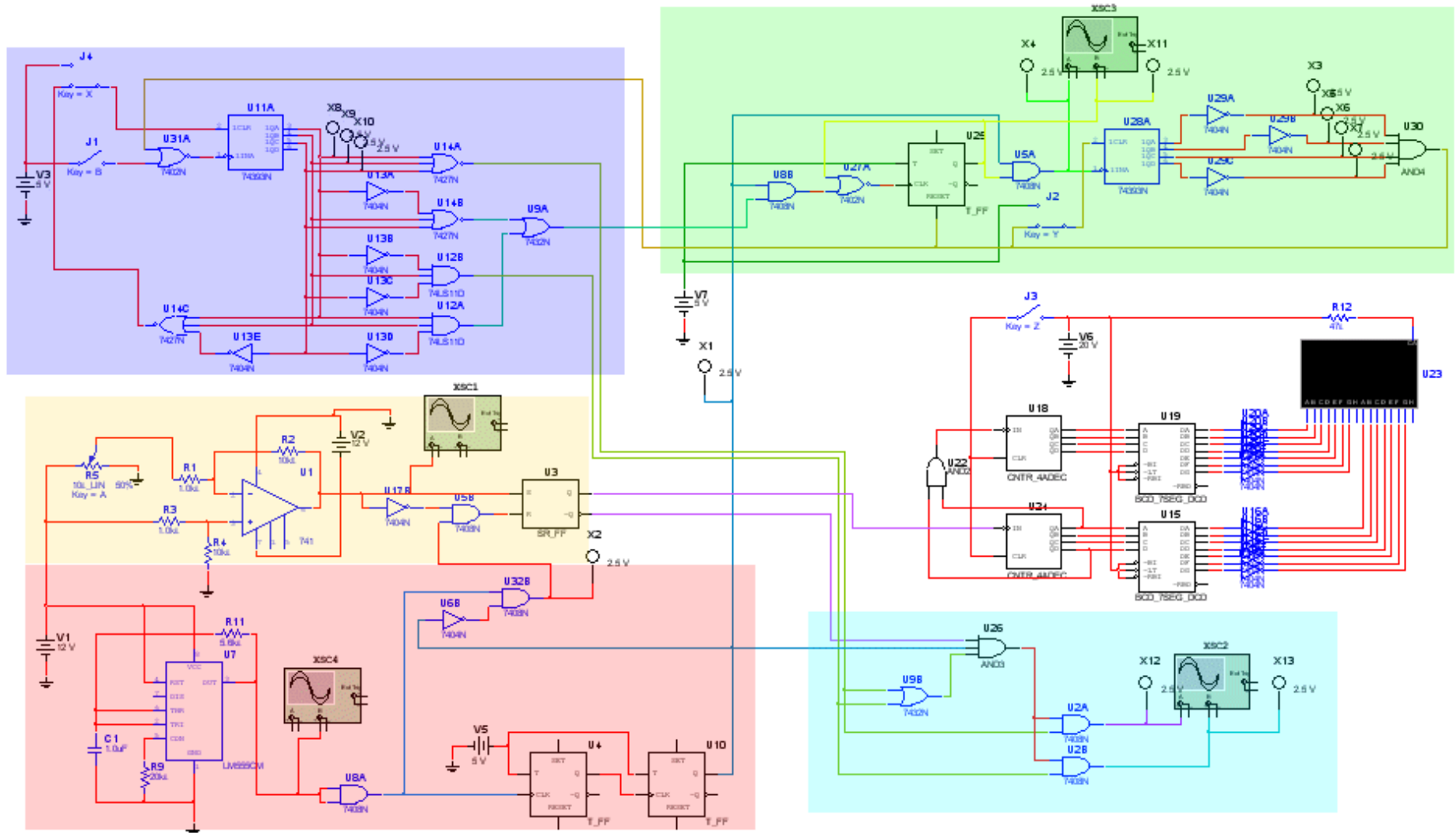


Hierarchy	
Visibility	Project View

Working Colaberation With Vert Counter

