STEM's Role in Mechatronics

Richard Gilbert

Professor College of Engineering
University of South Florida

Chemical and Biomedical Engineering Department

FLATE

Center for Molecular Delivery

This presentation is in support of FLATE's NSF-ATE grant objectives for professional development.

STEM's Role in Mechatronics

Working Definition for Mechatronics

- Megatronics is the integration of electronic, mechanical, hydraulic and/or pneumatic elements into subsystems to operate a process.

Common Characteristics of a Mechatronics Subsystem

- Megatronic subsystems are automated.
  - A robot arm that automatically welds two parts together **is** a mechatronic system
  - A model scale toy helicopter that is radio controlled is **not** a mechatronic system.
  - In this case, both are wonderful examples of very clever combination of various electronic and mechanic subsystems.
  - Their automation characteristics are the distinguishing factors.

    (Toy helicopter is controlled by **human**.)

    (Robot welding arm is controlled by **itself**.)

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Automation Characteristics of Mechatronics Subsystems

- Sense the process and make measurements
- Think about current status of process and make decisions.
- Generate an action and make changes in the process.

Automation Characteristics of Mechatronics Subsystems

- Sense the process and make measurements
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Sense the process and make measurements

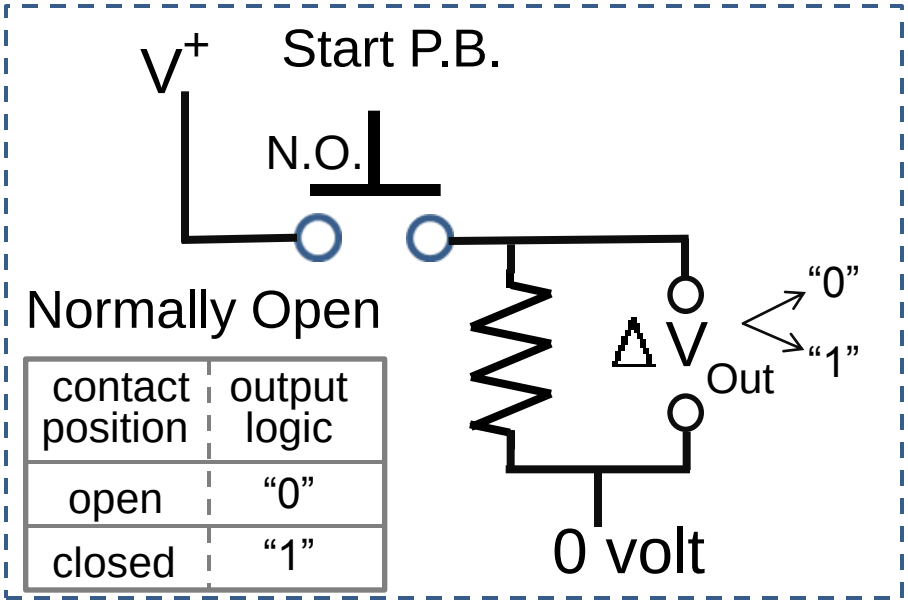
- Simplest Sensing capabilities
  - Detect a start or stop signal from a human.

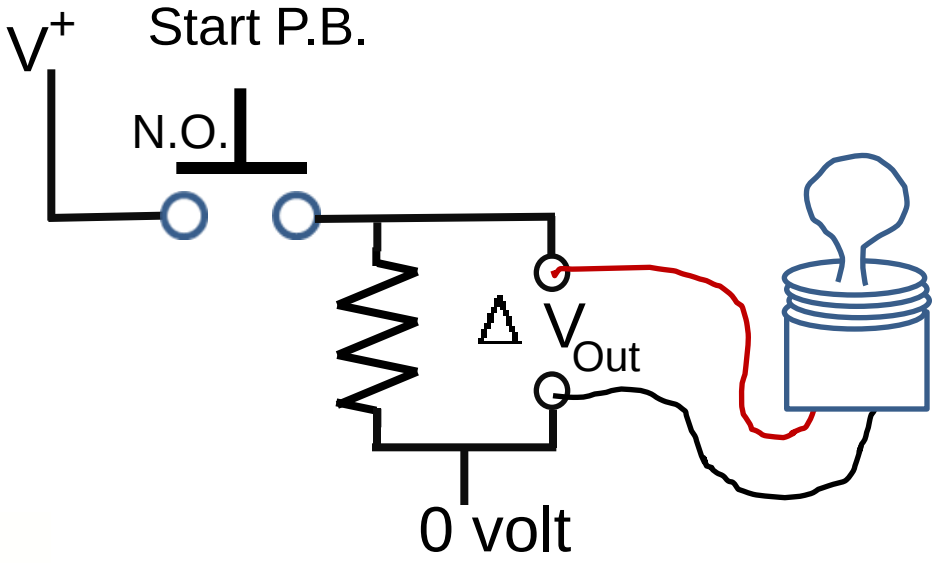
    Push Buttons
  - Detect an alarm signal from the process.

    Pressure sensors

- **Detect a start signal from a human.**

  A Start Push Button





- **Detect a start signal from a human.**

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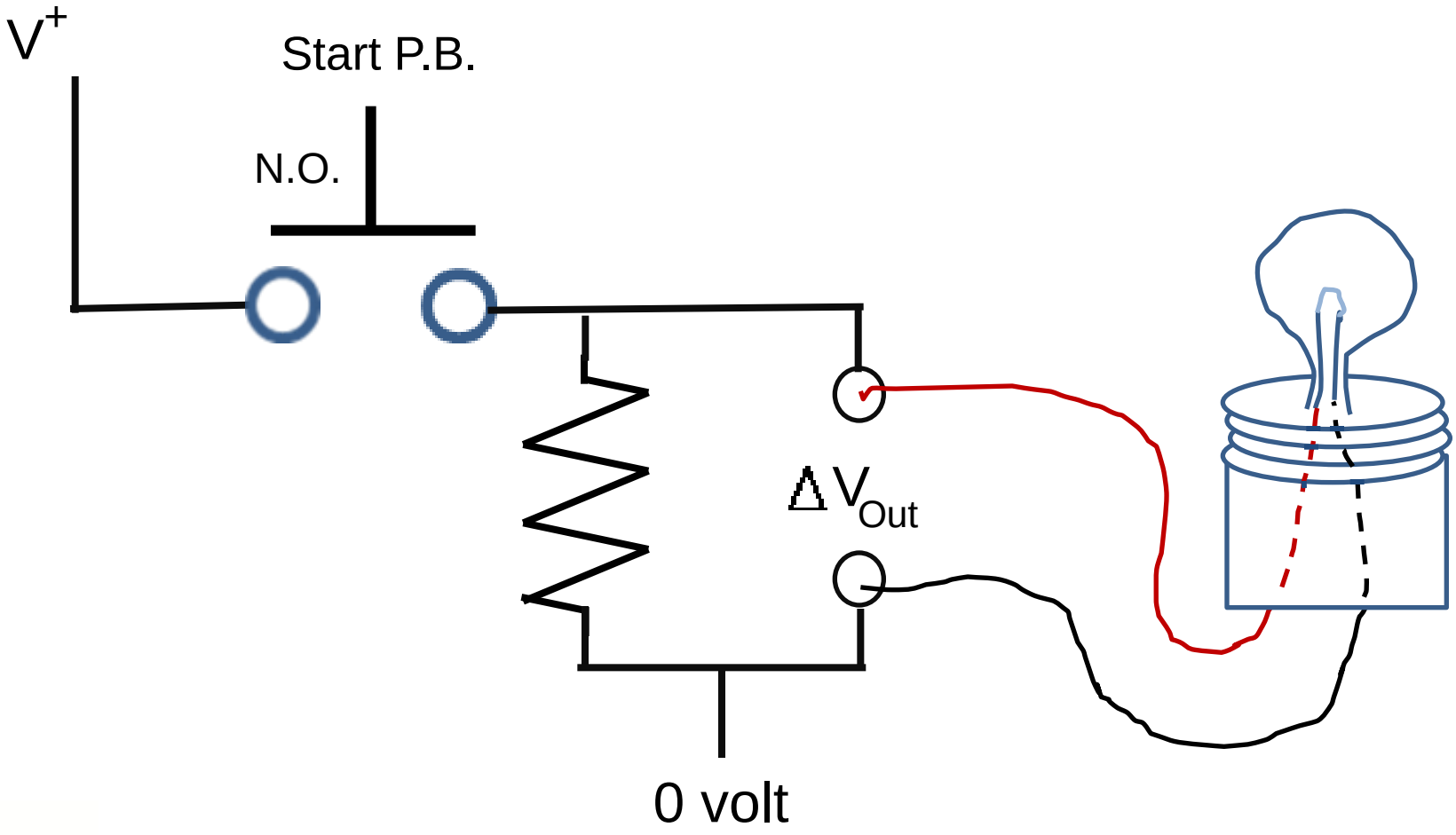

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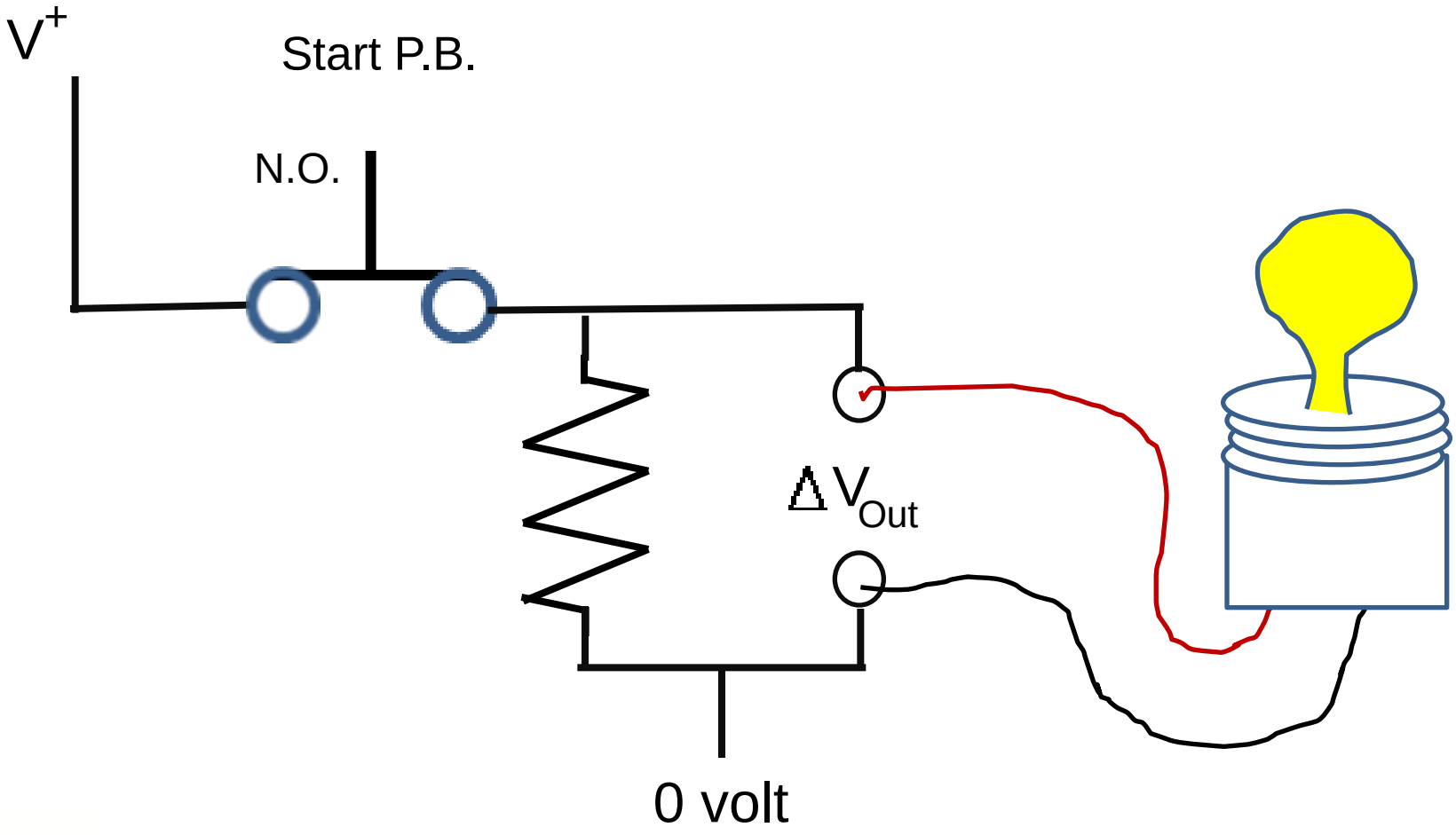

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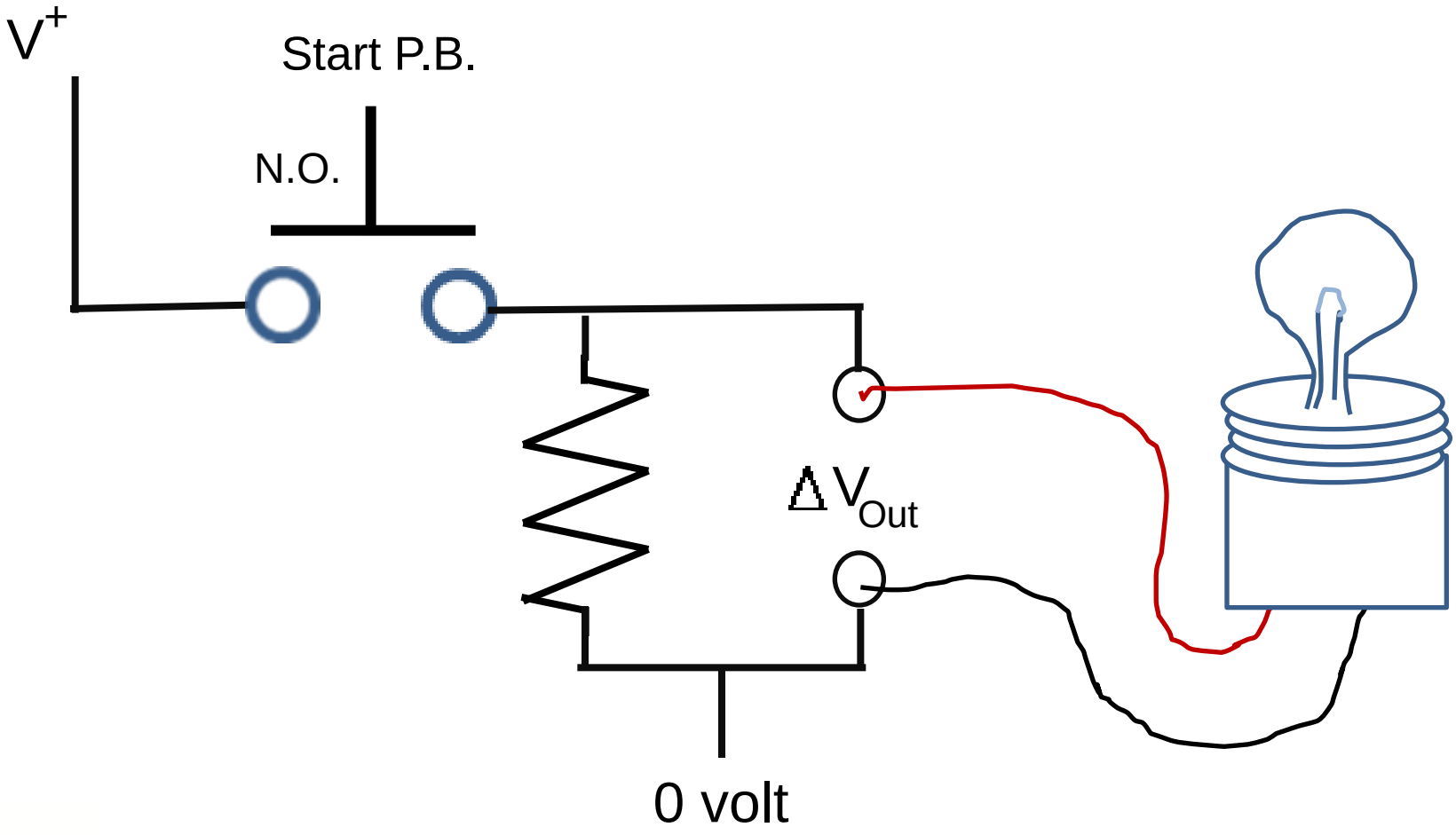

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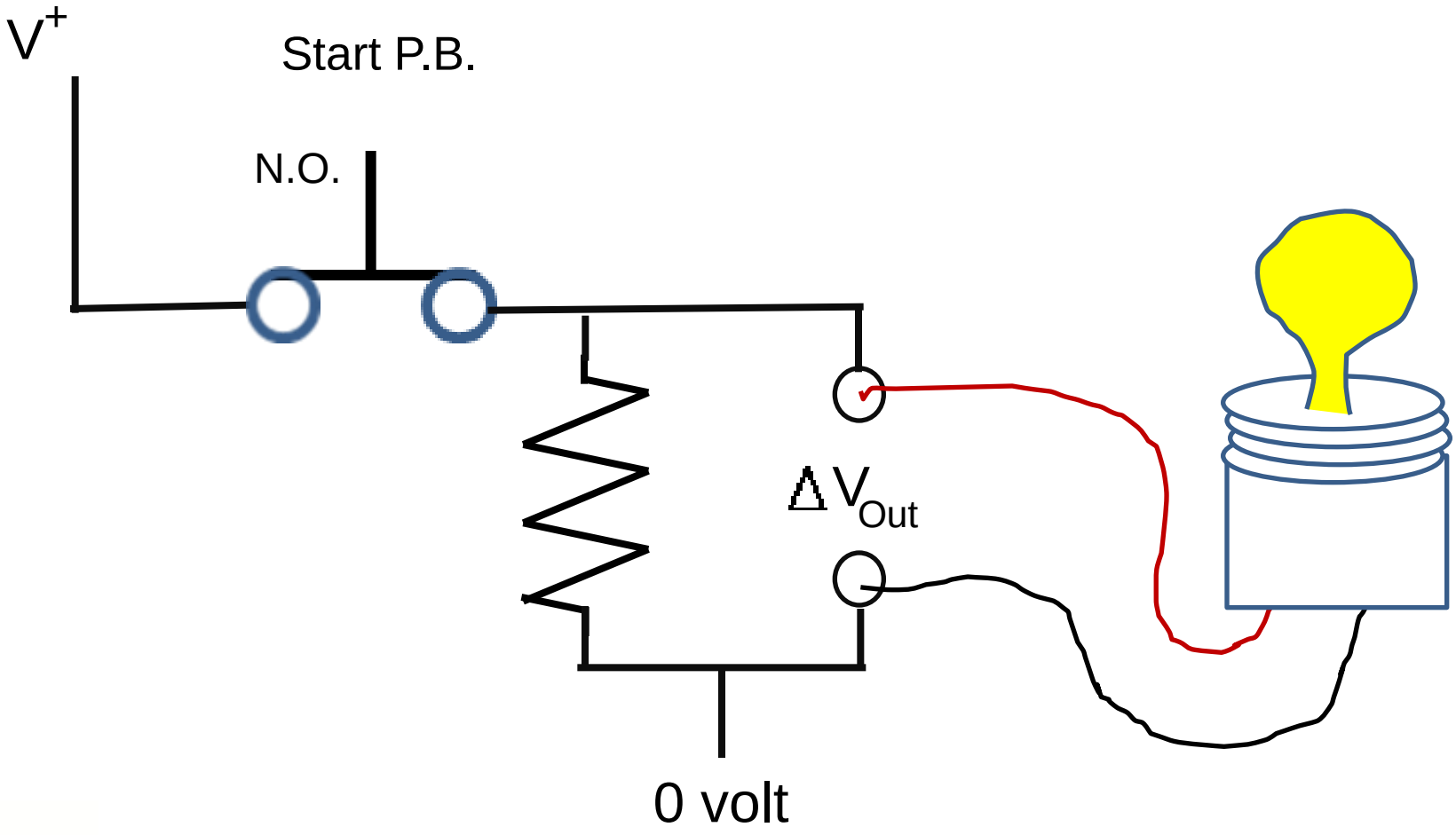