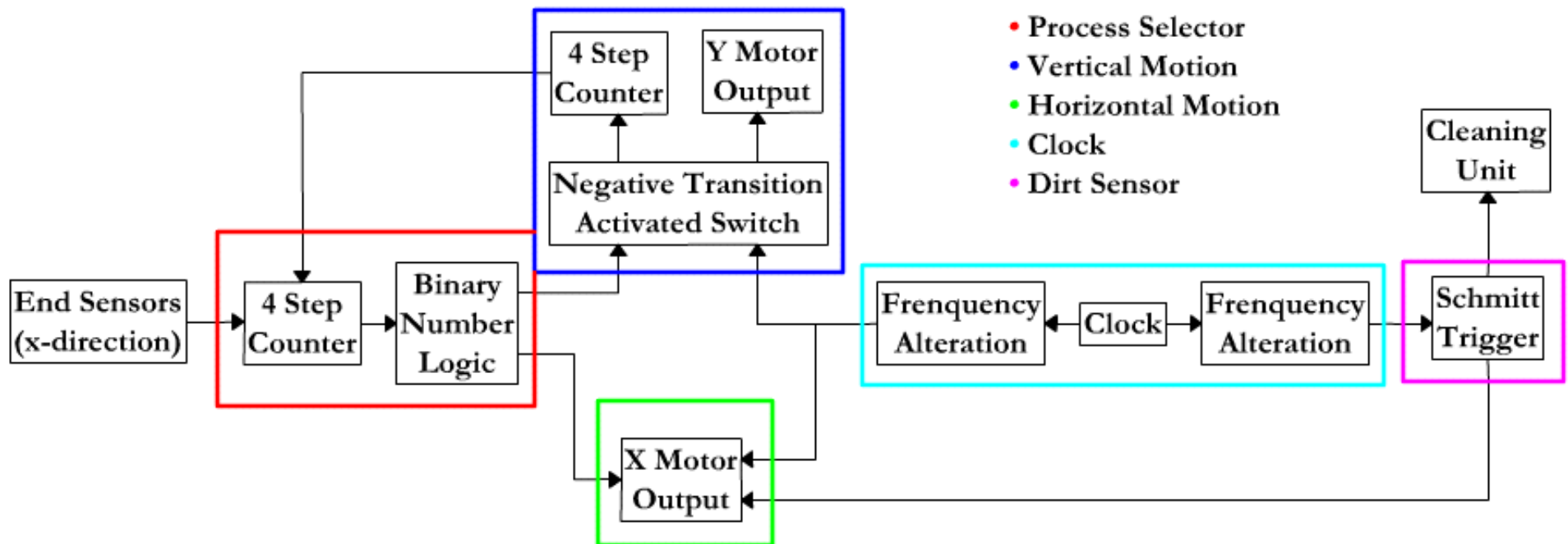
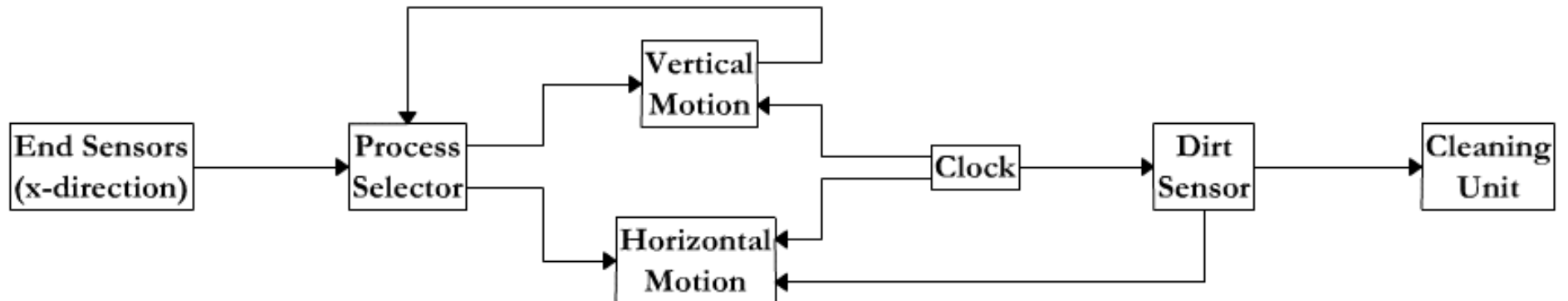
For Help, press F1