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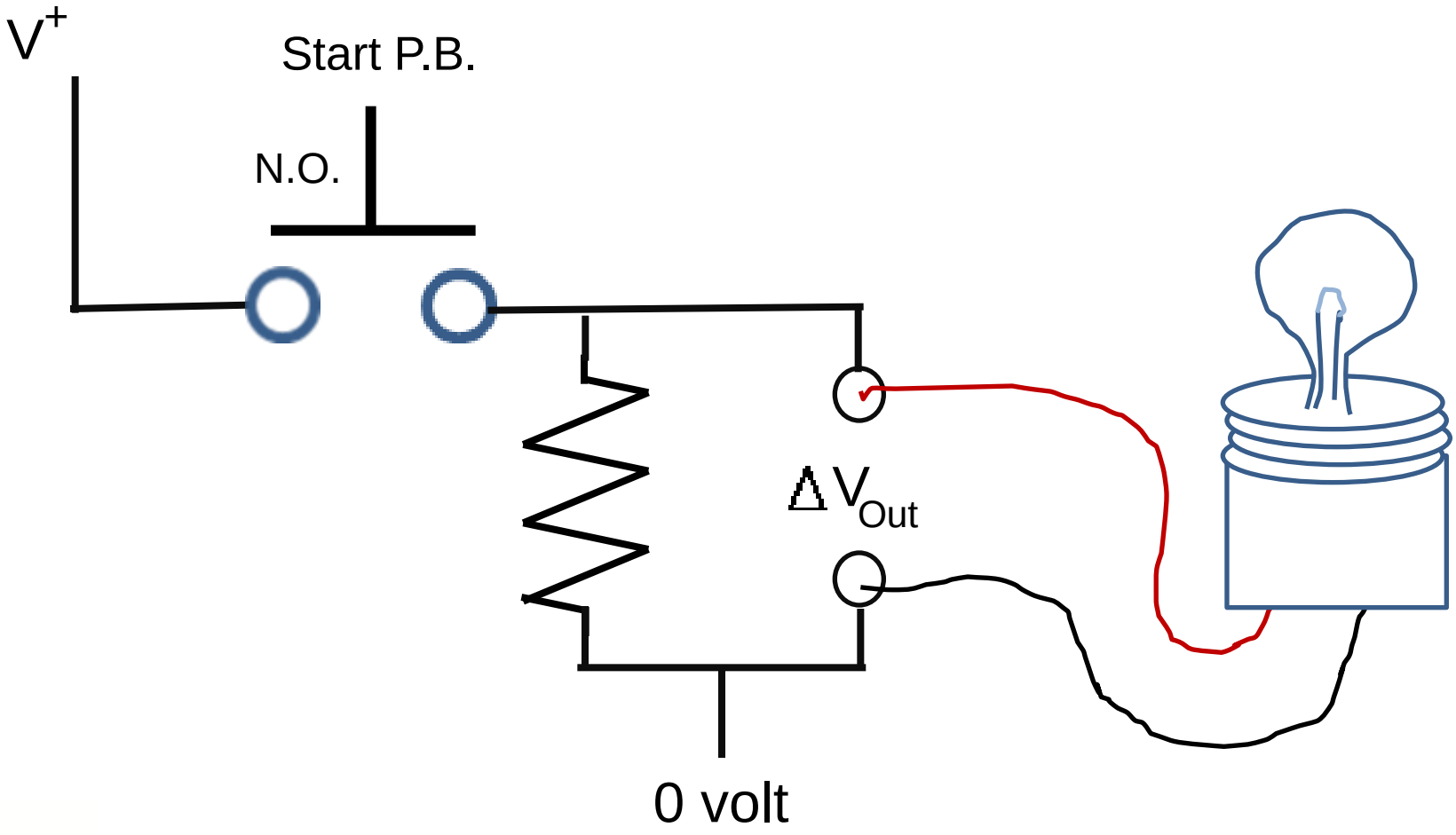
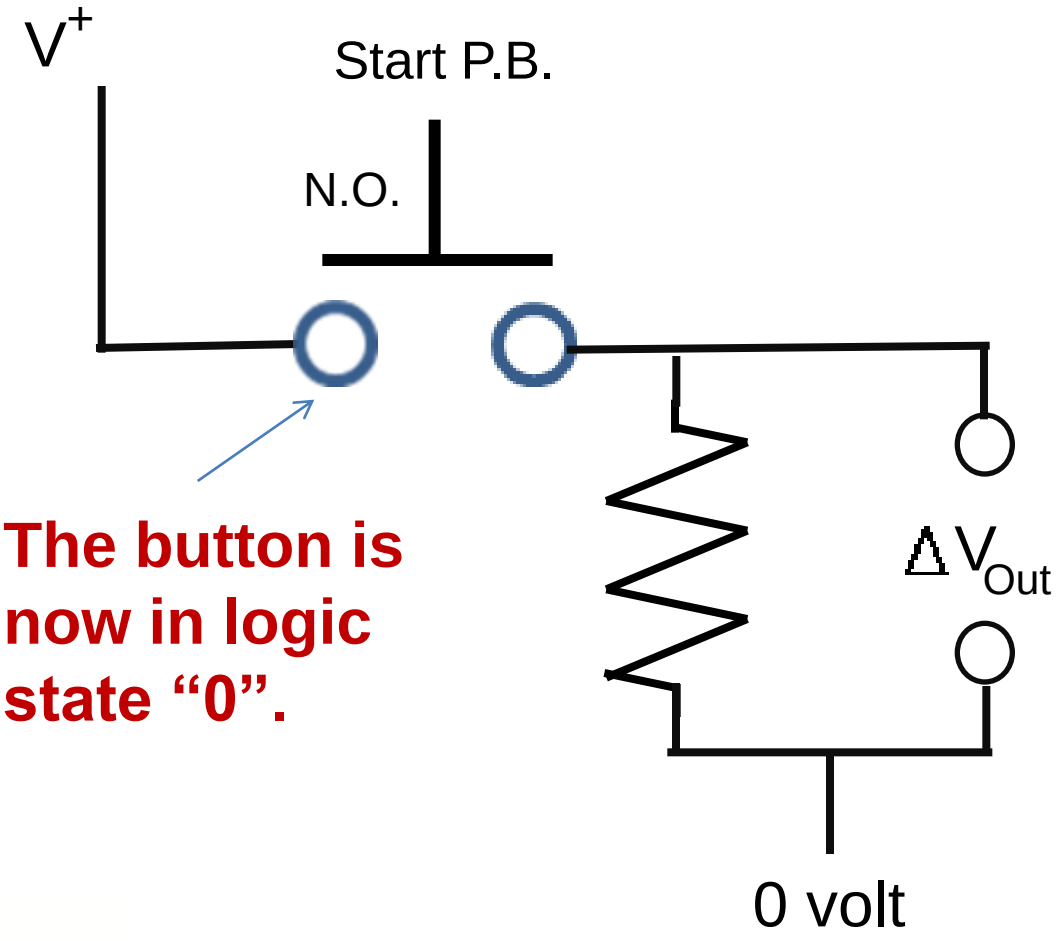
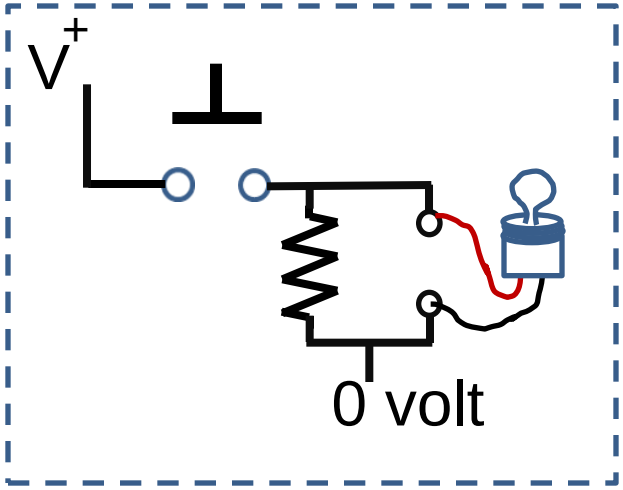


- **Detect a start signal from a human.**

A Start Push Button and its Logic States



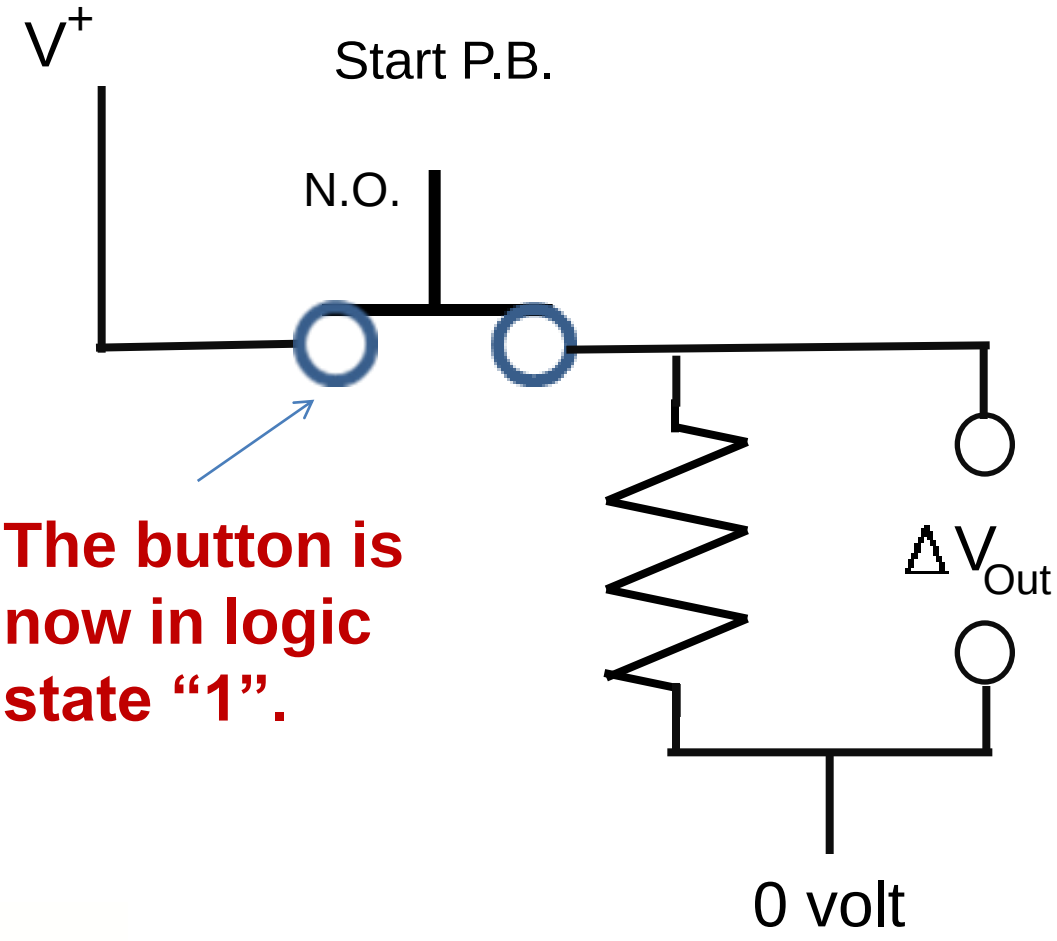
The button is now in logic state “0”.



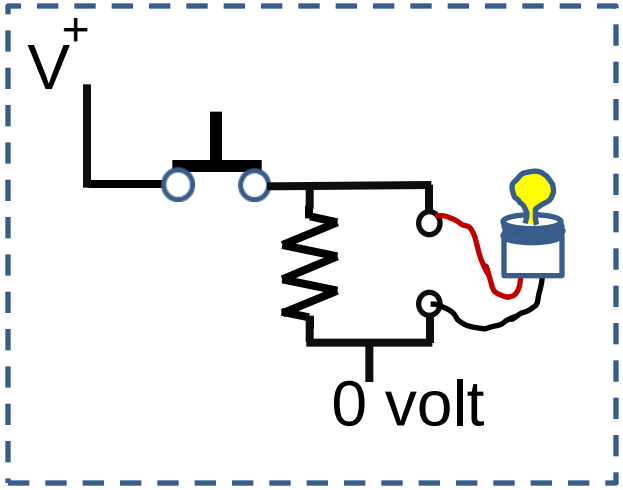
The button output signal as at logic “0”.

- **Detect a start signal from a human.**

A Start Push Button and its Logic States



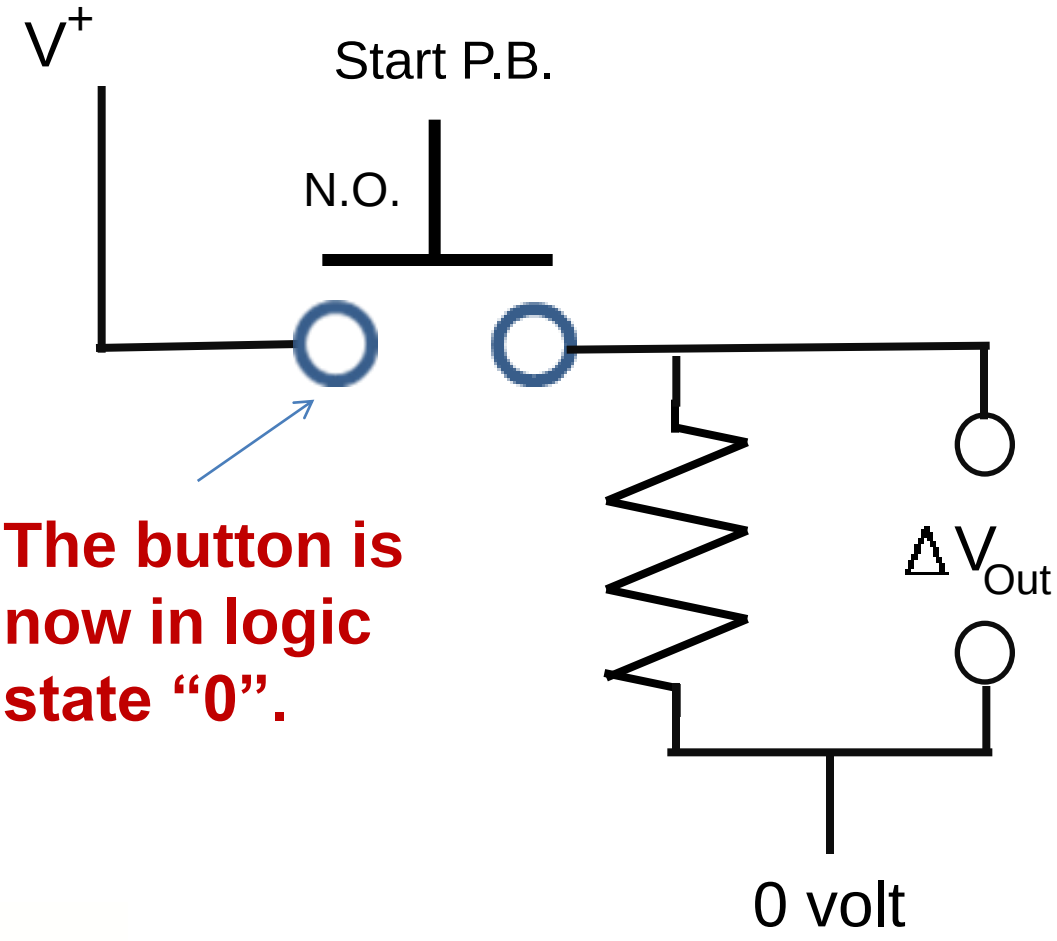
The button is now in logic state “1”.



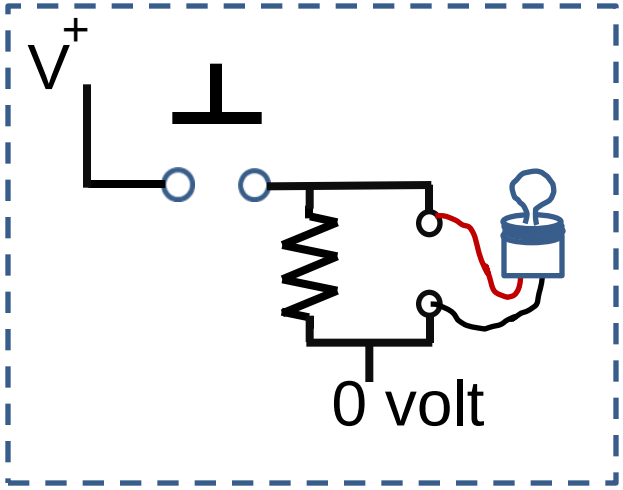
The button output signal as at logic “1”.

- **Detect a start signal from a human.**

A Start Push Button and its Logic States



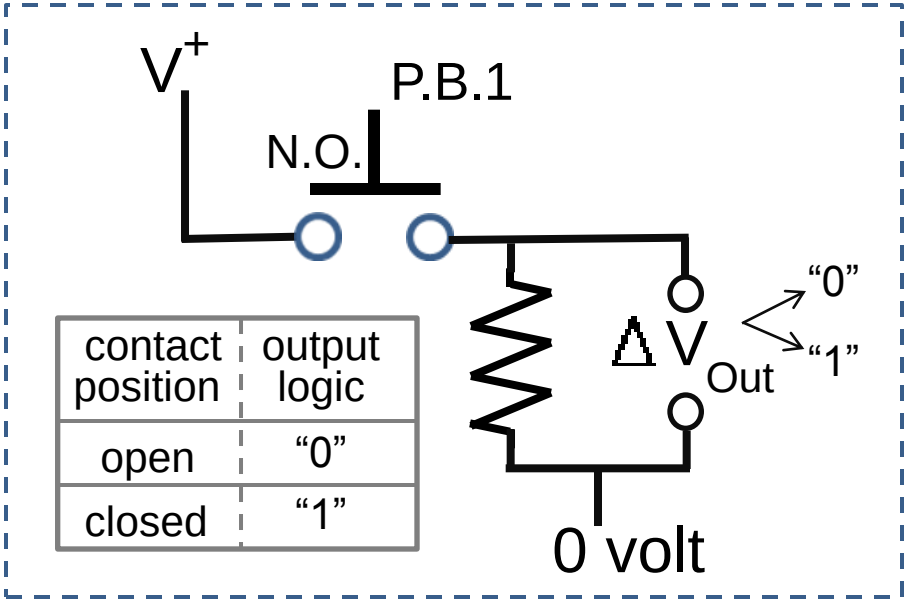
The button is now in logic state “0”.



The button output signal as at logic “0”.