# Circuit Analysis

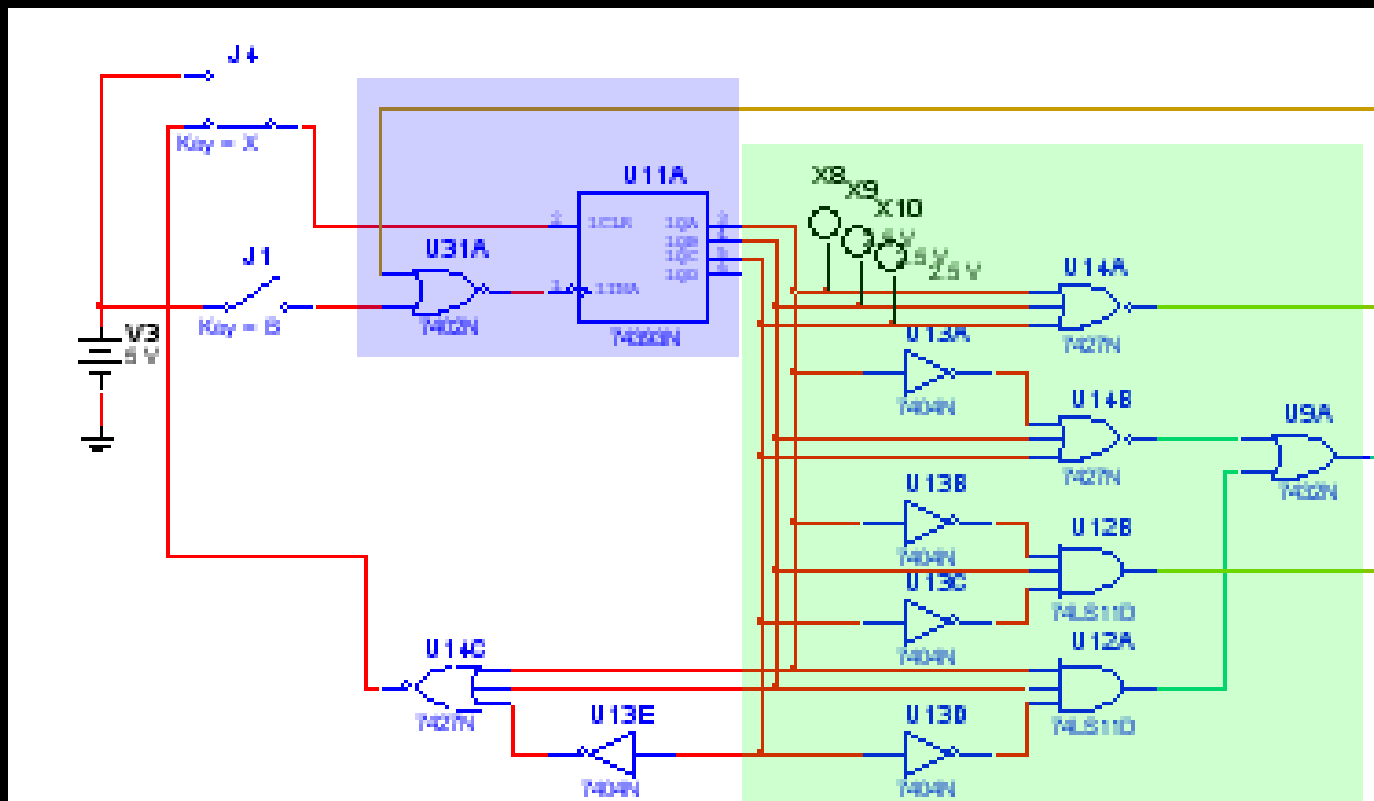




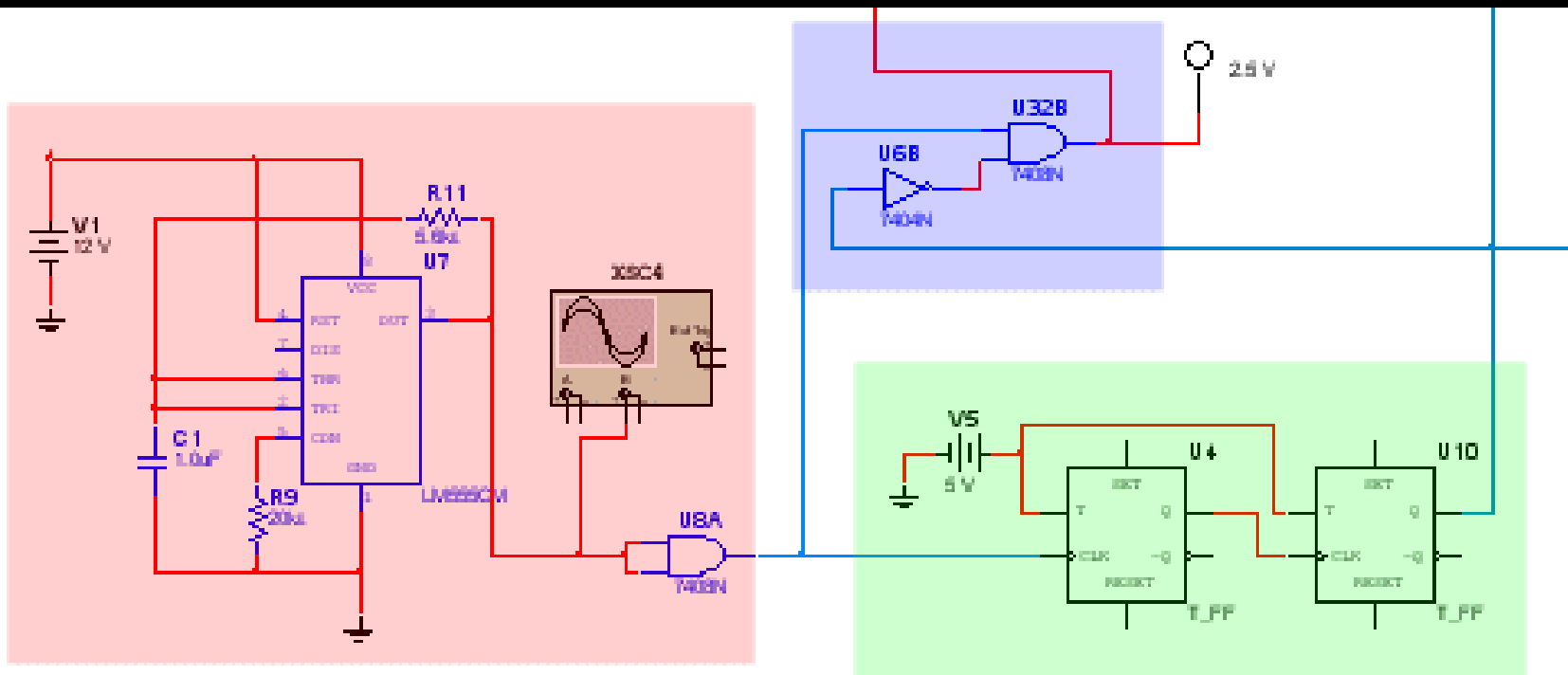
# Circuit Breakdown



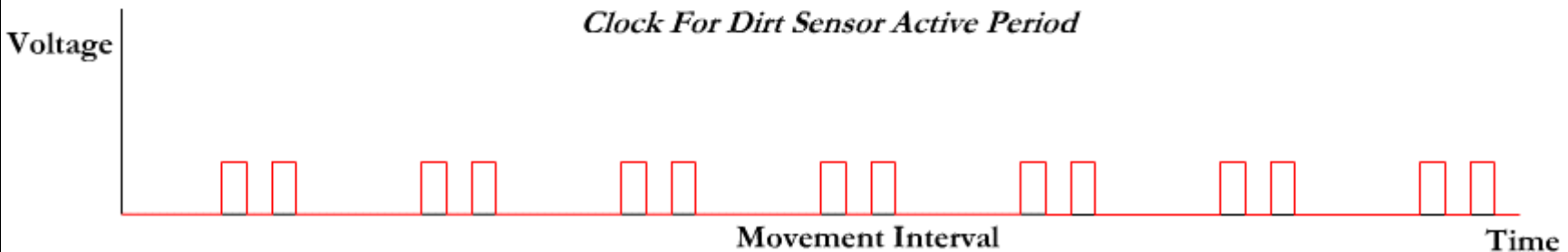
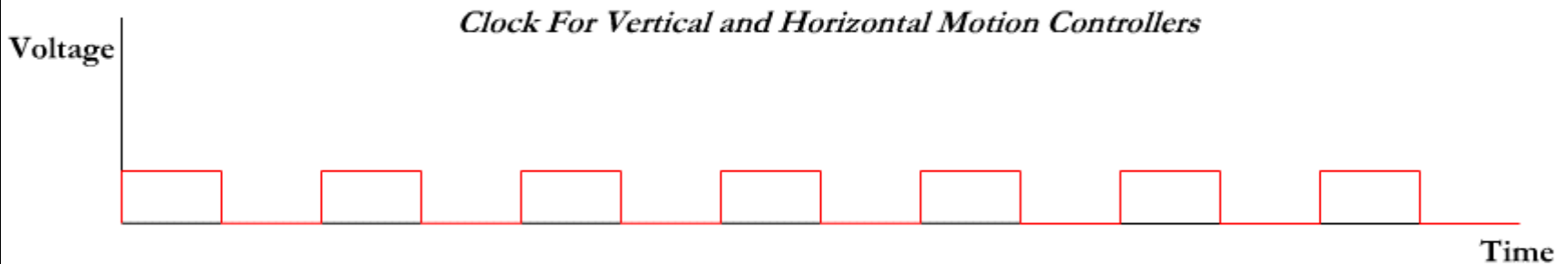
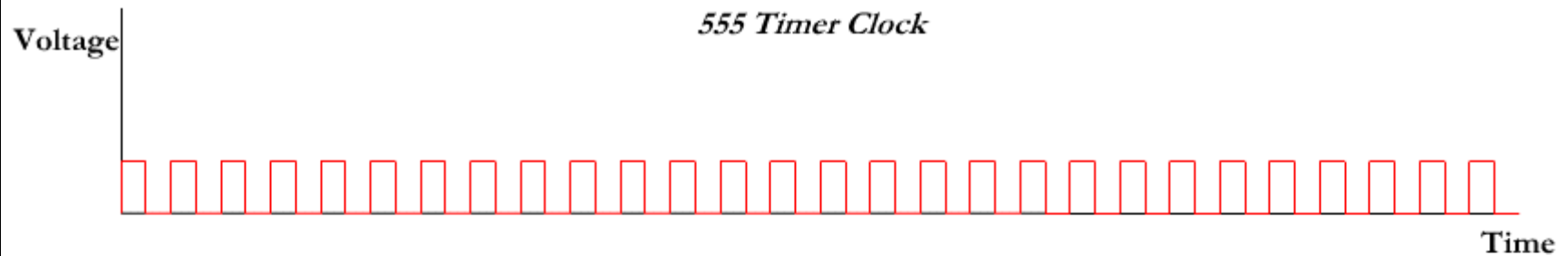
# Process Selector