- **Detect a start signal from a human.**
  - **When the button is not pushed then logic “0” is the output signal.**
  - **When the button is pushed then logic “1” is the output signal.**

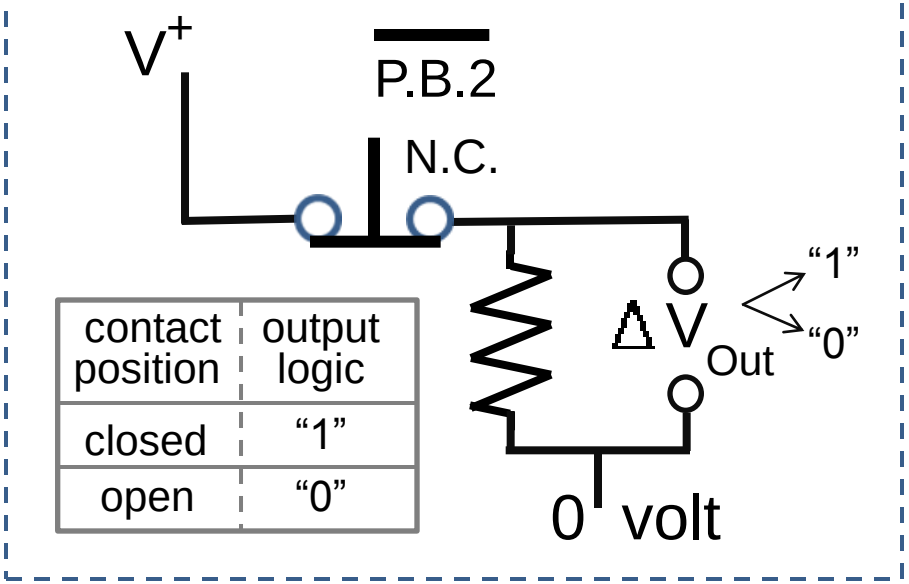
A Normally Open type of button



contact position	output logic
open	“0”
closed	“1”

- **When the button is not pushed then logic “1” is the output signal.**
- **When the button is pushed then logic “0” is the output signal.**

A Normally Closed type of button



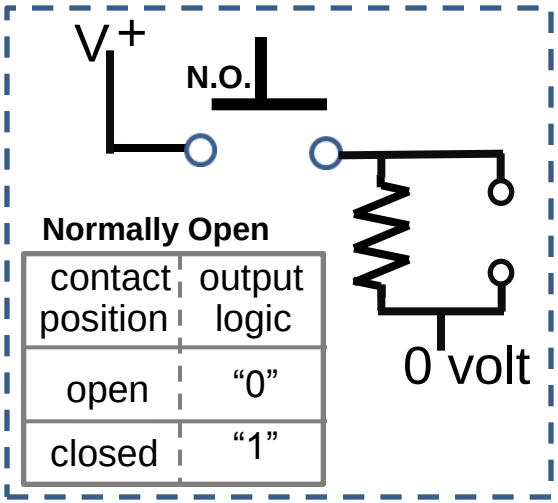
contact position	output logic
closed	“1”
open	“0”

Automation Characteristics of Mechatronics Subsystems

Sense the process and make measurements

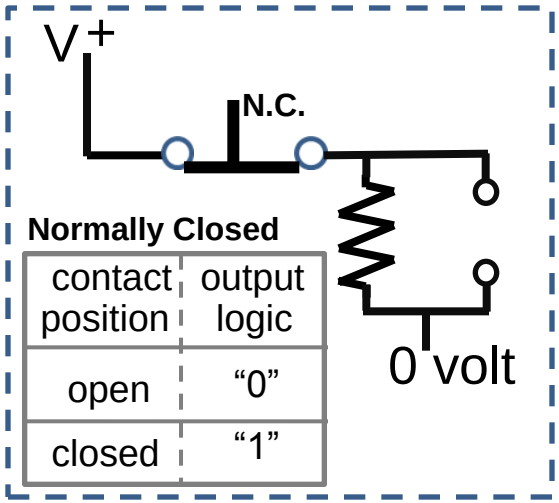
- Simplest Sensing capabilities
  - Detect signal from a human.

Push Buttons



Normally Open

contact position	output logic
open	“0”
closed	“1”



Normally Closed

contact position	output logic
open	“0”
closed	“1”

  - Detect an alarm signal from the process.

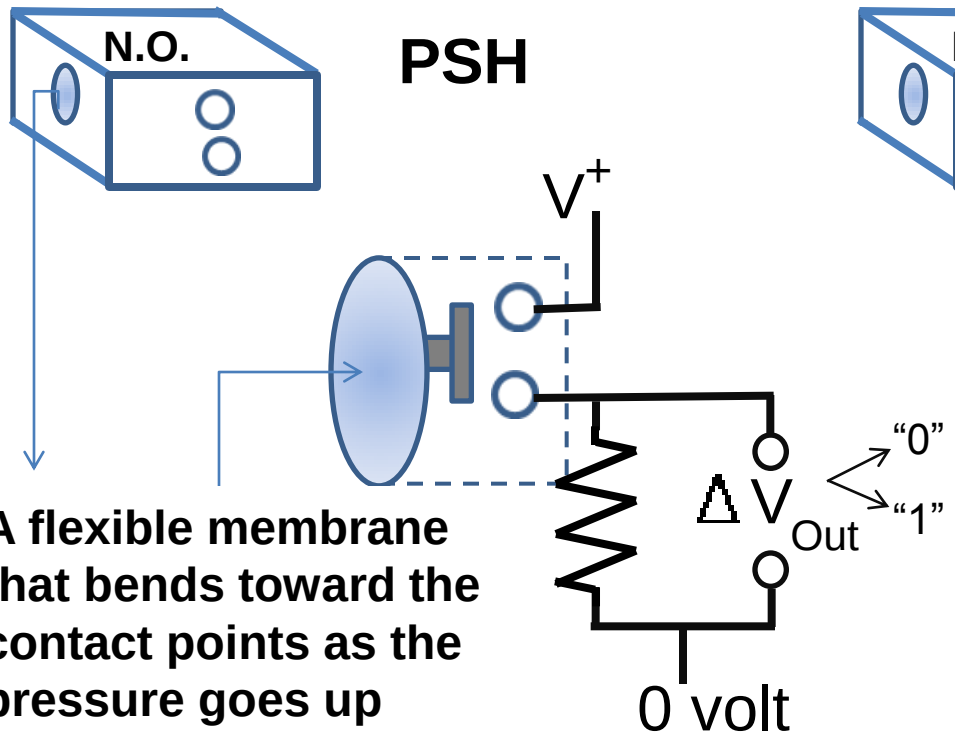
Pressure sensors

Automation Characteristics of Mechatronics Subsystems

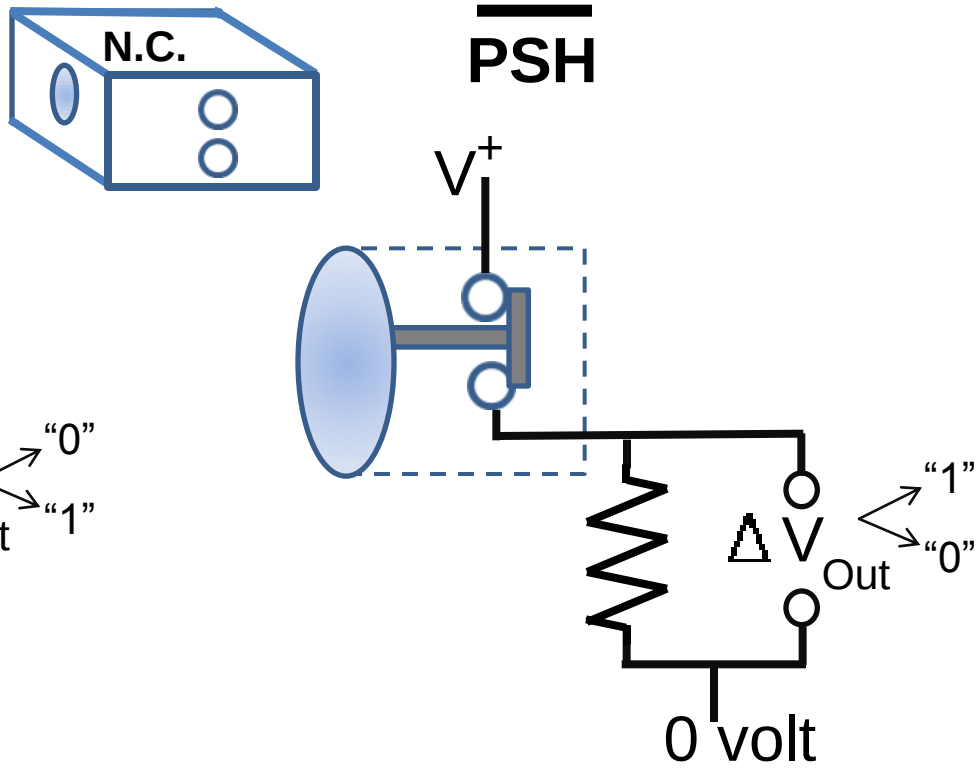
Sense the process and make measurements

- Simplest Sensing capabilities
  - Detect an alarm signal from the process.

Pressure sensors



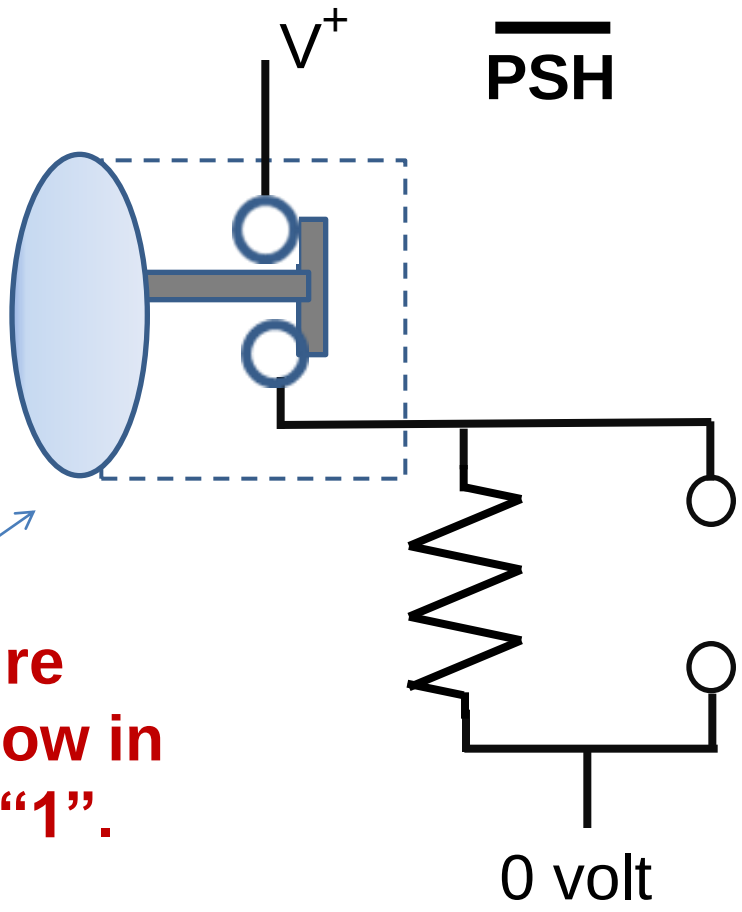
A flexible membrane that bends toward the contact points as the pressure goes up



Automation Characteristics of Mechatronics Subsystems

- Detect an alarm signal from the process.

  Pressure sensor logic states



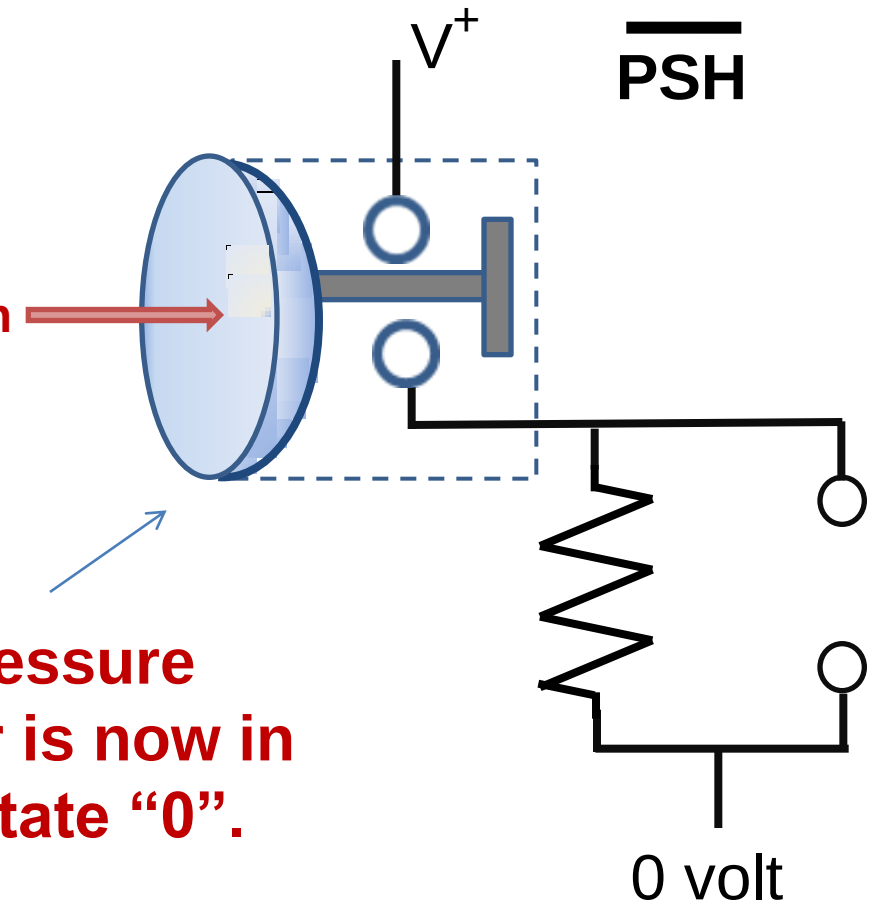
The pressure sensor is now in logic state “1”.

The sensor output signal is at logic “1”.

Automation Characteristics of Mechatronics Subsystems

- Detect an alarm signal from the process.

  Pressure sensor logic states



The pressure is higher than desired.

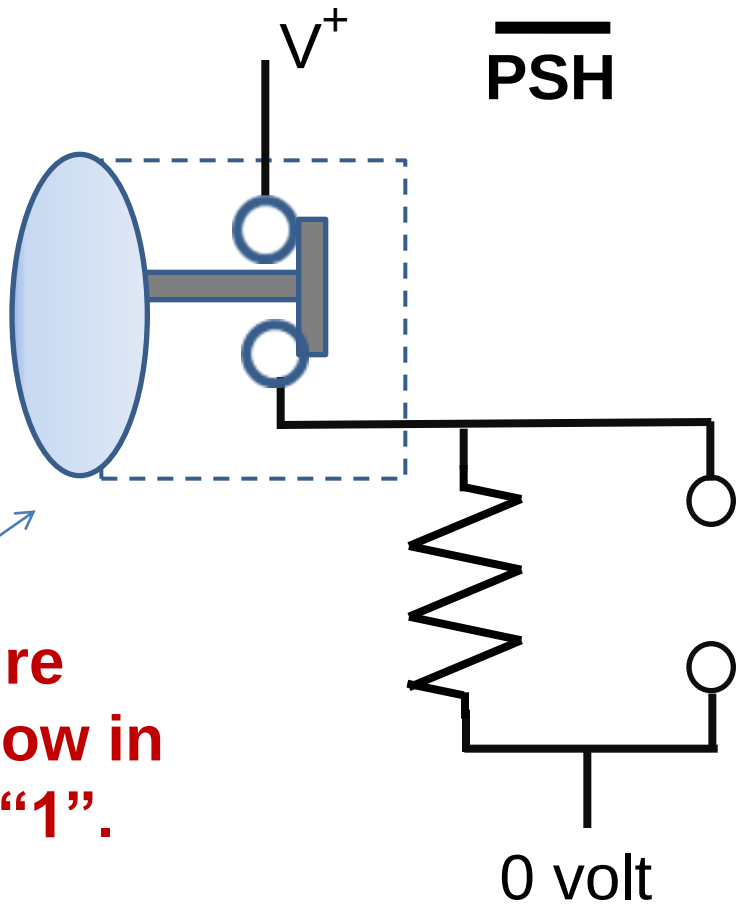
The pressure sensor is now in logic state “0”.

The sensor output signal is at logic “0”.

Automation Characteristics of Mechatronics Subsystems

- Detect an alarm signal from the process.

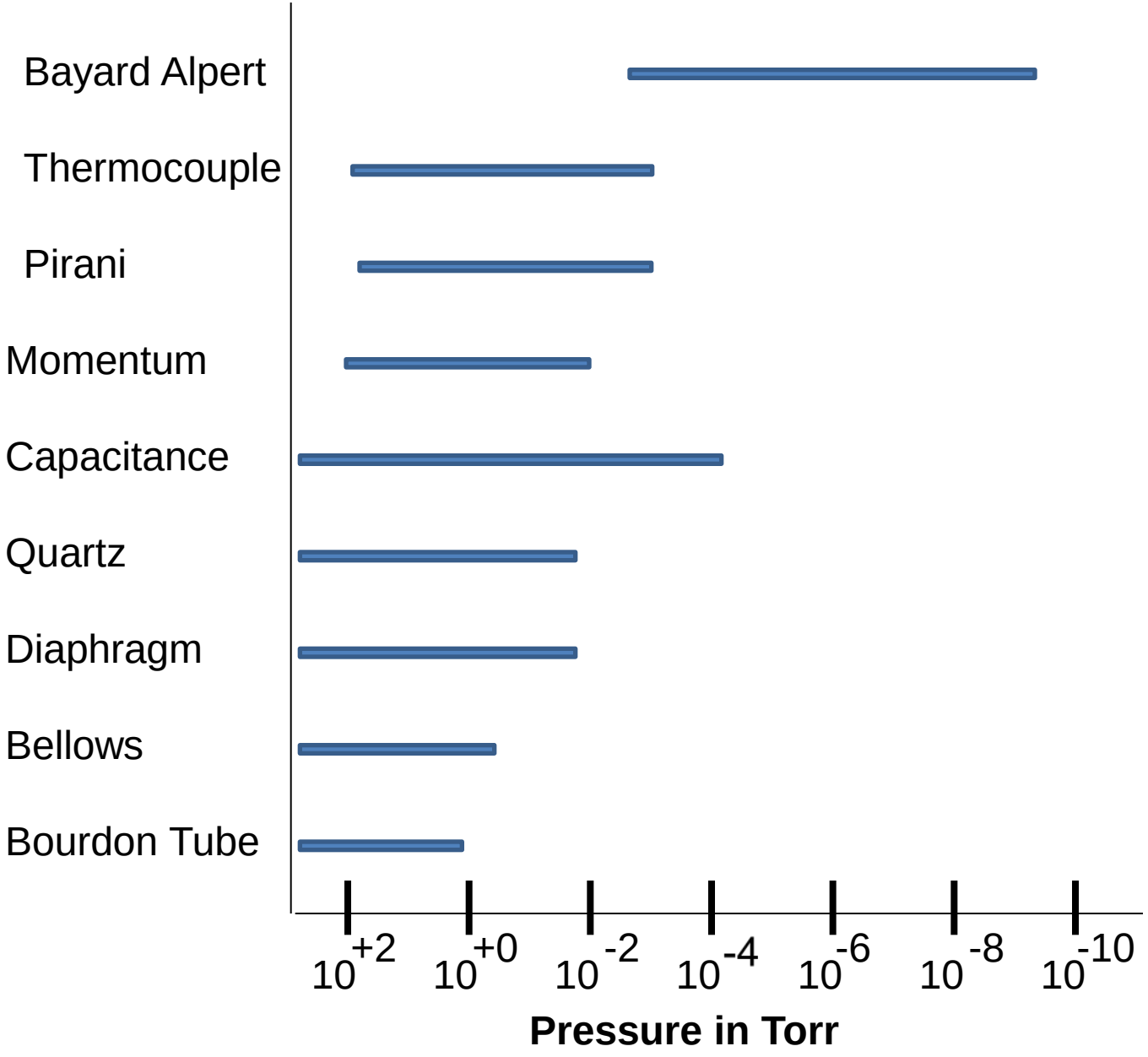
  Pressure sensor logic states



The pressure sensor is now in logic state “1”.

The sensor output signal is at logic “1”.

Some Pressure Gauge Types



Automation Characteristics of Mechatronics Subsystems

- Sense the process and make measurements
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Automation Characteristics of Mechatronics Subsystems

- Sense the process → Start P.B. → PSH
  → $\overline{\text{Start P.B.}}$ → $\overline{\text{PSH}}$
- Think about current status of process and make decisions.
- Generate an action and make changes in the process.

Generate an action and make changes in the process

- Simplest action to make a change in the process
  - Turn on a motor

    Vacuum pump

Generate an action and make changes in the process

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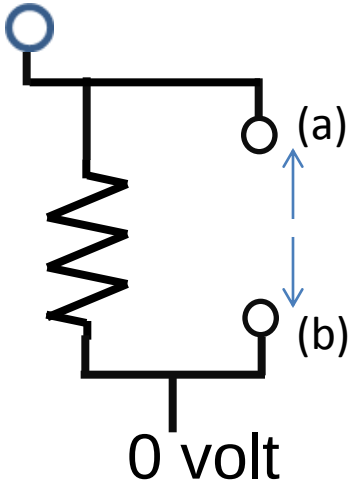
Vacuum pump



Use the voltage difference between location (a) and (b) to turn on a motor.