# Clock

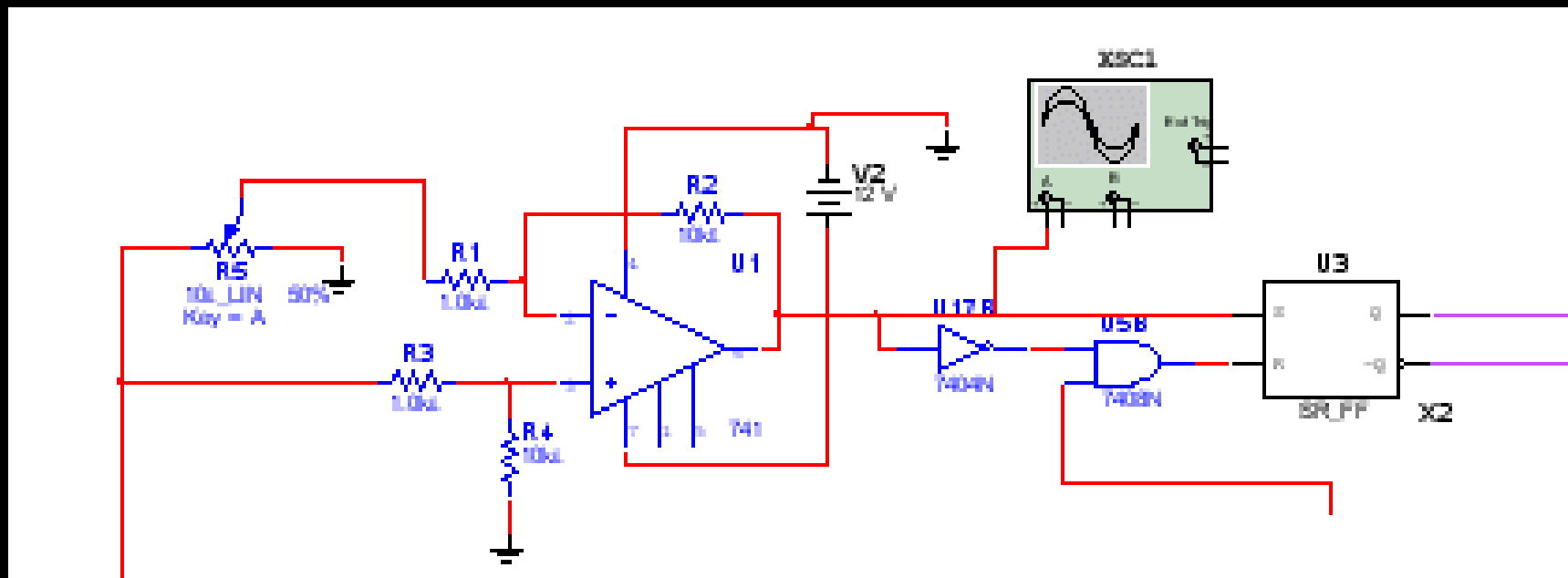


# Clock Signal Analysis

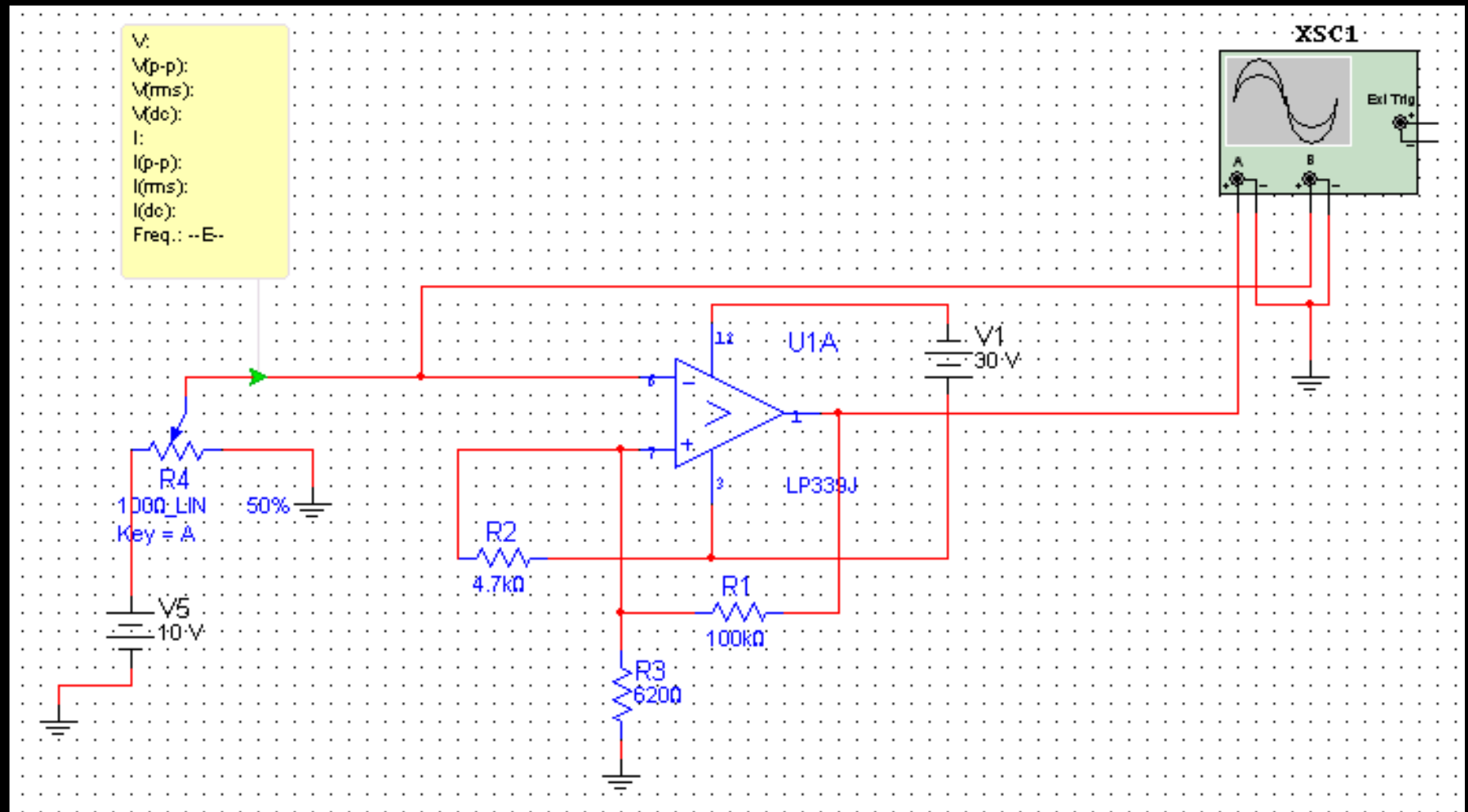