No voltage difference

Motor is **not** ON

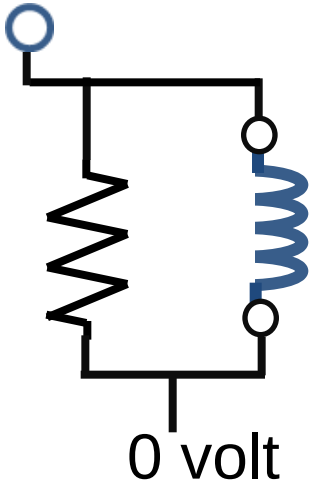
Voltage difference

Motor is ON

Generate an action and make changes in the process

- Simplest action to make a change in the process
  - Turn on a motor

Vacuum pump



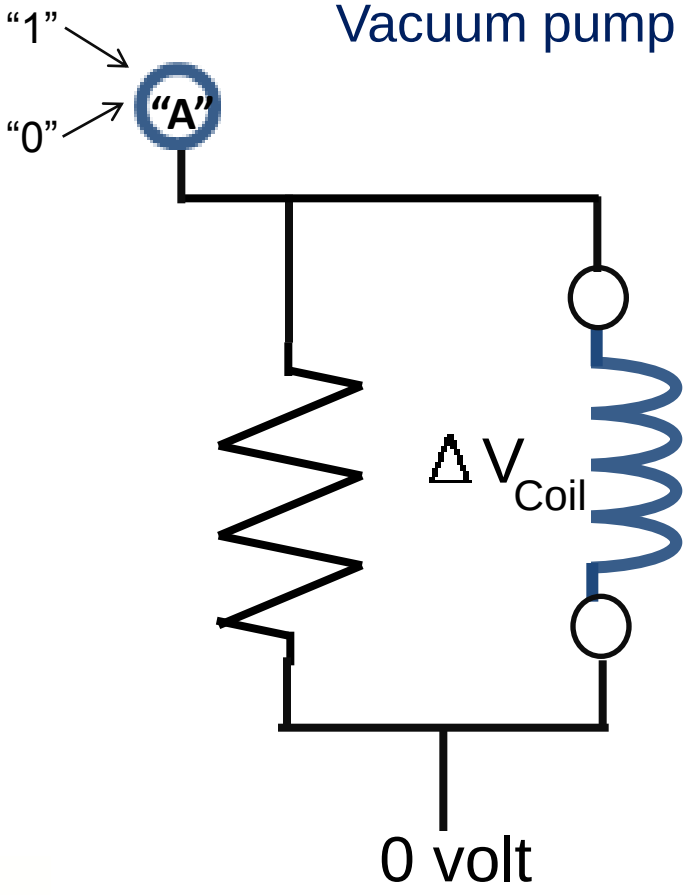
No voltage difference across the coil
No magnetism around the coil

Voltage difference across the coil
Magnetism around the coil

Generate an action and make changes in the process

- Simplest action to make a change in the process
  - Turn on a motor

Vacuum pump



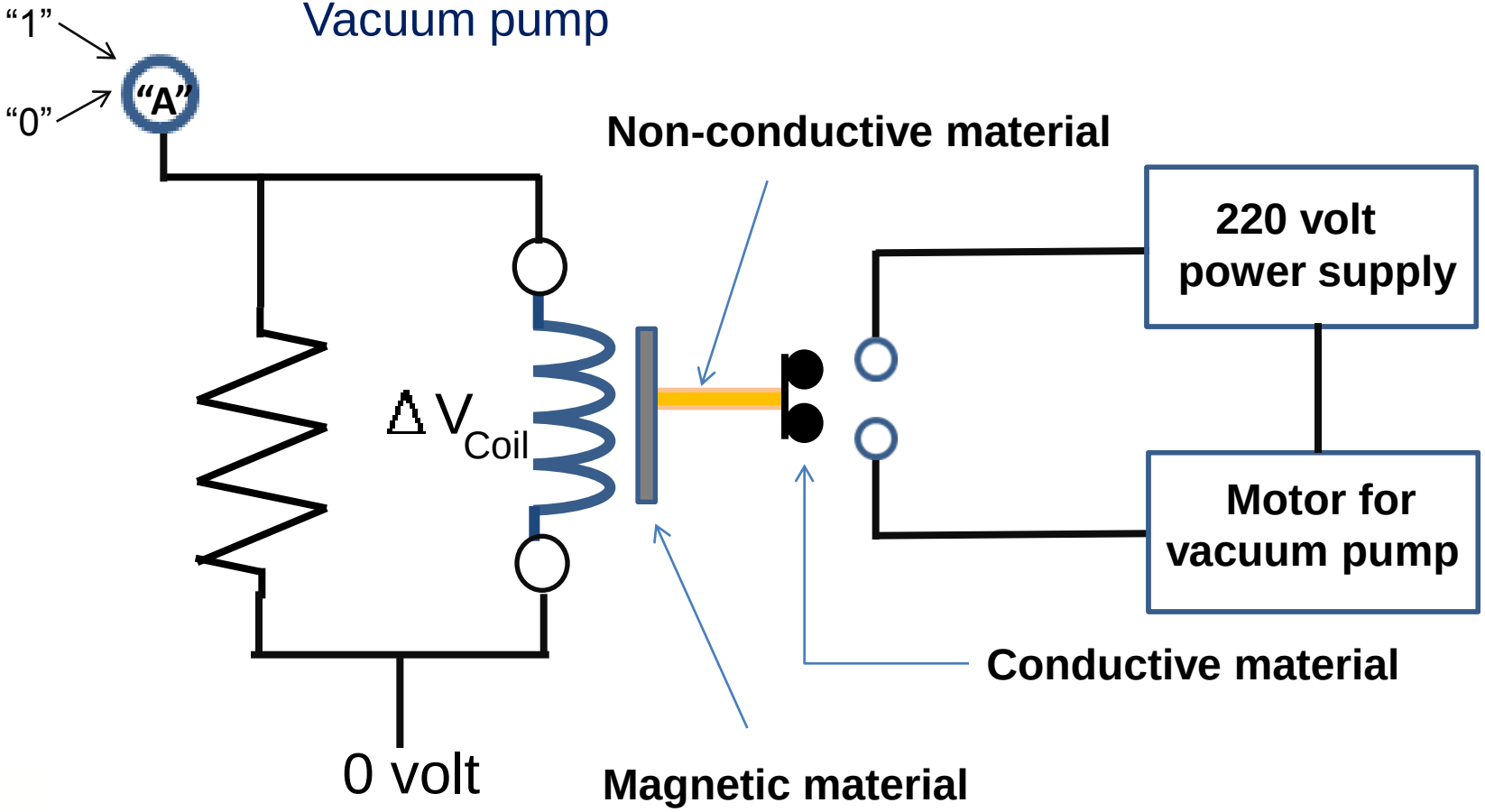
If terminal "**A**" is at Logic "0"
No magnetism around the coil

If terminal "**A**" is at logic "1"
Magnetism around the coil

Generate an action and make changes in the process

- Simplest action to make a change in the process
  - Turn on a motor

Vacuum pump



Generate an action and make changes in the process

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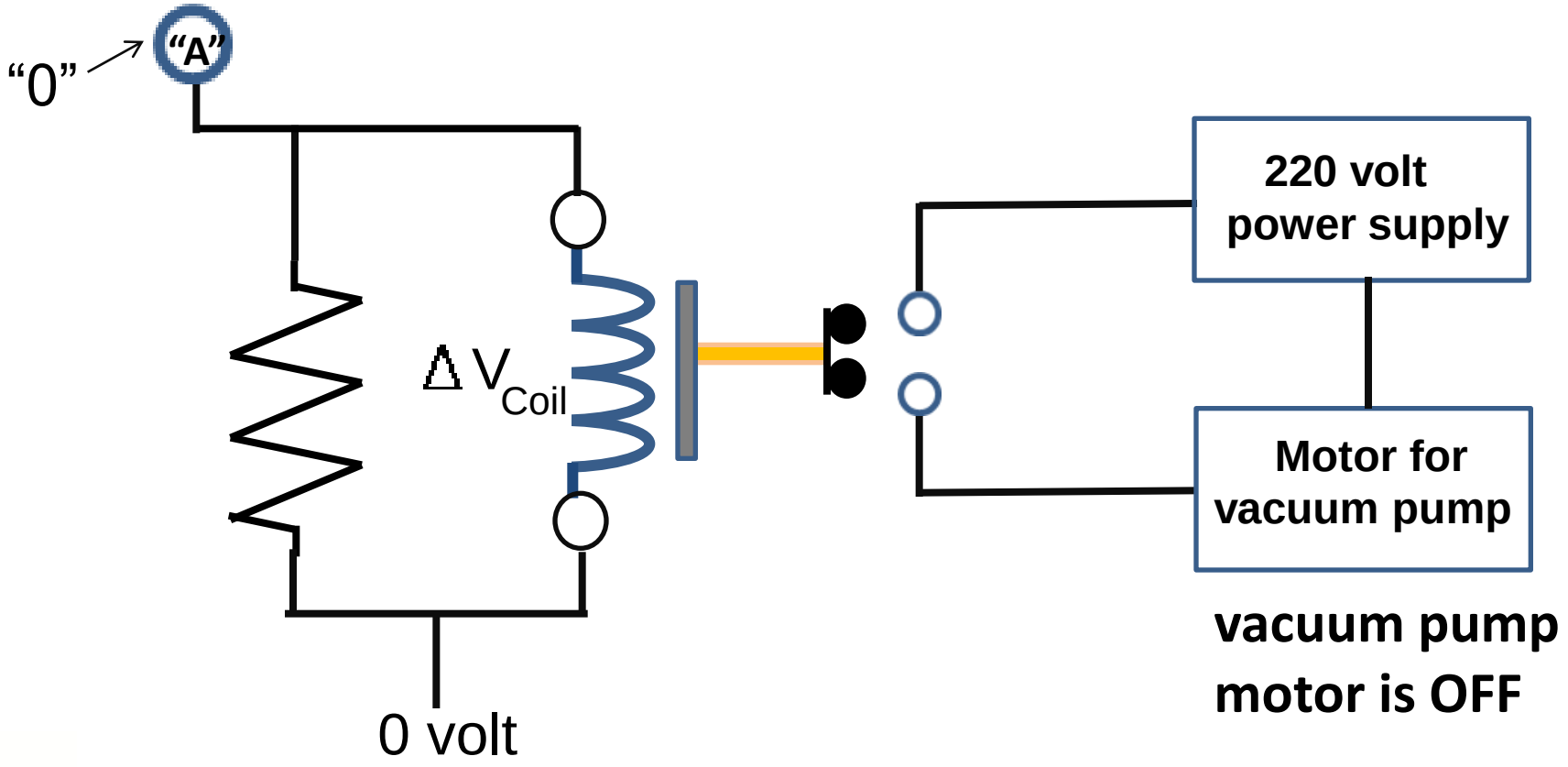
Vacuum pump



Generate an action and make changes in the process

- Simplest action to make a change in the process
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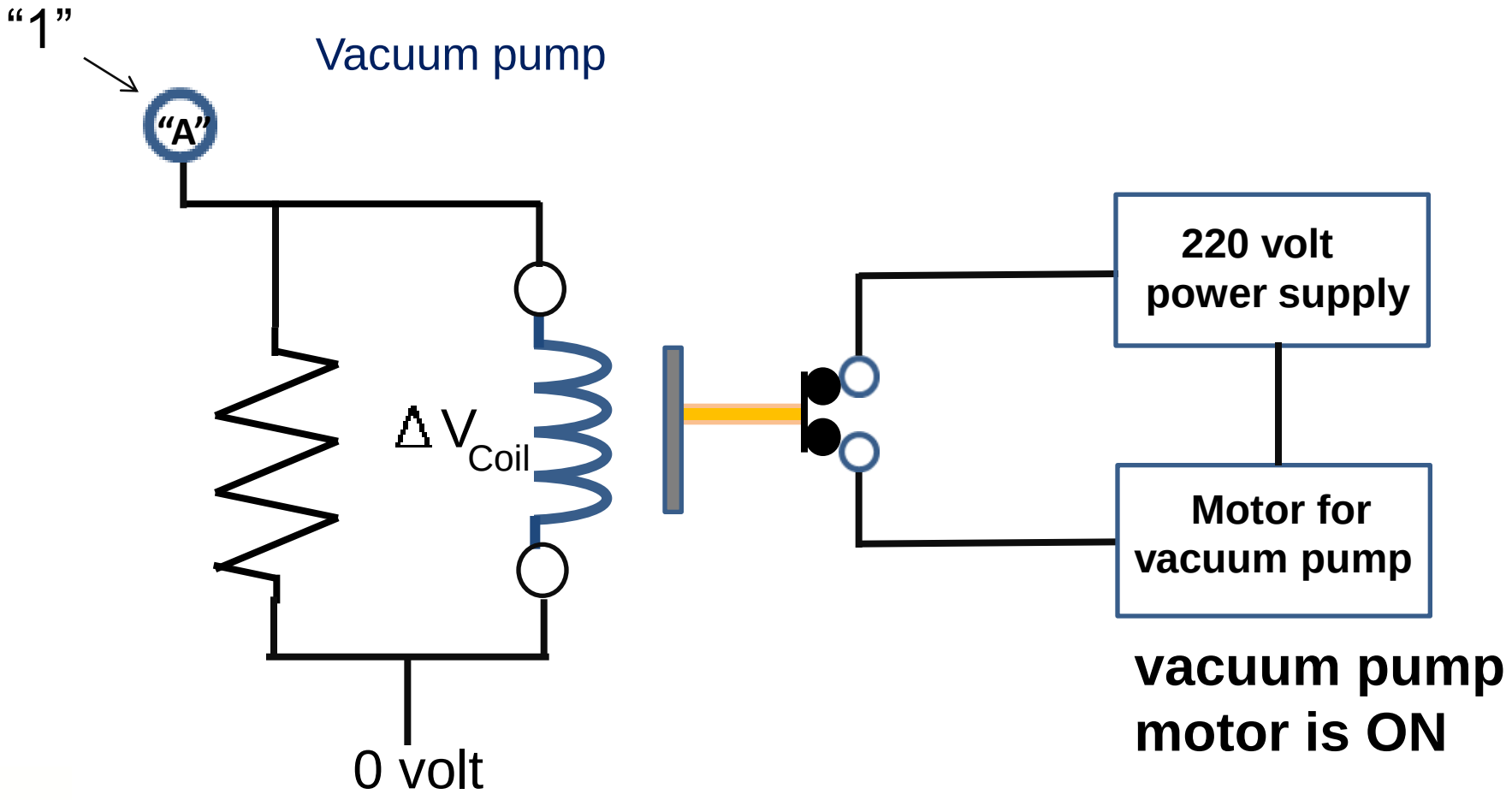

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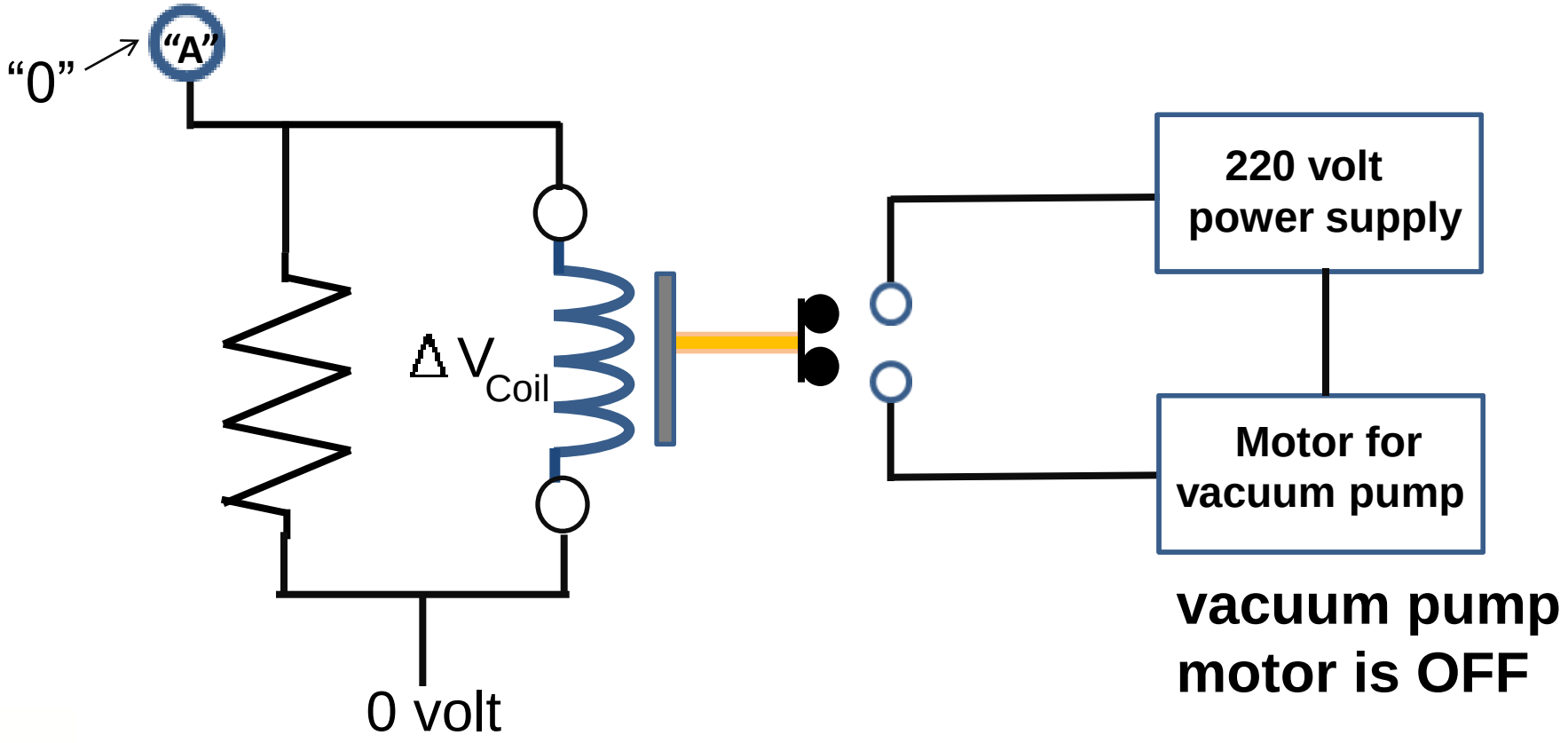
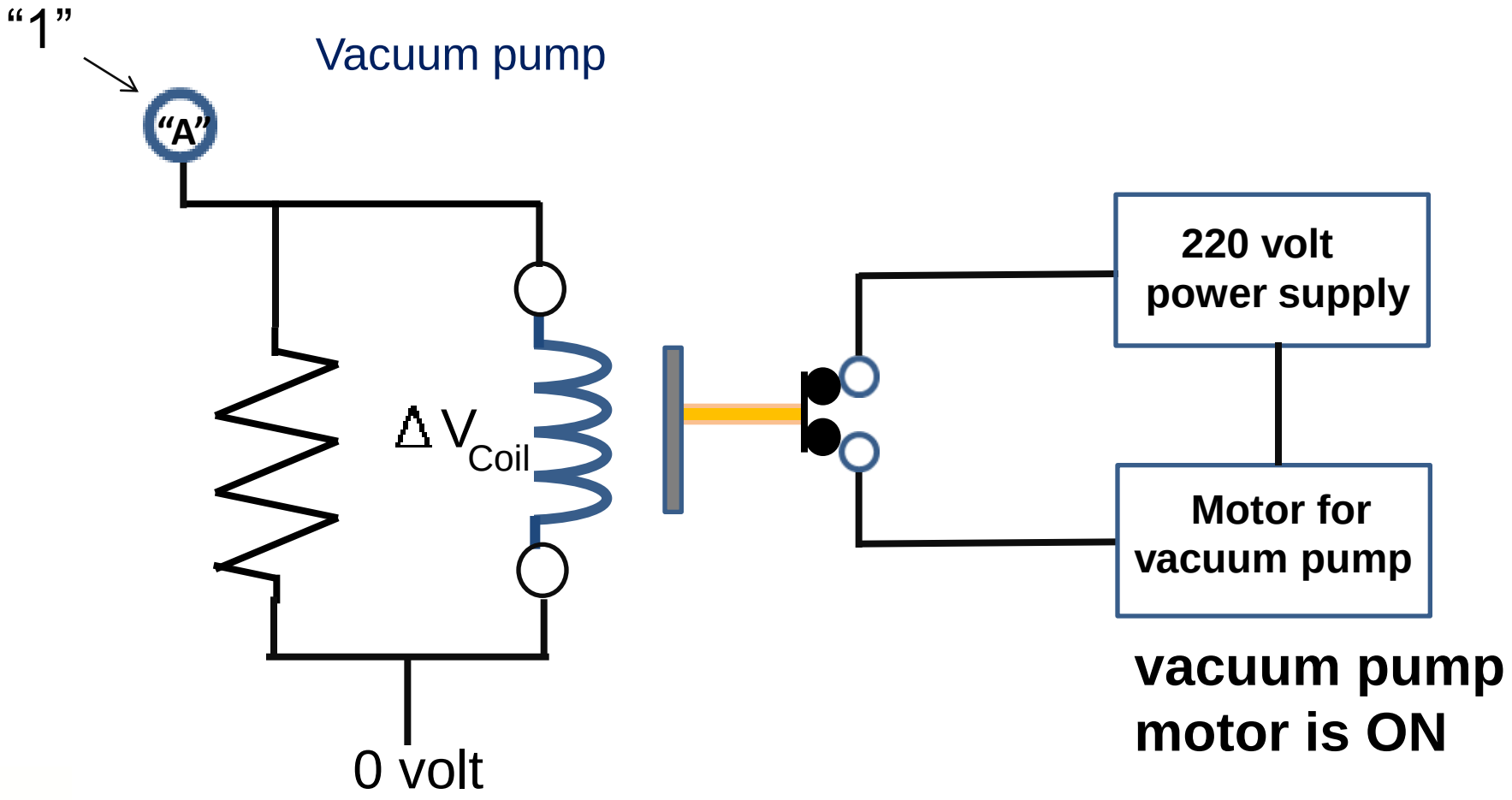
Vacuum pump