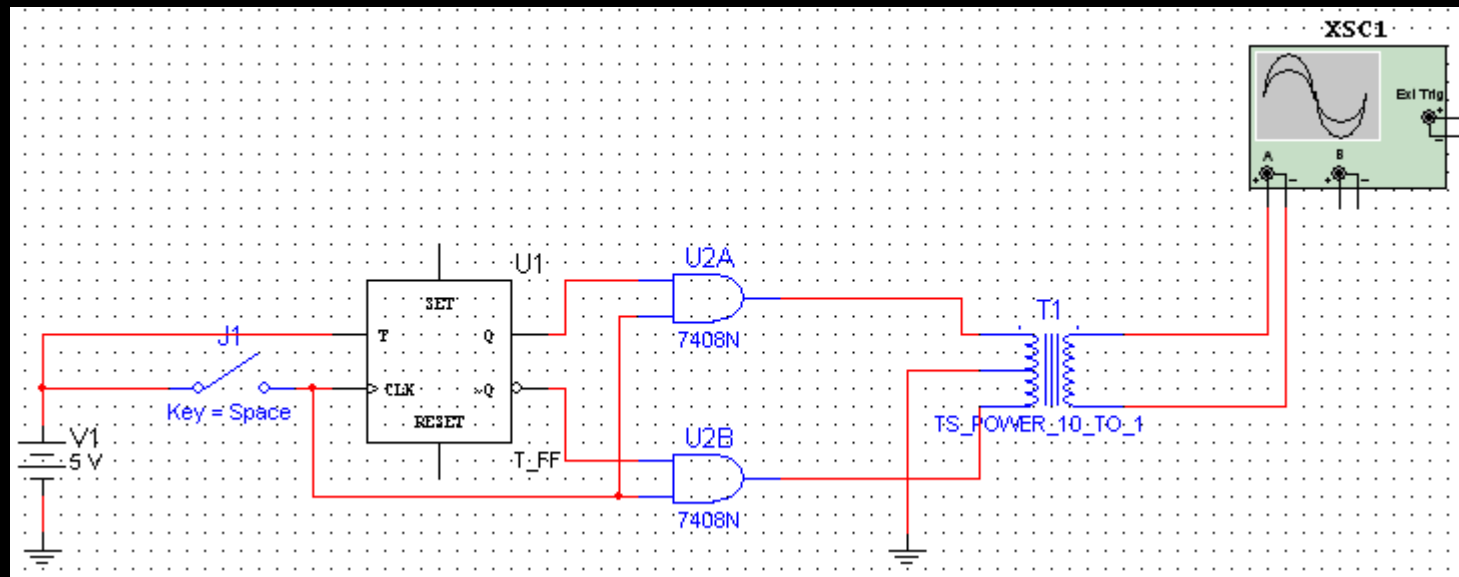
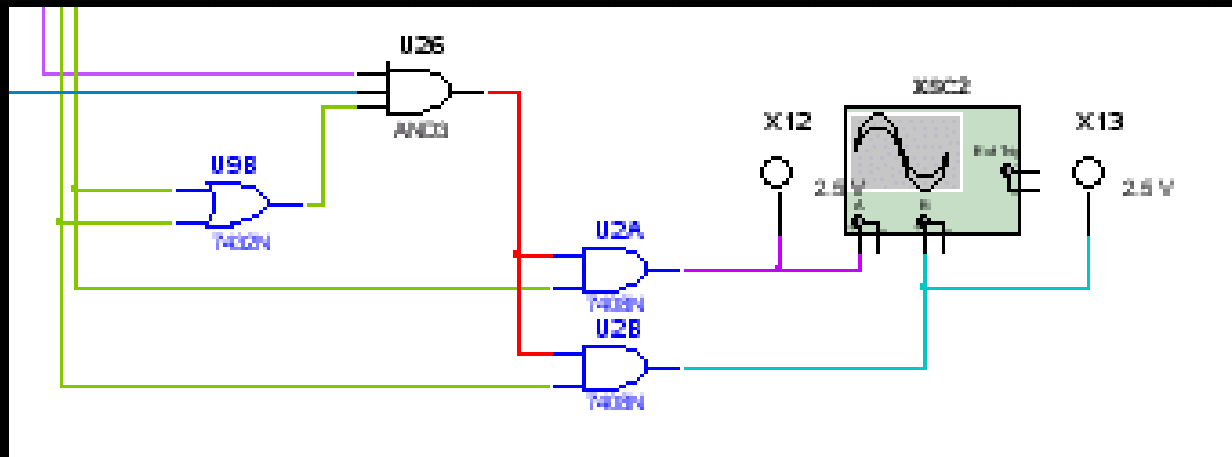
# Dirt Sensor