Generate an action and make changes in the process

- Simplest action to make a change in the process
  - Turn on a motor



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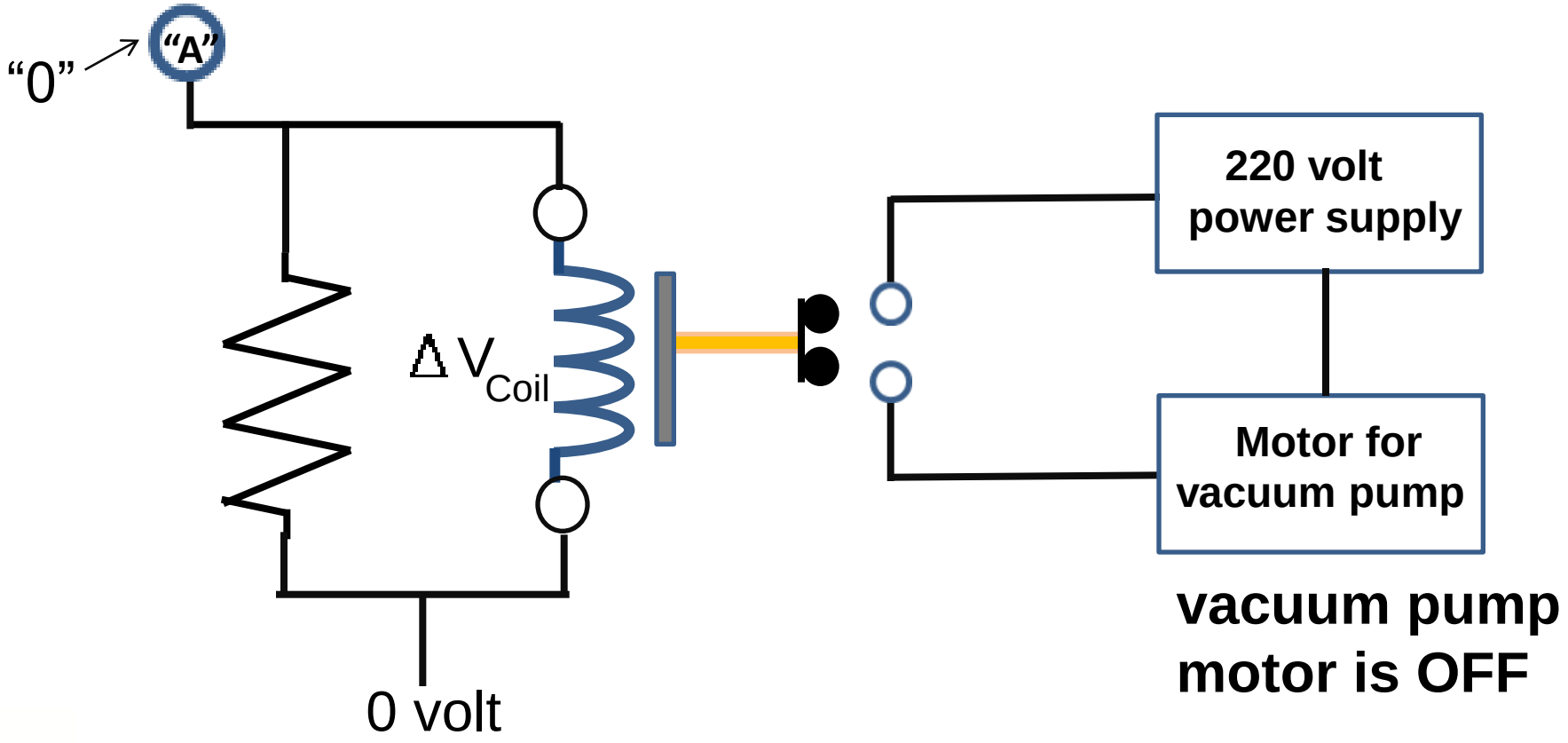

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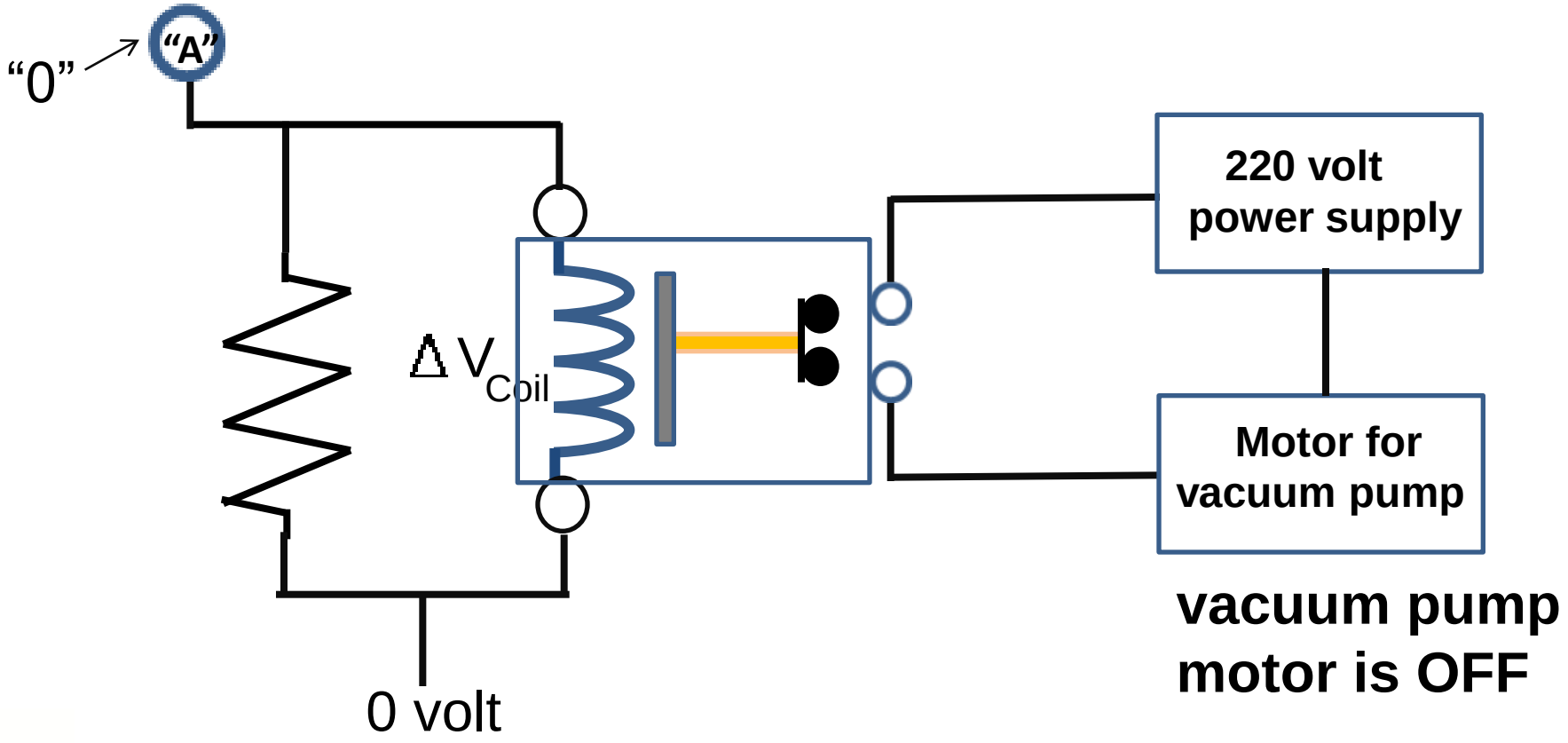

Generate an action and make changes in the process

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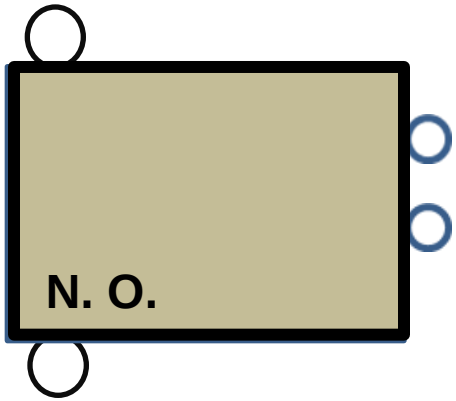
    Vacuum pump



Normally Open Relay

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- Sense the process and make measurements
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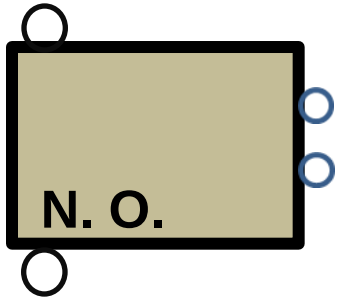
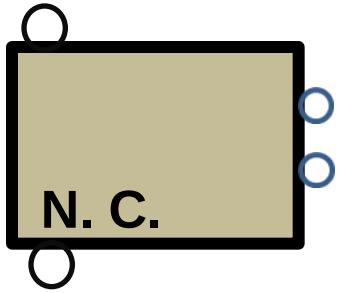
Automation Characteristics of Mechatronics Subsystems

- Sense the process
  - Start P.B.
  - PSH
  - $\overline{\text{Start P.B.}}$
  - $\overline{\text{PSH}}$
- Think about current status of process and make decisions.
- Generate an action



Normally Open Relay

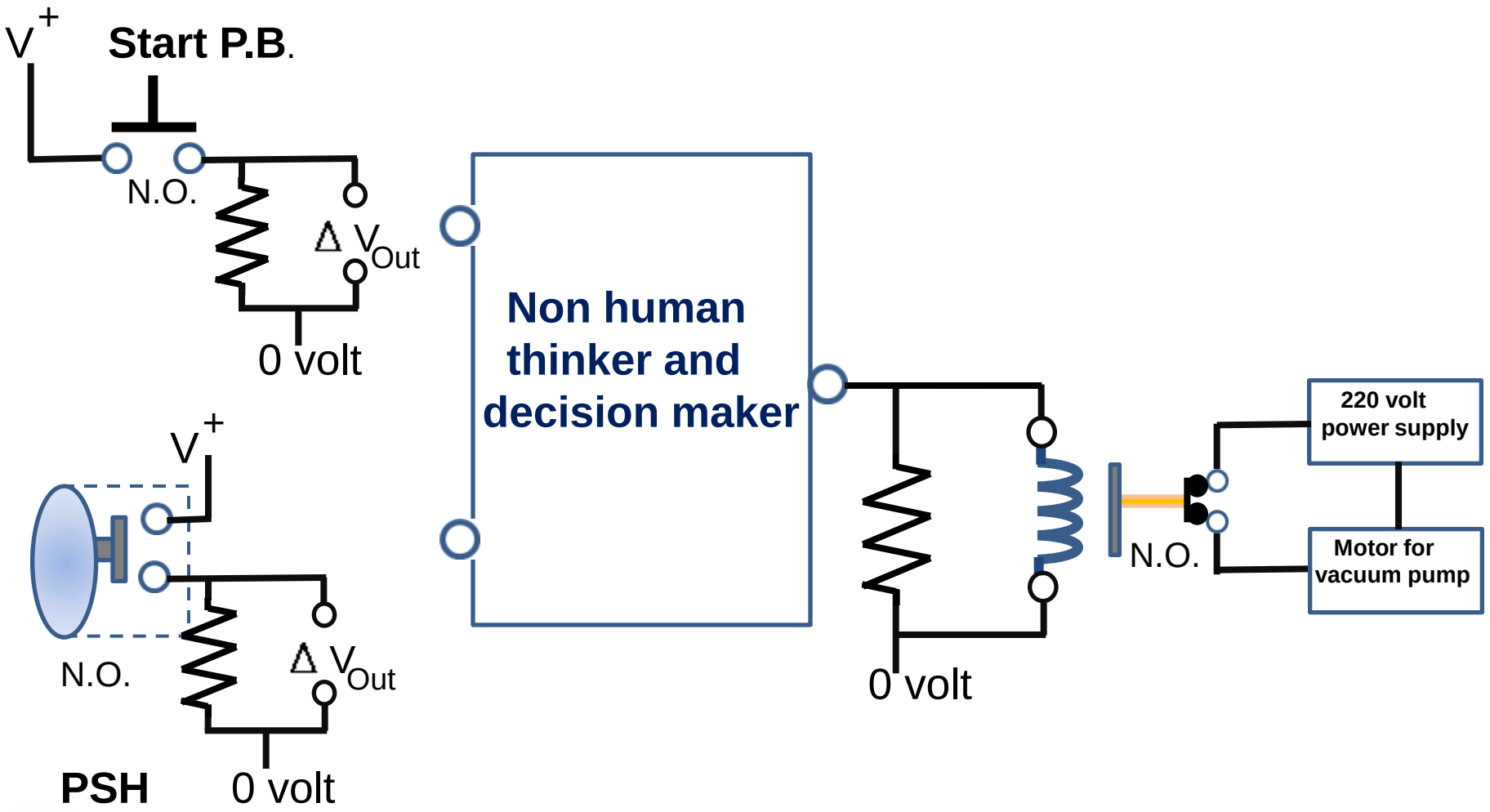


Normally Closed Relay

Think about current status of process and make decision.

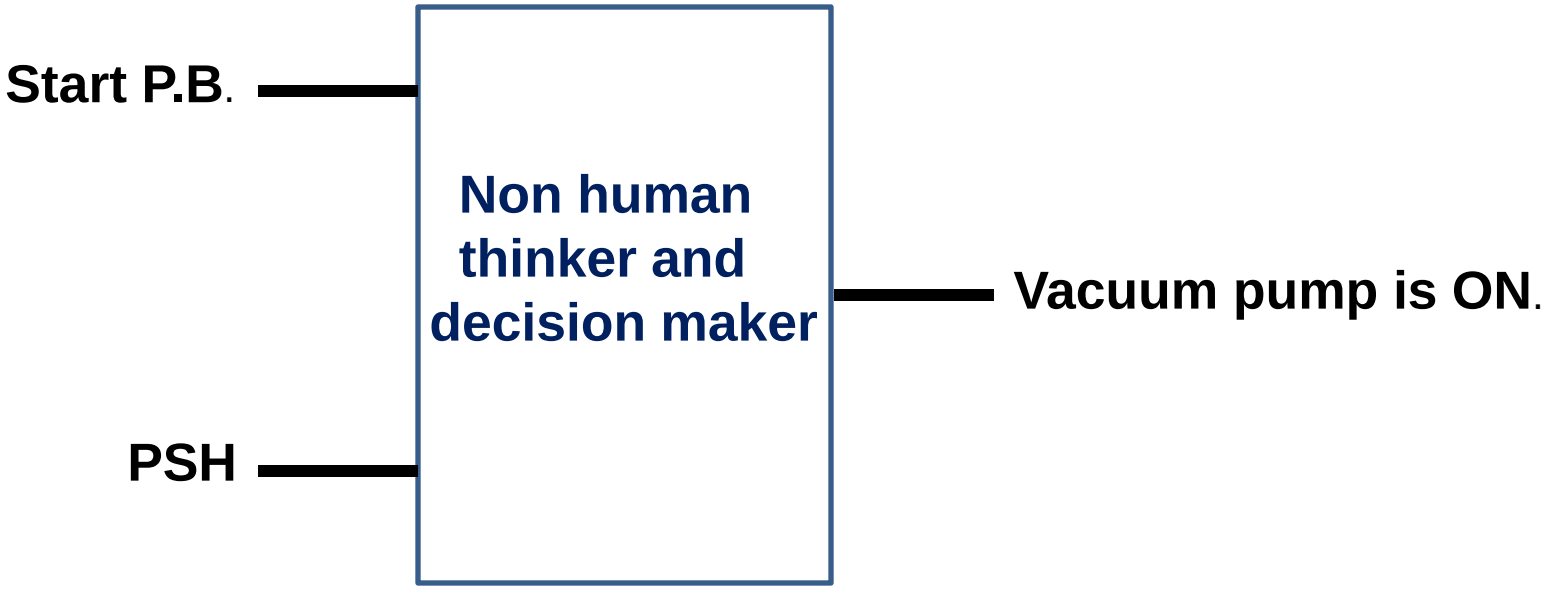
Think about current status of process and make decision.

- Simplest decision is when to turn on the vacuum pump.



Think about current status of process and make decision.

- Simplest decision is when to turn on the vacuum pump.



The vacuum pump should be ON when “Start” is at logic “1”

AND

The pressure gauge is in alarm (at logic “1”)

Think about current status of process and make decision.

- AND Concept:
  - The AND is a mathematical concept that humans use all the time to think logically.
  - The AND is so important that we have;
    - built devices that can perform this mathematical concept.
    - created an algebra, Boolean Algebra, that uses it.

The vacuum pump should be ON when “Start” is at logic “1”

AND

The pressure gauge is in alarm (at logic “1”)

Think about current status of process and make decision.

- The two rules that govern the AND Concept:

Rule #1: The output of an AND device is at logic “1” only when all of the inputs to the device are at logic “1”

Rule #2: The output of an AND device is at logic “0” when Rule #1 is not in play.