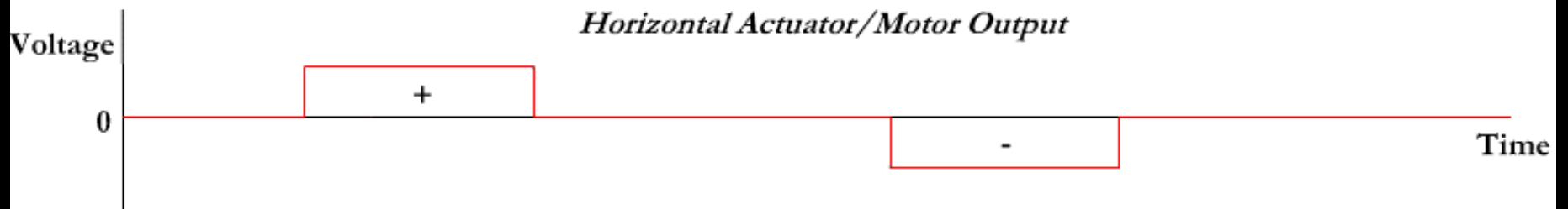
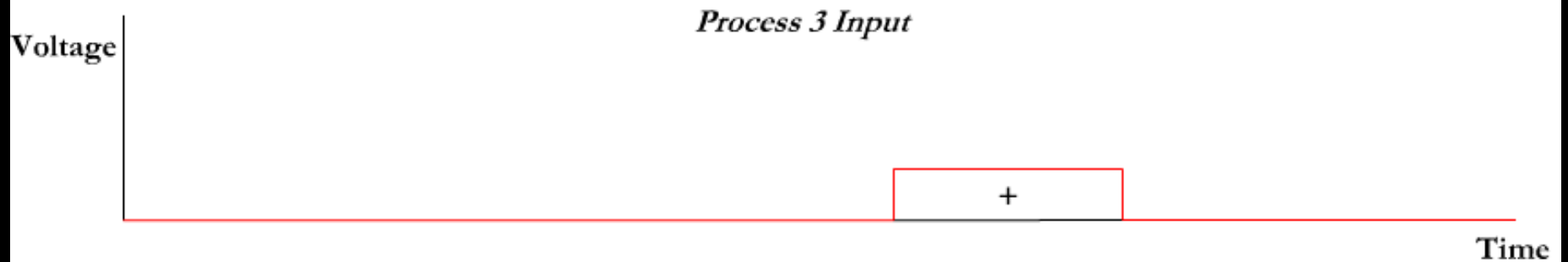
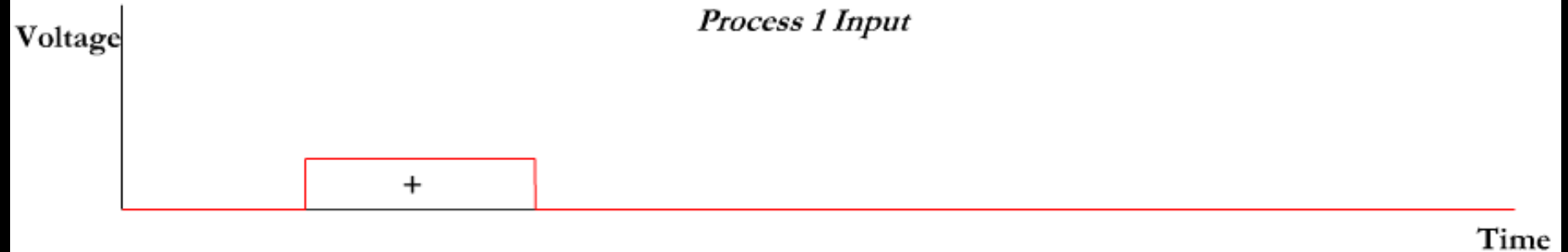
# Dirt Sensor