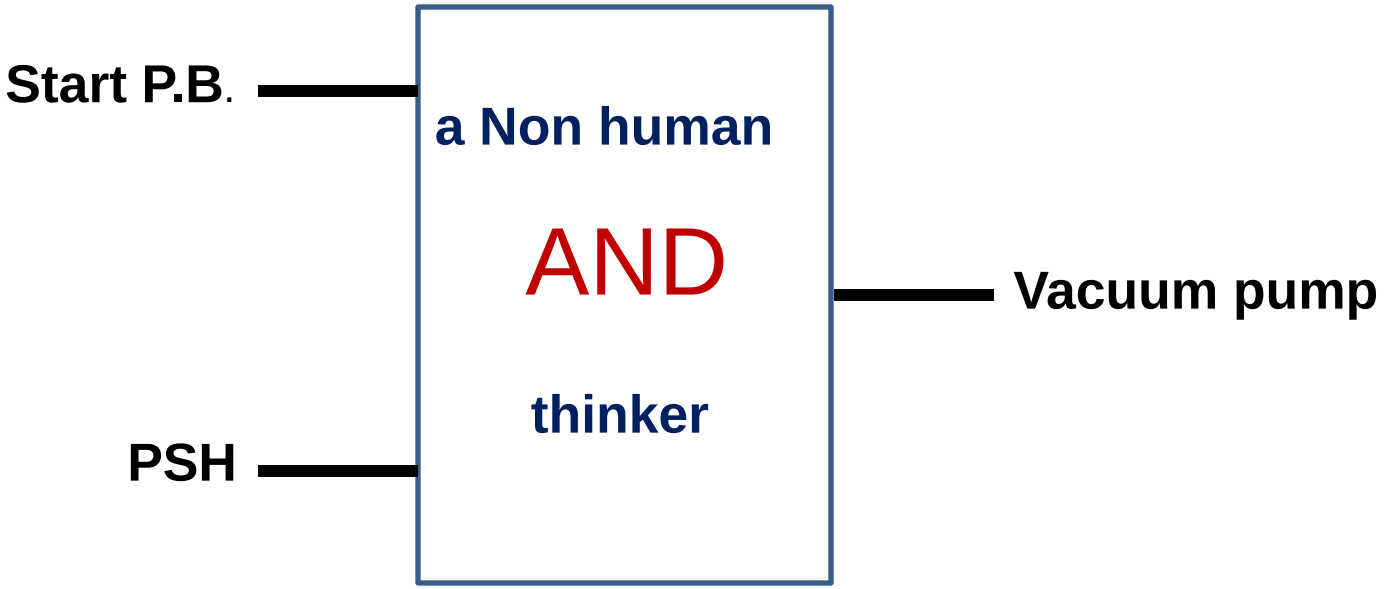
The vacuum pump should be ON when “Start” is at logic “1”

AND

The pressure gauge is in alarm (at logic “1”)

Think about current status of process and make decision.

- Simplest decision is when to turn on the vacuum pump.



The vacuum pump should be ON when “Start” is at logic “1”
AND
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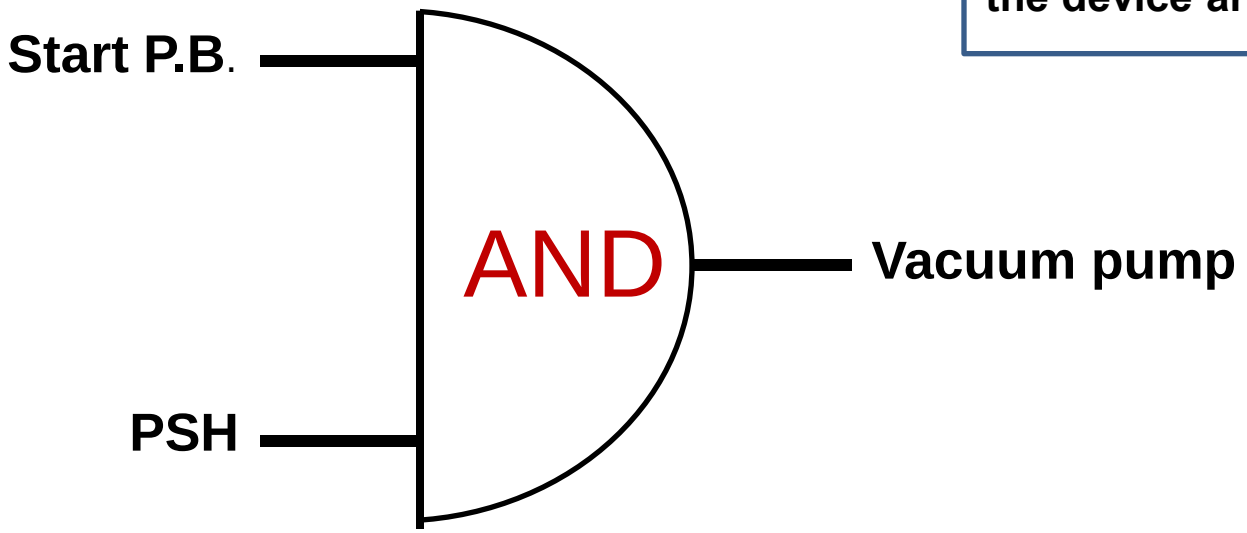
Think about current status of process and make decision.

- Simplest decision is when to turn on the vacuum pump.

Rule #1: **The output of an AND device is at logic "1" only when all of the inputs to the device are at logic "1"**

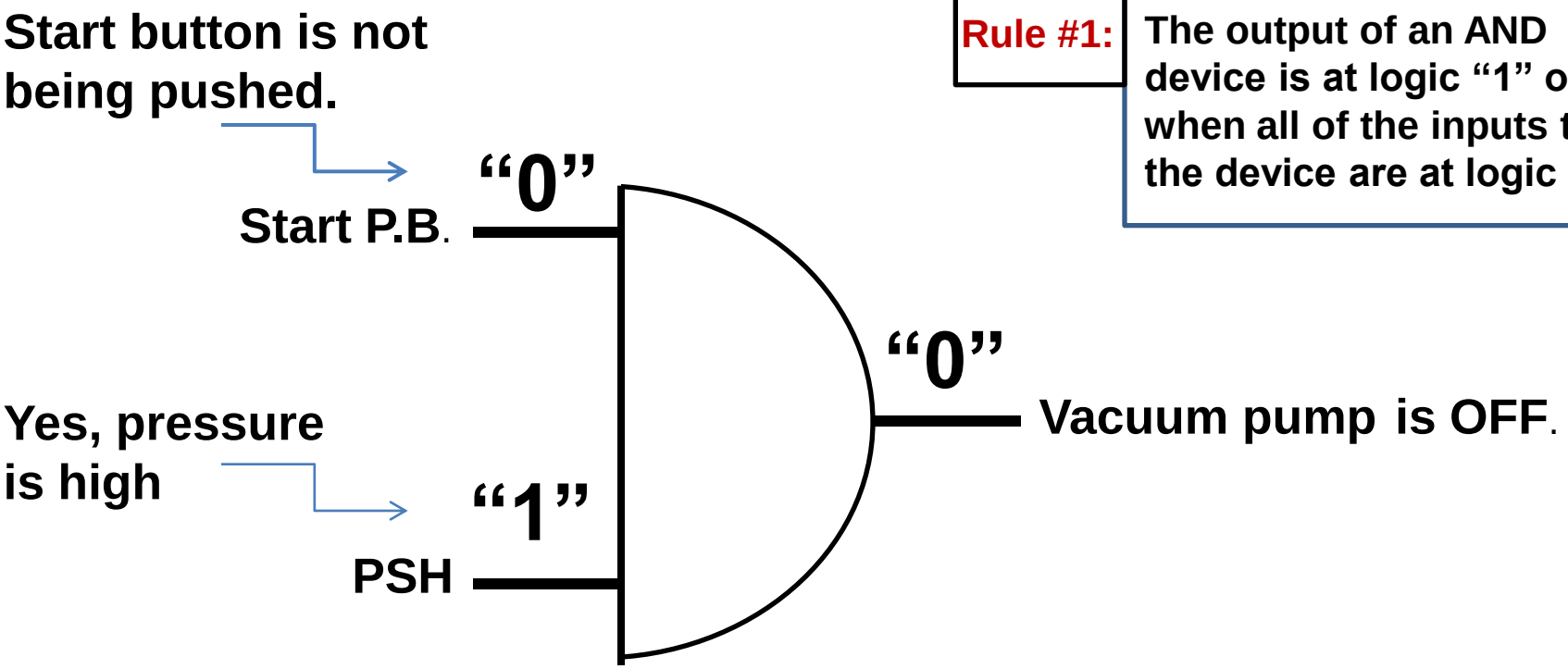


The vacuum pump should be ON when "Start" is at logic "1"
AND
The pressure gauge is in alarm (at logic "1")

Think about current status of process and make decision.

- Simplest decision is when to turn on the vacuum pump.

Rule #1: **The output of an AND device is at logic "1" only when all of the inputs to the device are at logic "1"**



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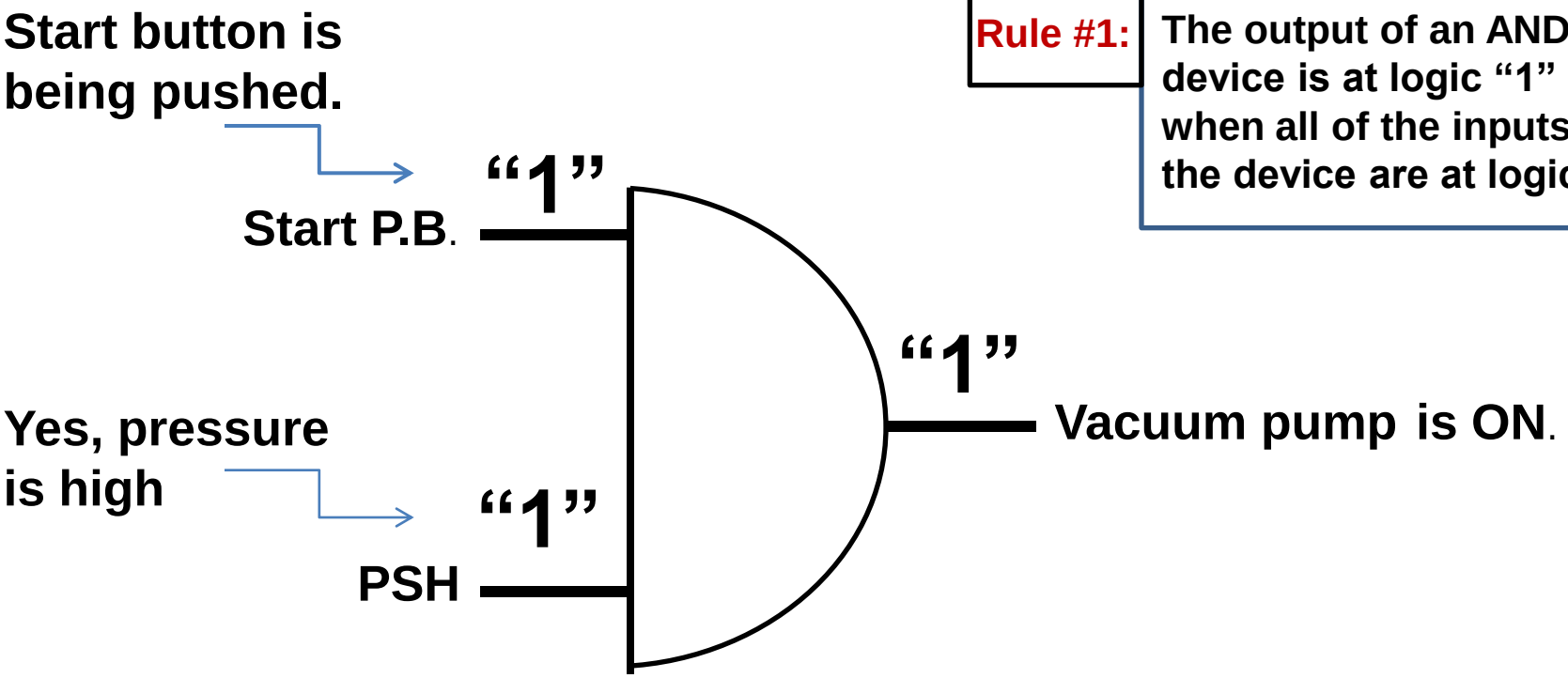

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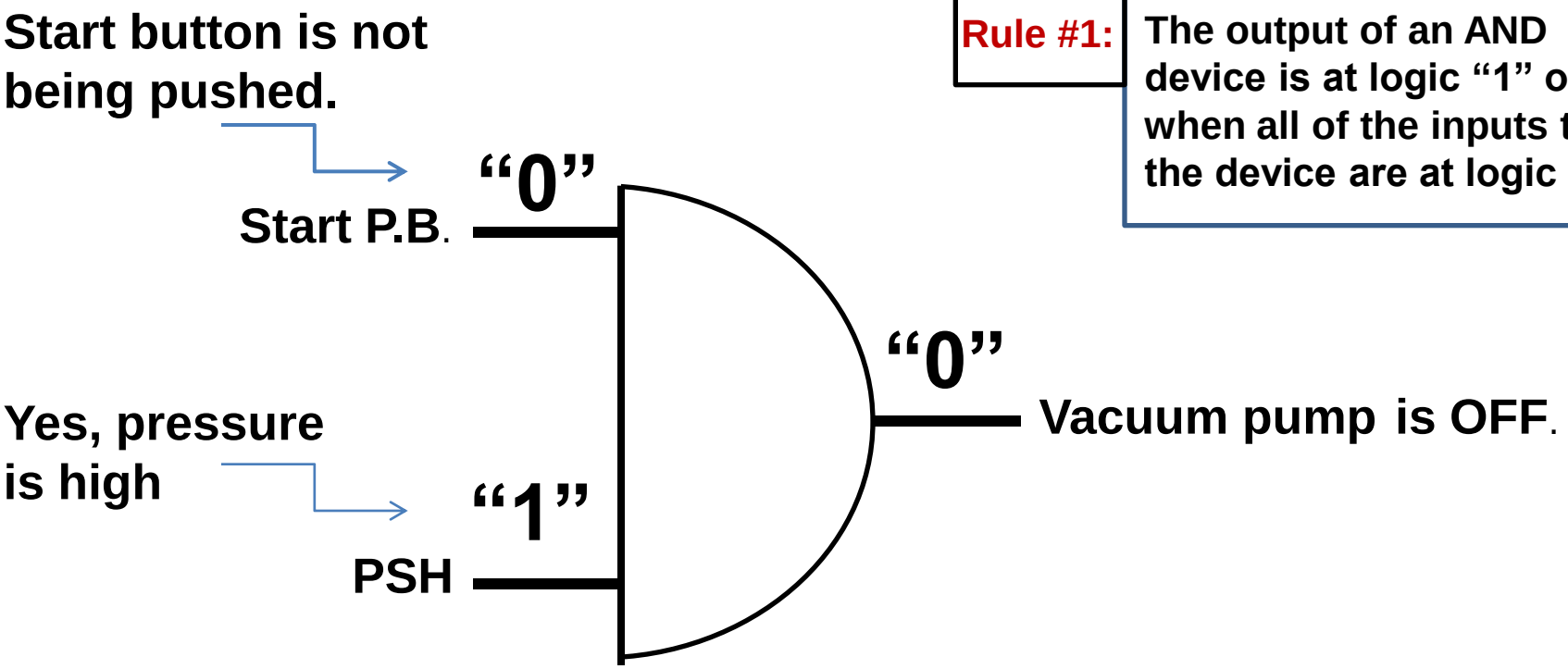


The vacuum pump should be ON when "Start" is at logic "1"

AND

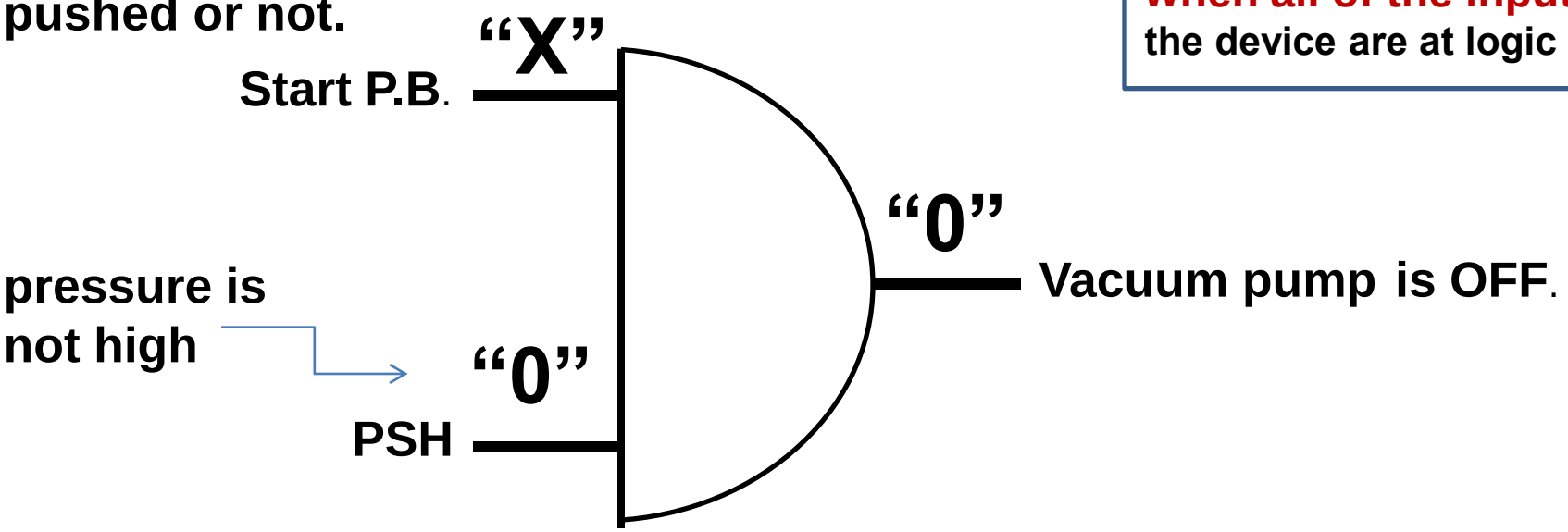
The pressure gauge is in alarm (at logic "1")

Think about current status of process and make decision.

- Simplest decision is when to turn on the vacuum pump.

It does not matter if Start button is pushed or not.

Rule #1: **The output of an AND device is at logic "1" only when all of the inputs to the device are at logic "1"**



The vacuum pump should be ON when "Start" is at logic "1"

AND

The pressure gauge is in alarm (at logic "1")

Think about current status of process and make decision.

- Complete rule set for non-human AND thinkers

Rule #1:	**The output of an AND device is at logic "1" only when all of the inputs to the device are at logic "1"**
Rule #2:	**The output of an AND device is at logic "0" when Rule #1 is not in play.**
Rule #3:	**If the non-human AND thinker breaks either Rule #1 or Rule #2, it is removed from system and scraped.**

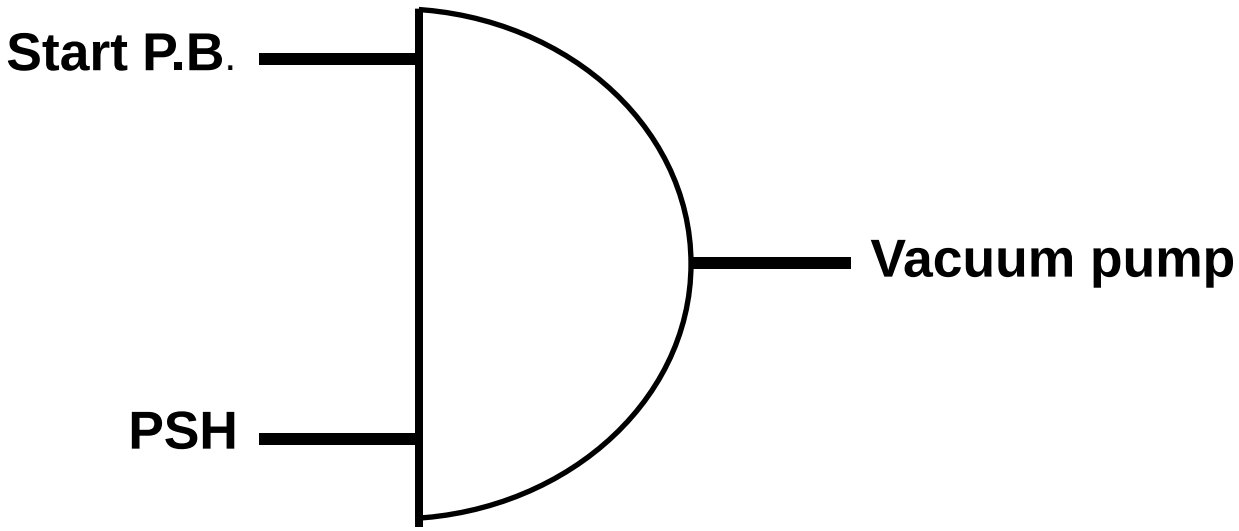
Note: (Something to think about)

When humans **AND** thinkers break Rule #1 or Rule #2, we say they didn't understand and just let them do it wrong again.

FLATE

Think about current status of process and make decision.

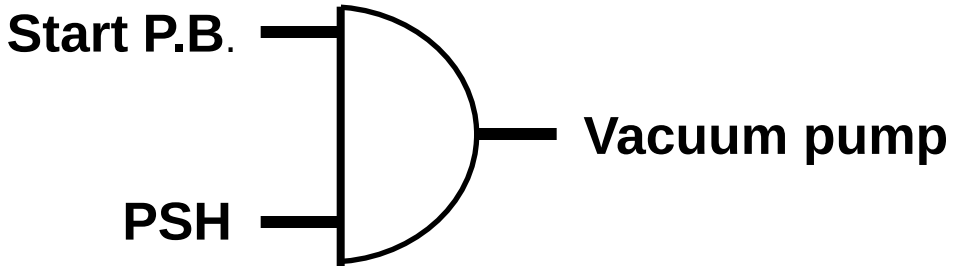
- Function Diagram for Magatronic process segment



If the Megatronic system performs this function what will happen?

Think about current status of process and make decision.

- Function Diagram for Magatronic process segment



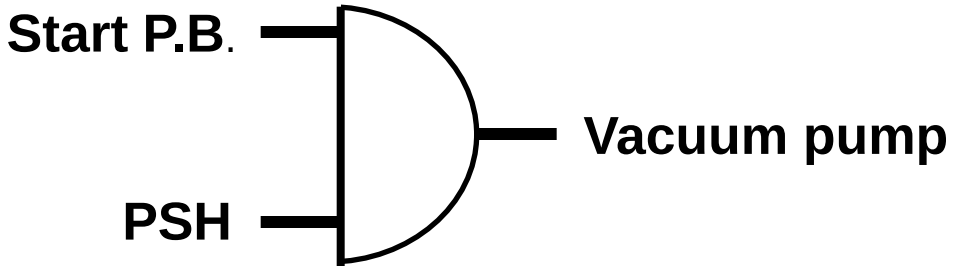
If the Megatronic system performs this function what will happen?

The Megatronic system will not keep the pump running after the start pushbutton has been released!

How do we fix that problem?

Think about current status of process and make decision.

- Function Diagram for Magatronic process segment

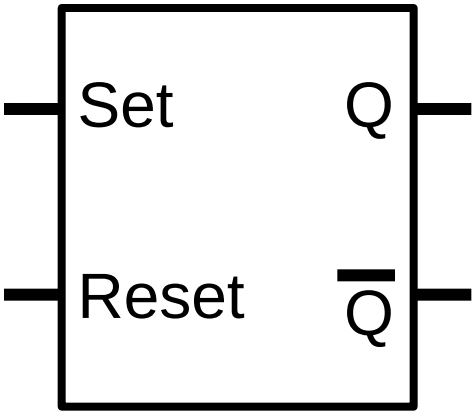


The Megatronic system must include a non human memory device.

After we make one and install it into the Megatronic system, how do use use it?

Think about current status of process and make decision.

- Symbol for “1 bit” non human memory device



Rules of Operation:

Rule #1: **If the Set input is at logic “1” the Q output goes to logic “1”**

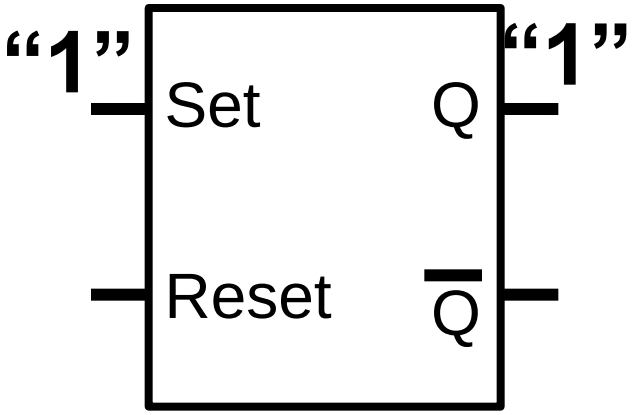
Rule #2: **The Q output remains at logic “1” even after the Set input returns to logic “0”**

Rule #3: **If the Reset input is at logic “1” the Q output goes to logic “0”**

Rule #4: **The Q output remains at logic “0” even after the Reset input returns to logic “0”**

Think about current status of process and make decision.

- Symbol for “1 bit” non human memory device



Rule #1: **If the Set input is at logic “1” the Q output goes to logic “1”**

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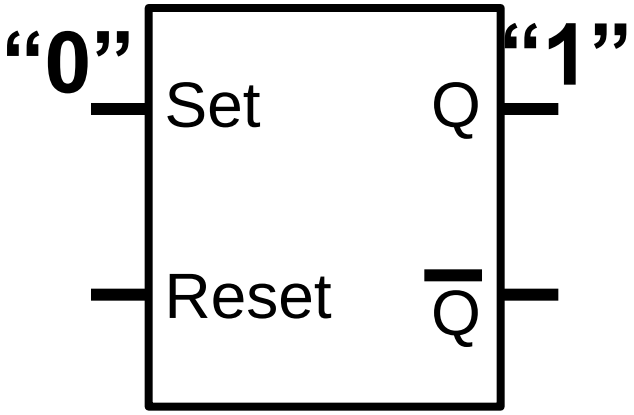
Rules of Operation:

Think about current status of process and make decision.

- Symbol for “1 bit” non human memory device



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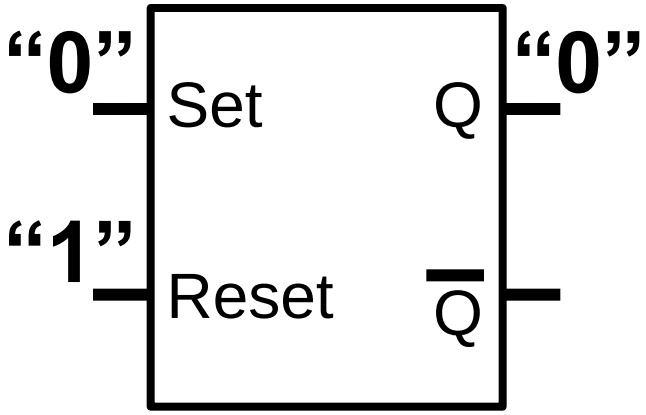
Rule #3: **If the Reset input is at logic “1” the Q output goes to logic “0”**

Rules of Operation:

Think about current status of process and make decision.

- Symbol for “1 bit” non human memory device



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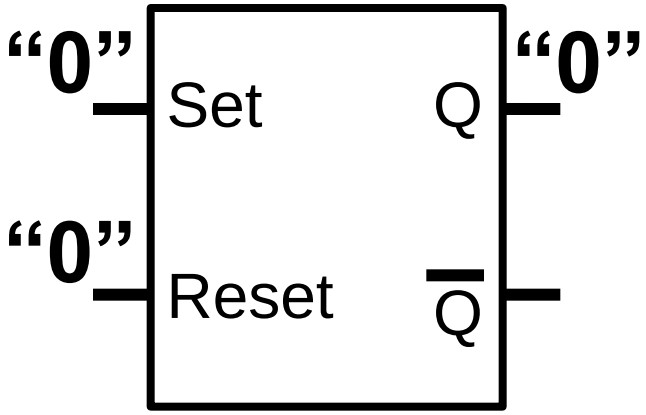
Think about current status of process and make decision.

- Symbol for “1 bit” non human memory device



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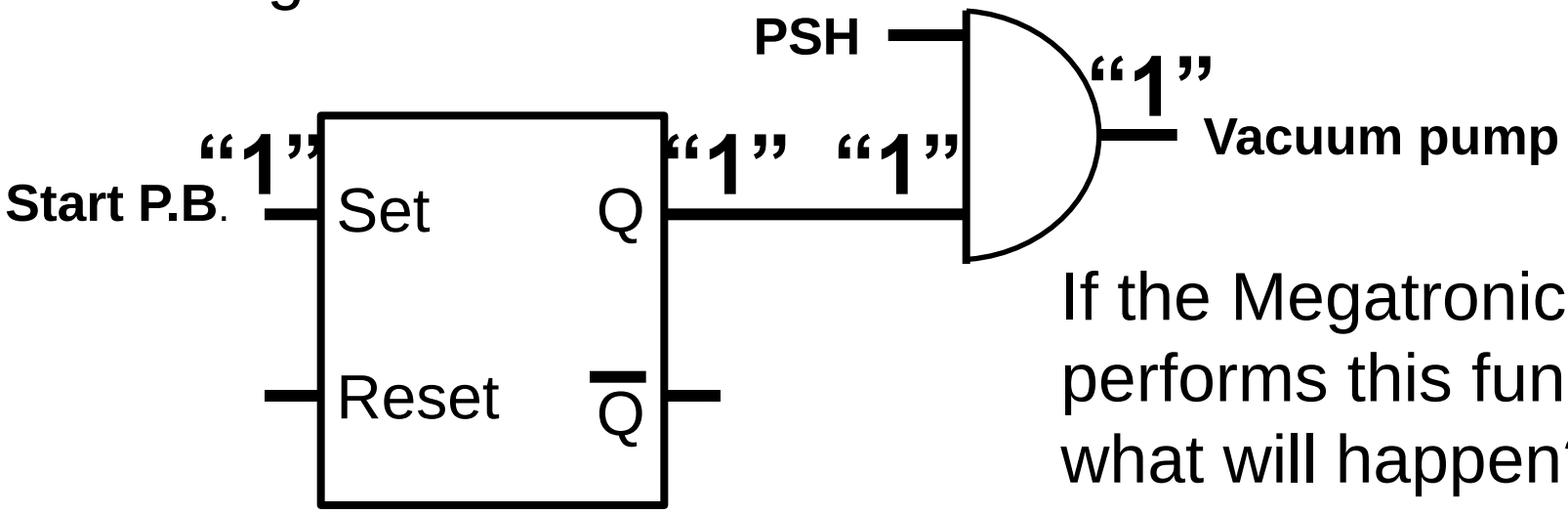
Think about current status of process and make decision.

- Revised Function Diagram for Magatronic process segment

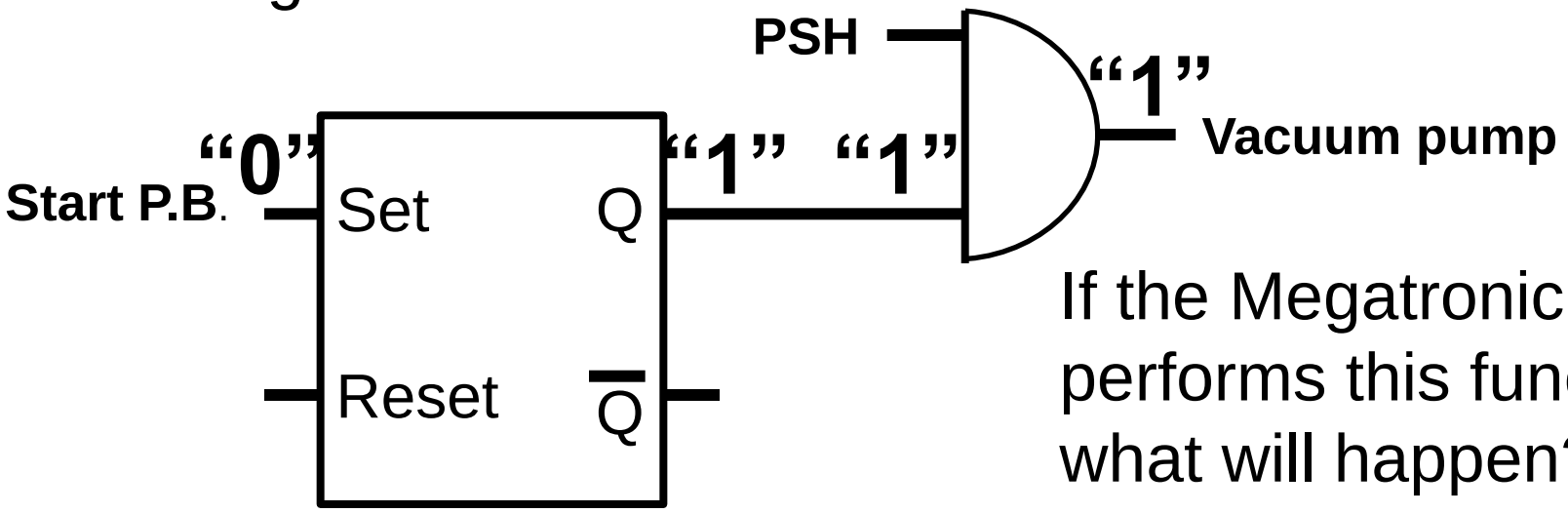


If the Megatronic system performs this function what will happen?

The Mechatronic system will keep the pump running after the start pushbutton has been released!

Think about current status of process and make decision.

- Revised Function Diagram for Magatronic process segment



If the Megatronic system performs this function what will happen?

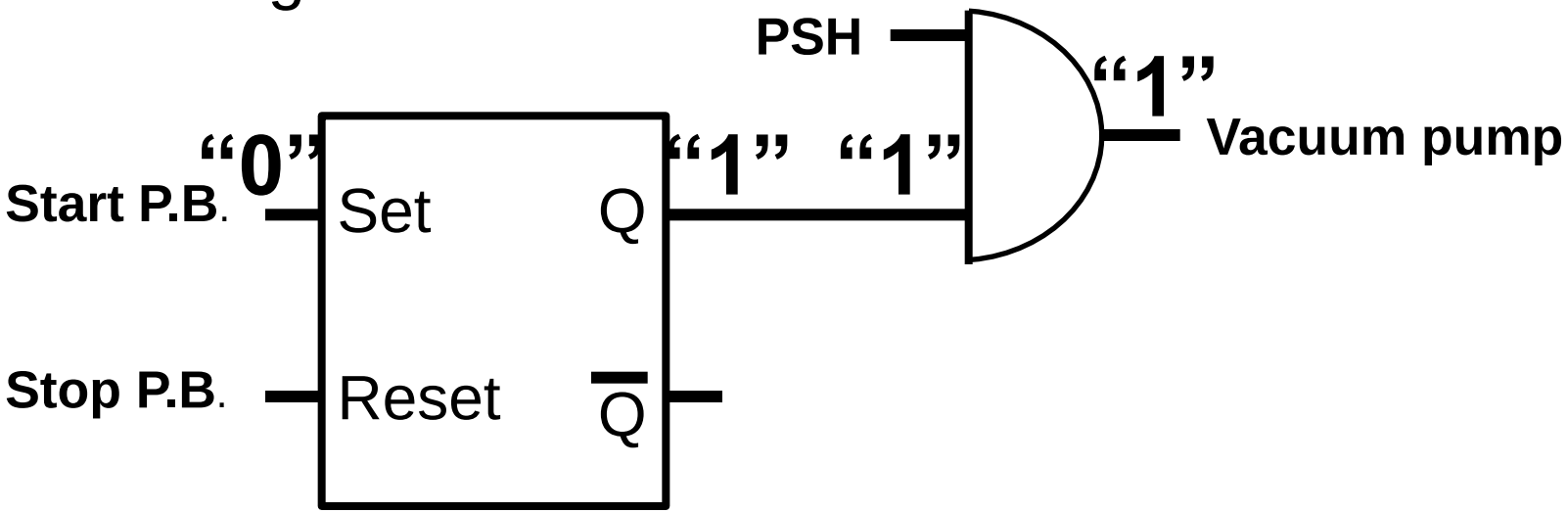
The Mechatronic system will keep the pump running after the start pushbutton has been released!

BUT there is no way for a human to turn OFF the vacuum pump!

How do we fix that problem?

Think about current status of process and make decision.

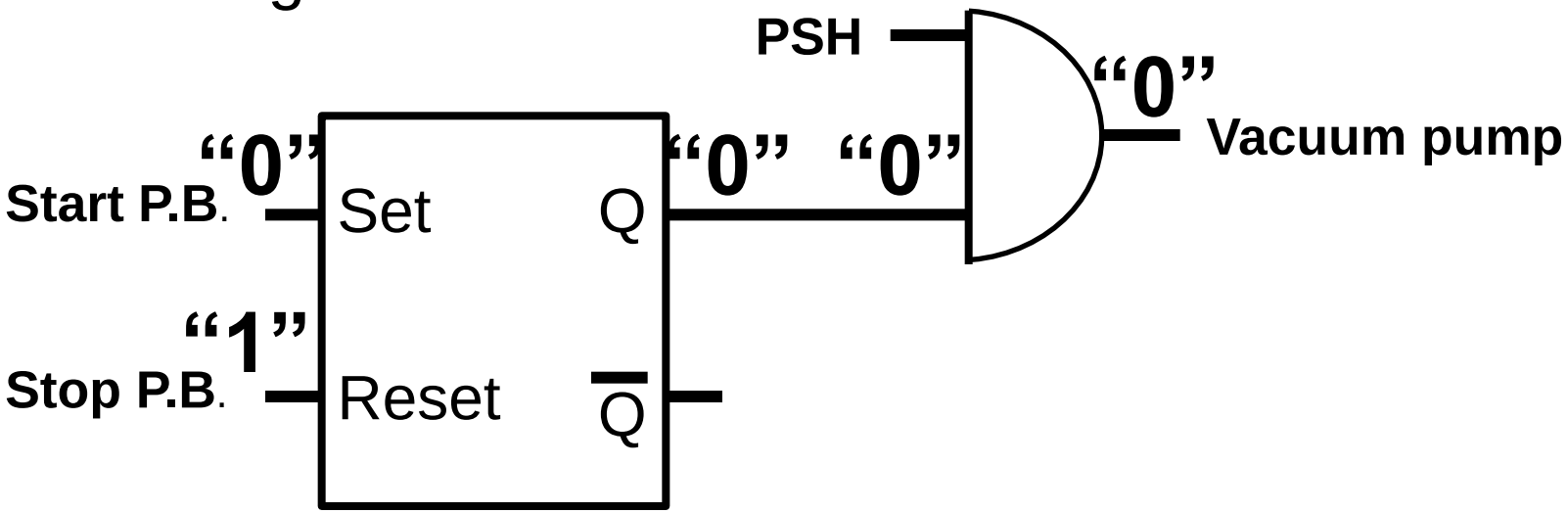
- Revised Function Diagram for Magatronic process segment



When you push the Stop button, a logic "1" appears at the Reset input. This makes a logic "0" show up at the Q output. This makes the output of the AND device go to logic"0" and the pump stops running.

Think about current status of process and make decision.

- Revised Function Diagram for Magatronic process segment



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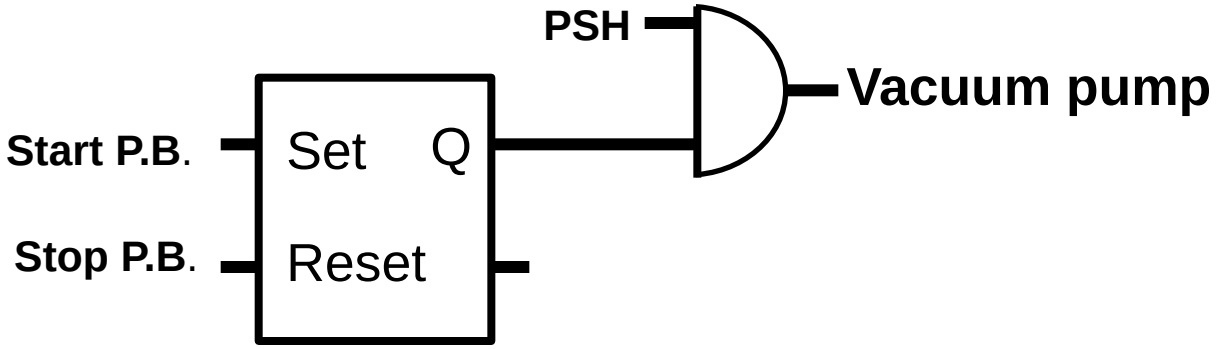
Automation Characteristics of Mechatronics Subsystems

- Sense the process and make measurements
- Think about current status of process and make decisions.
- Generate an action and make changes in the process.