# Horizontal Motion

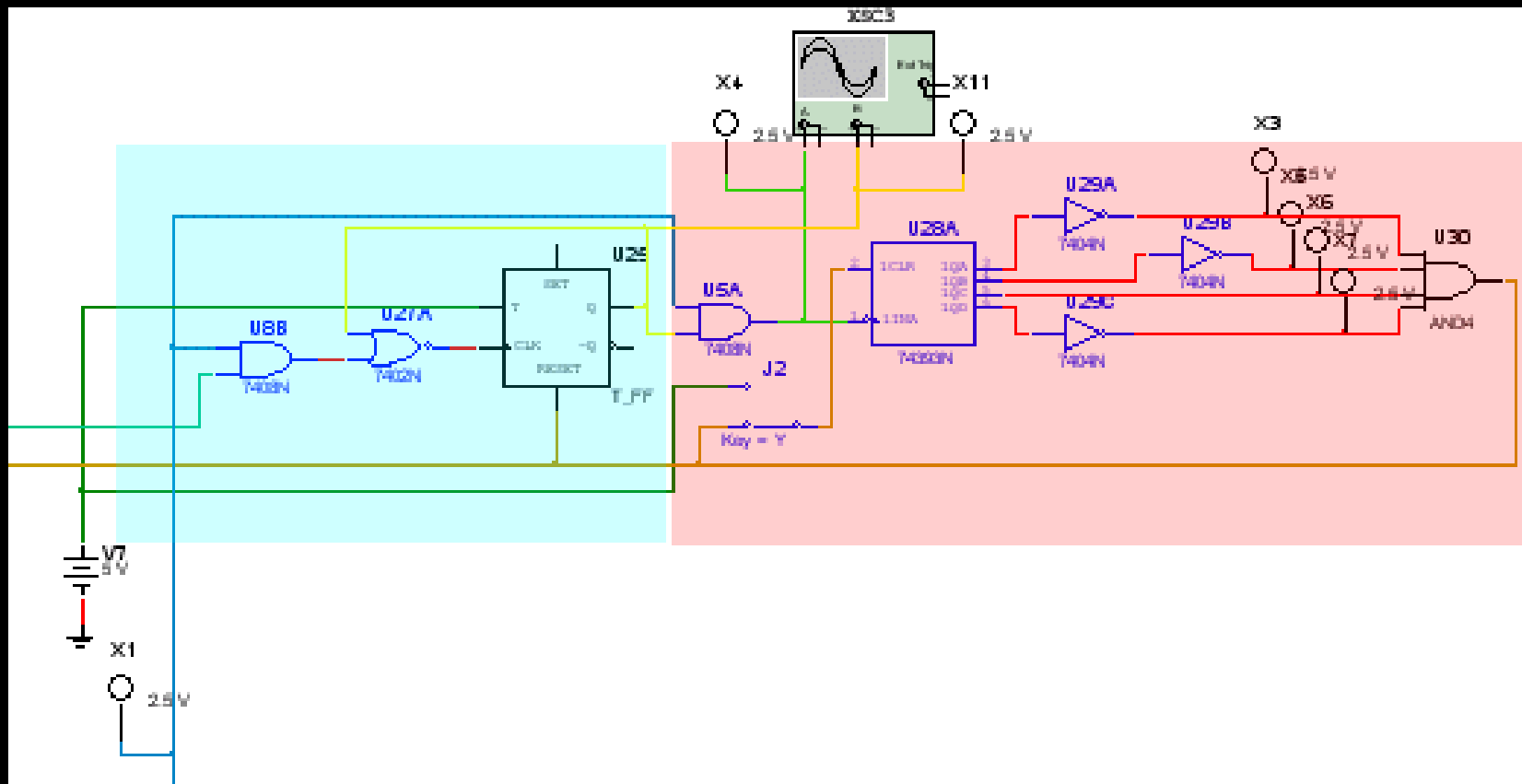


# Horizontal Motion

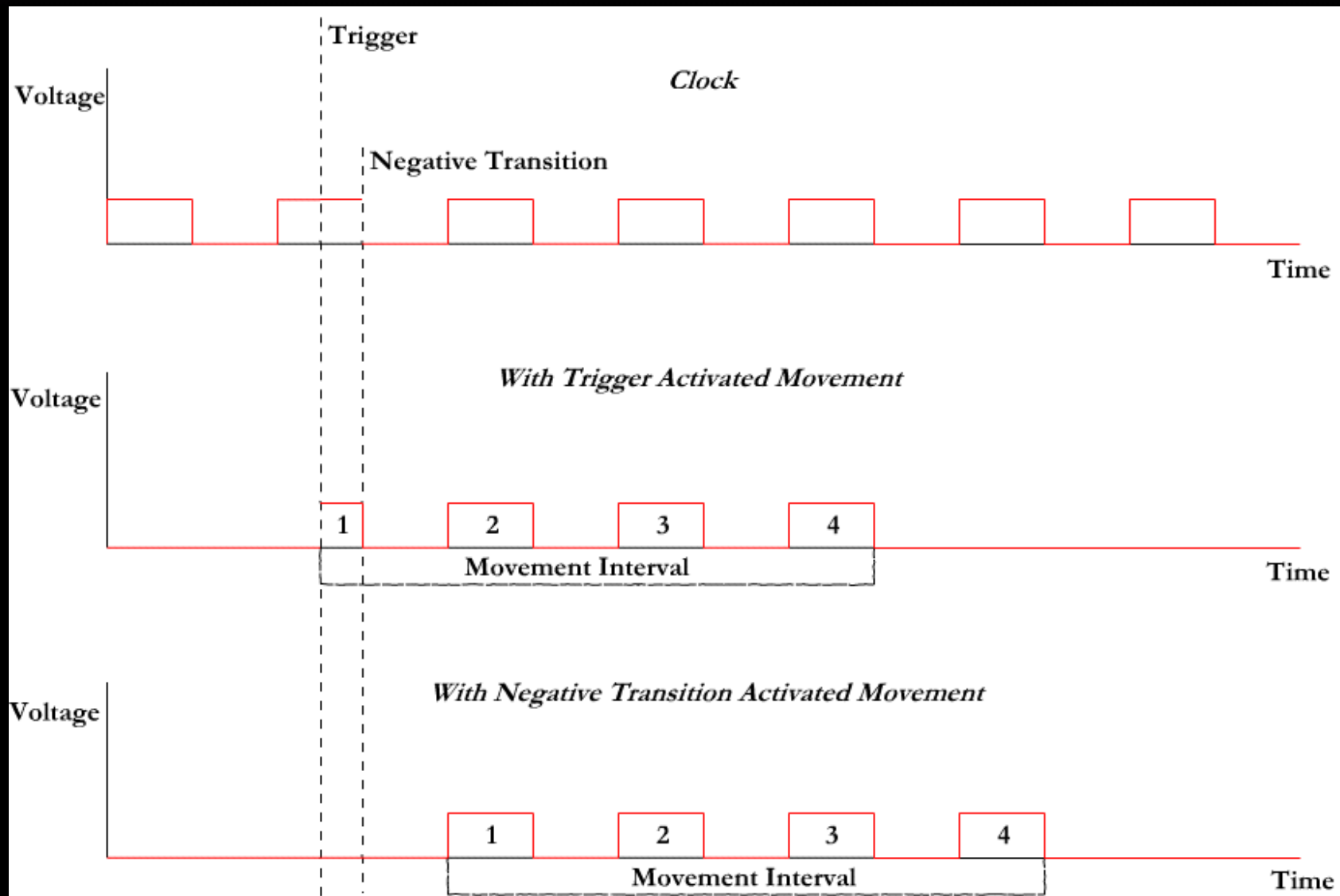




# Vertical Motion



# Negative Transition Activated Switch



# Output Analysis

- ▶ Two possible scan pattern options
  - ▶ Option 1
  - ▶ Option 2

One more time...