Automation Characteristics of Mechatronics Subsystems

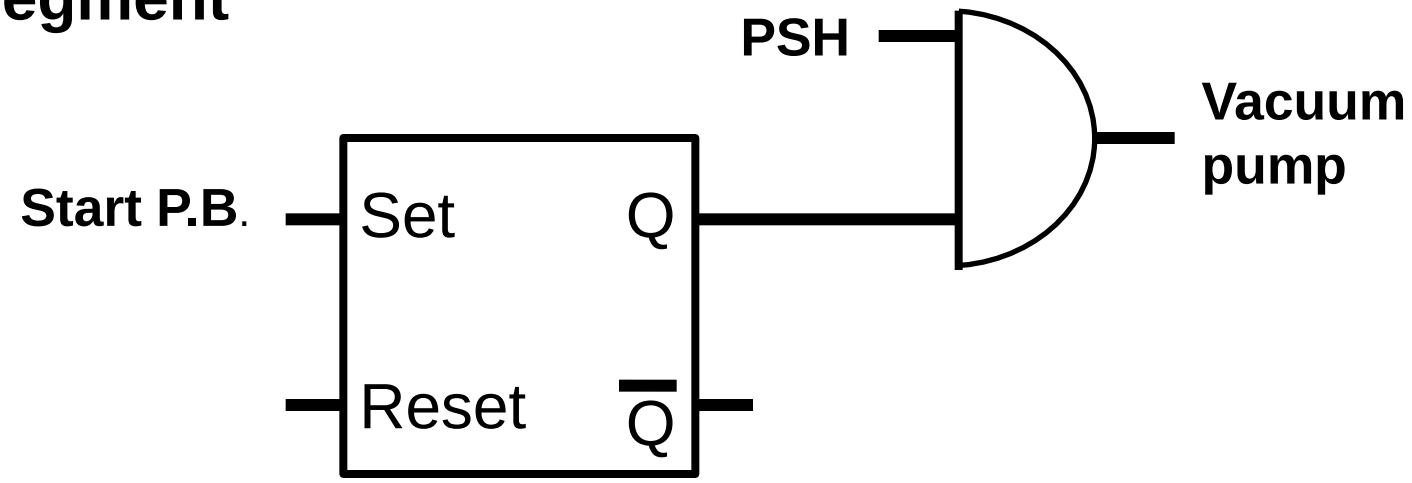
- Sense the process → Start P.B. / PSH → $\overline{\text{Start P.B.}}$ / $\overline{\text{PSH}}$

- Think about current status of process and make decisions.



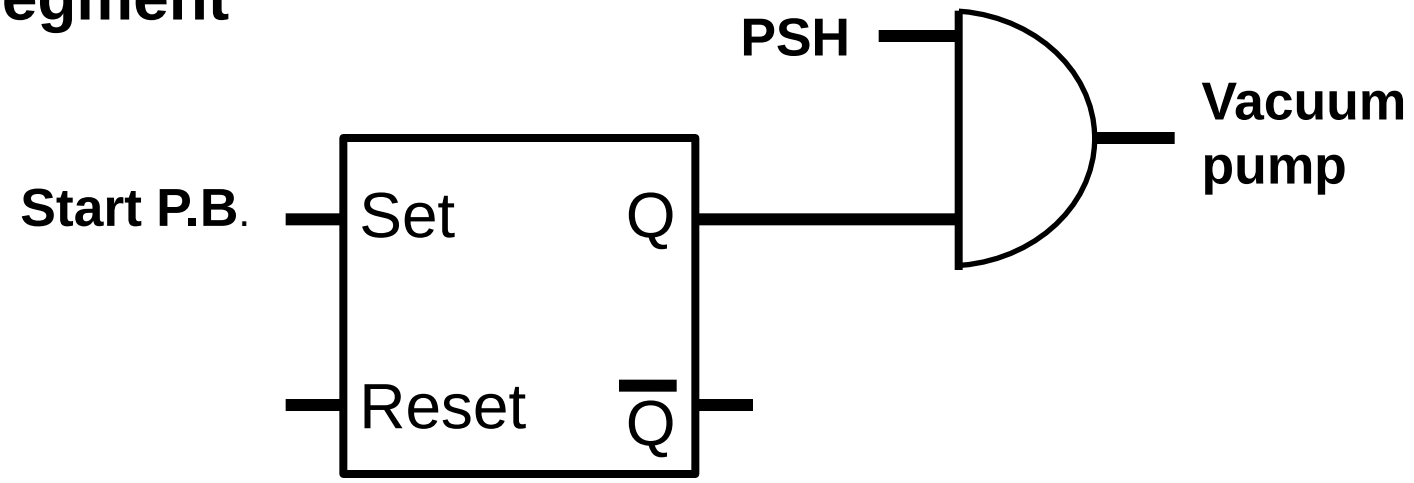
- Generate an action → **Normally Open Relay** / **Normally Closed Relay**

- **Programming a Function Diagram for Mechatronics process segment**

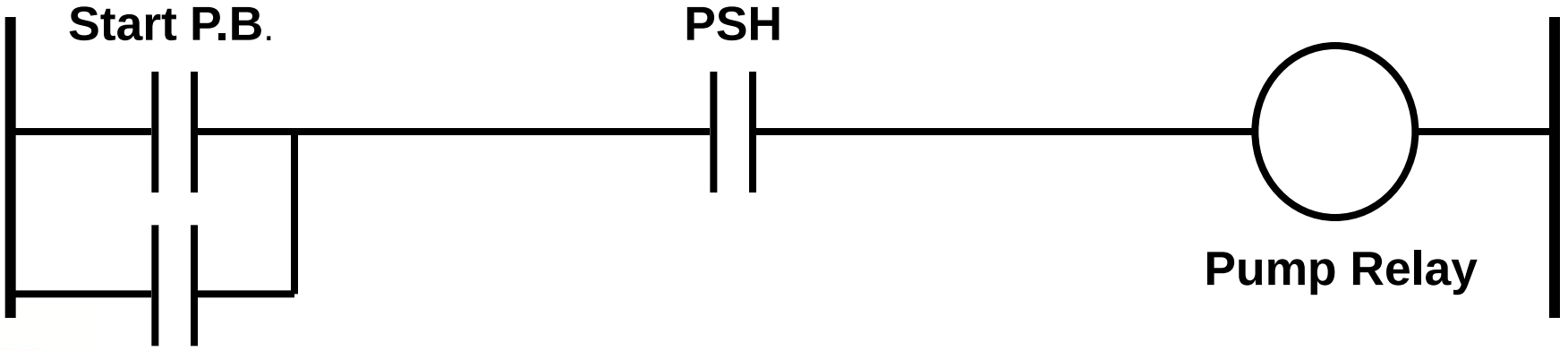


  - Magatronic systems use may different types of computer languages.
  - The Function Diagram information is programmed into the Magatronic system's computer.
  - The Ladder Logic language is often used when a Program Logic Controller is installed in the System

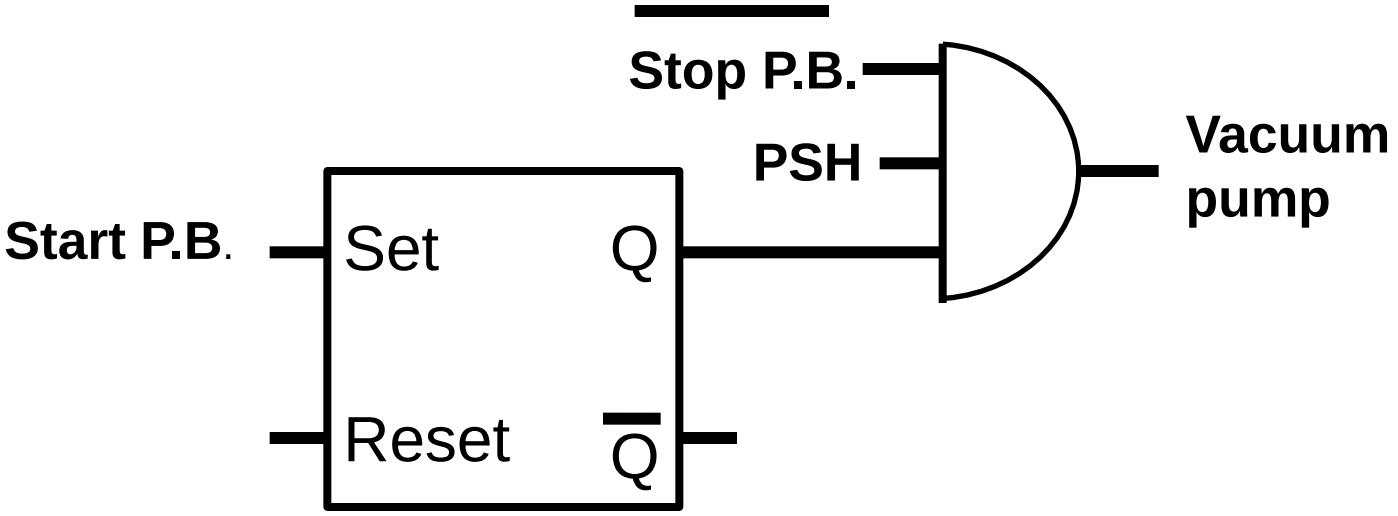
- **Programming a Function Diagram for Mechatronics process segment**



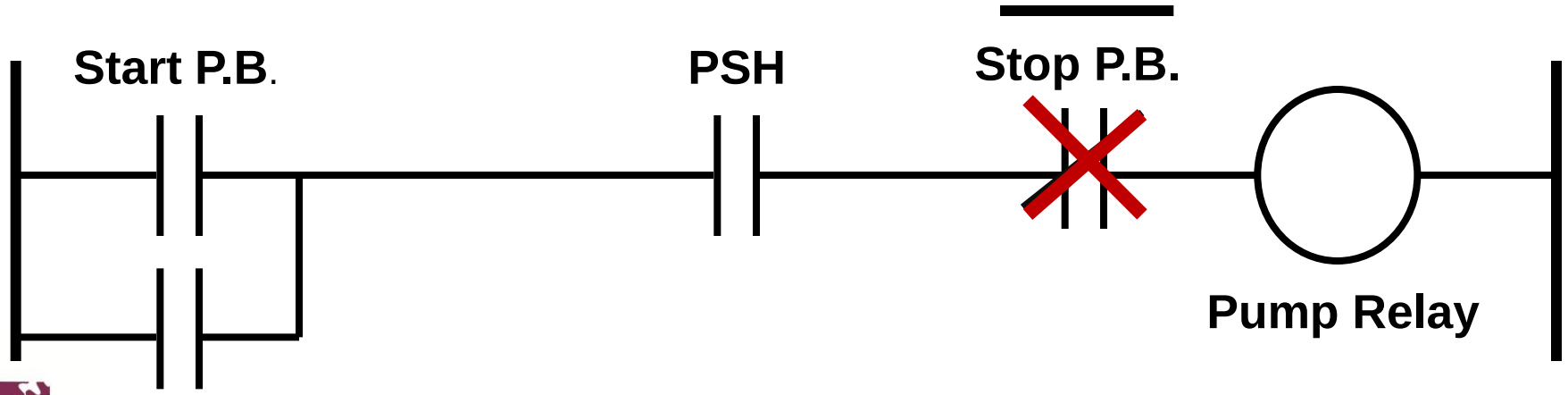
- **Ladder Logic language program for Function Diagram**



- **Modified Function Diagram**



- **Modified Ladder Logic language program**



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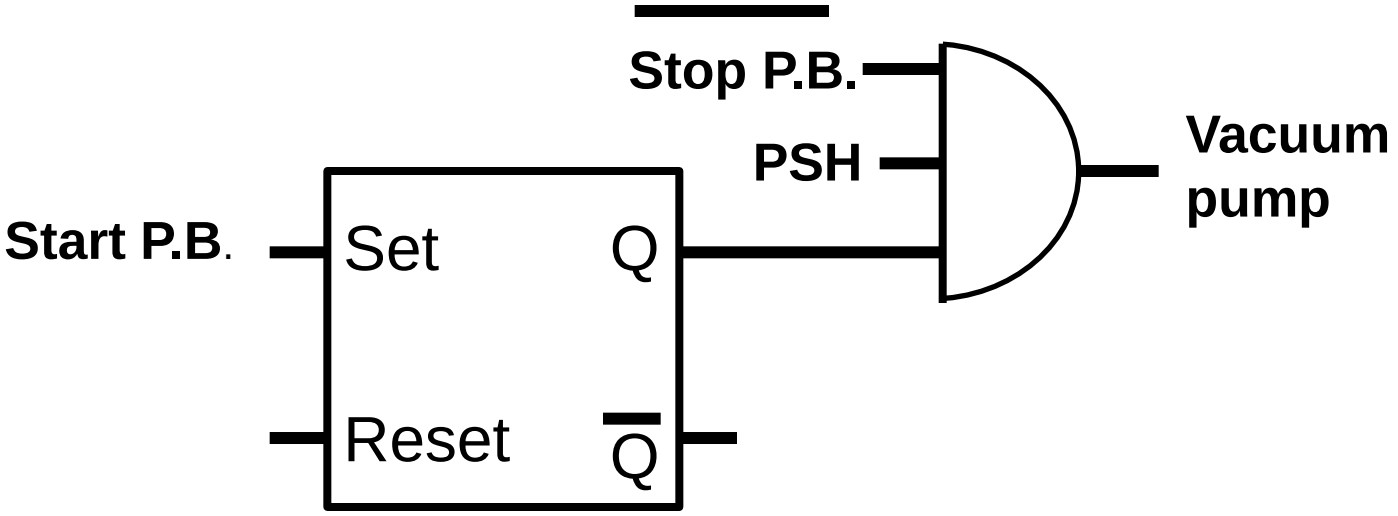

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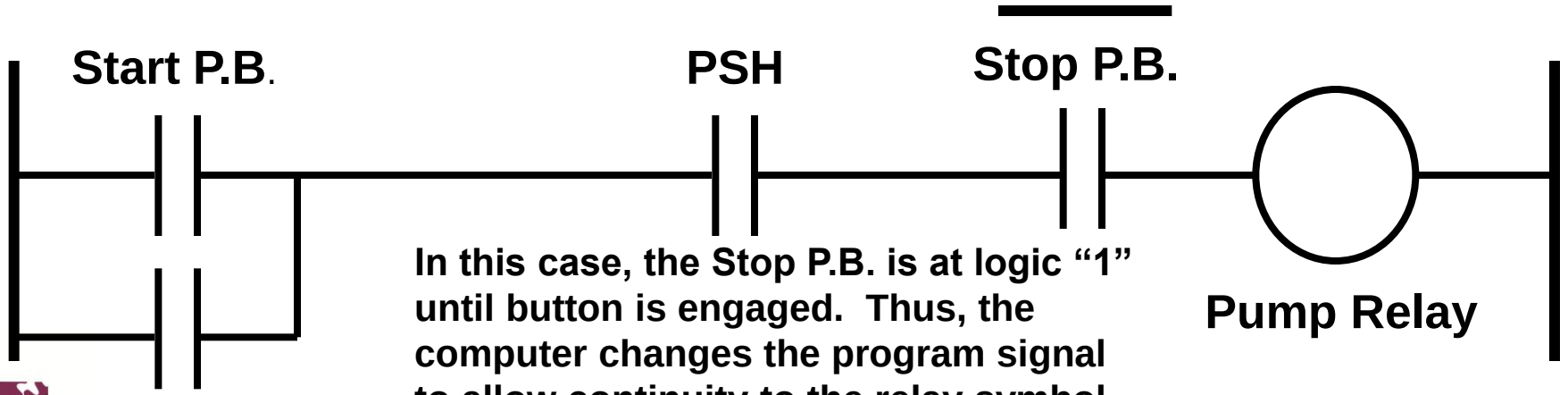

In this case, the Stop P.B. is at logic "1" until button is engaged. Thus, the computer changes the program signal to allow continuity to the relay symbol unless the button is engaged.

Automation Characteristics of Mechatronics Subsystems

- Sense the process and make measurements
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- Generate an action and make changes in the process.

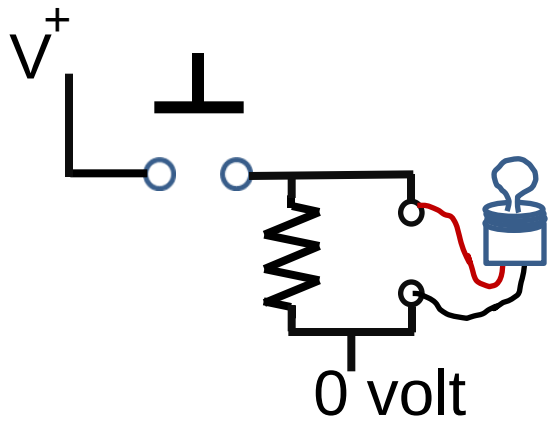
Megatronics Subsystem Function Diagram

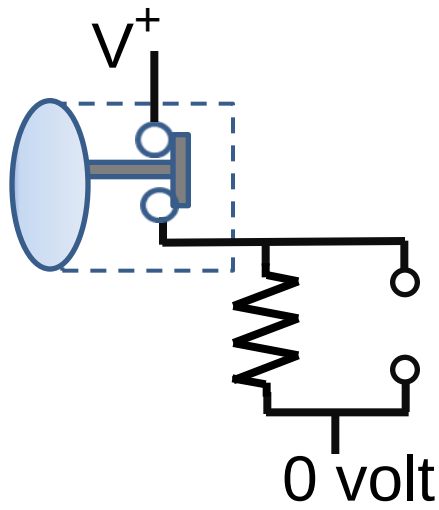
- A Ladder Logic Program of example Function Diagram

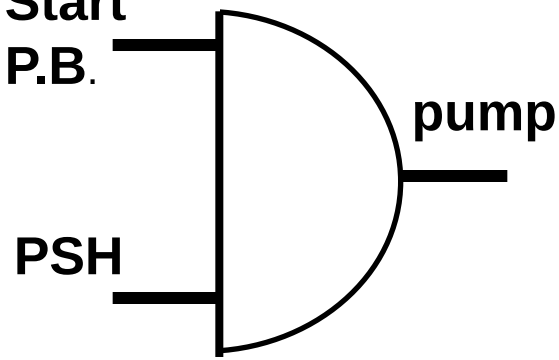
STEM Connections

STEM Connections

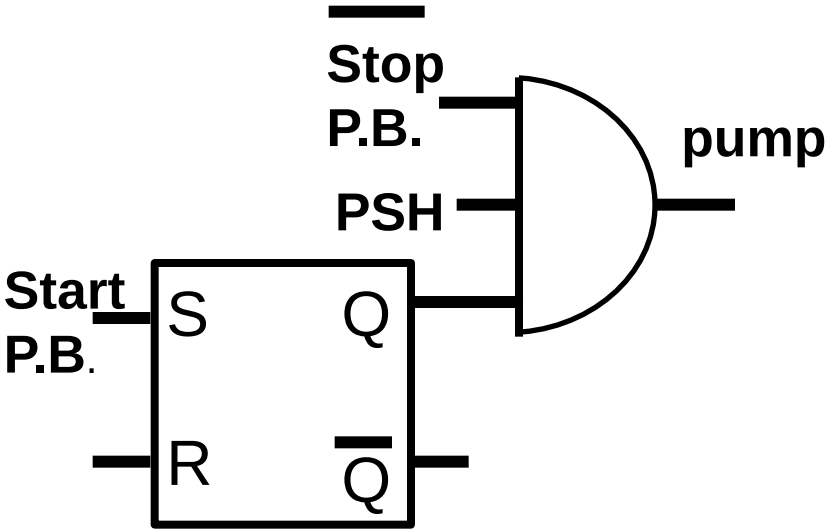
- chemistry
- mathematics







- physics



- Innovative thinking
- Open ended problem solving

Automation Characteristics of Mechatronics Subsystems

- Sense the process and make measurements
- Think about current status of process and make decisions.
- Generate an action and make changes in the process.

Megatronics Subsystem Function Diagram

- A Ladder Logic Program of example Function Diagram

STEM Connections

Physics, chemistry, math,
and innovative thinking

Science Educators Workshop **Questions?**

Thanks for your attention!

FLATE