Logic control of electro-pneumatic systems

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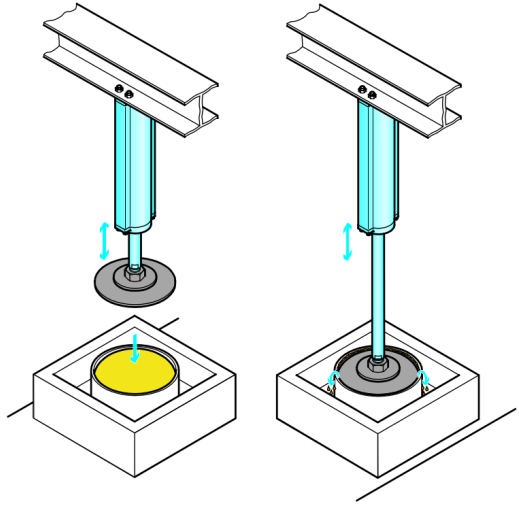
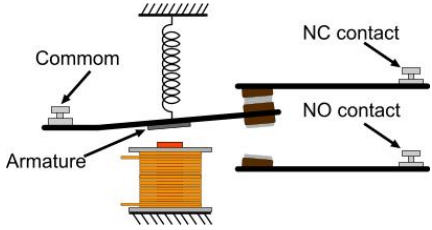
Cheese pressing example, sequence A+A-

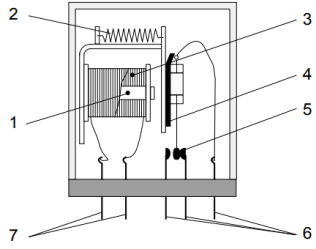


From FESTO Didactic

The Relay



From pcbheaven.com



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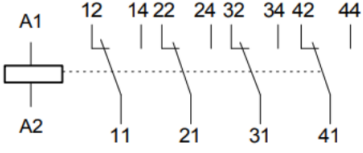

From FESTO didactic

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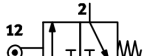
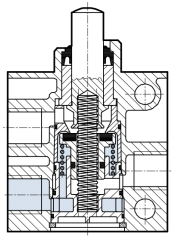
Other key components

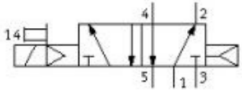
Sources: FESTO didactic, electroschematics.com, automation-insights.blog

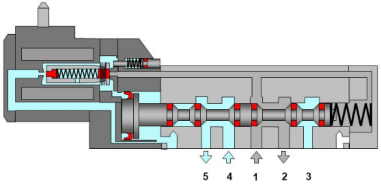
Limit switch



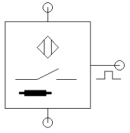


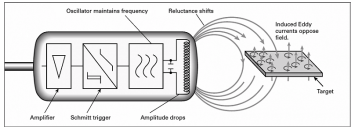
Solenoid valve

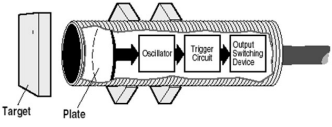




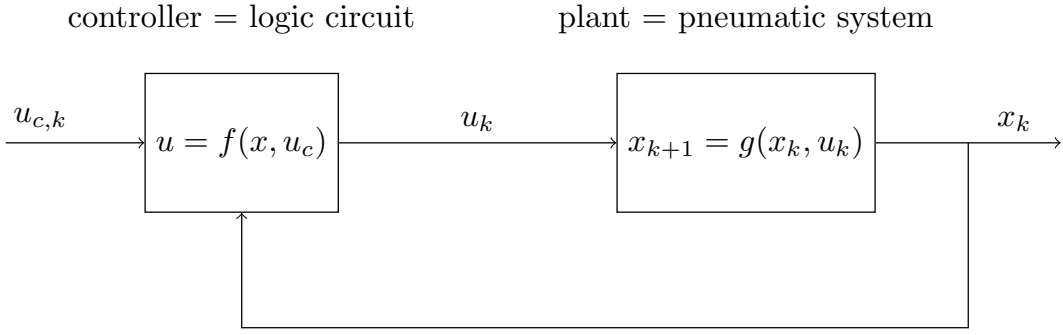
Proximity sensor







A logic control loop



Cheese pressing example - Variables

State variables

$x = \begin{bmatrix} x_R & x_E \end{bmatrix}^T$ with

$$x_R = \begin{cases} 1 & \text{Cylinder retracted} \\ 0 & \text{not retracted} \end{cases}$$

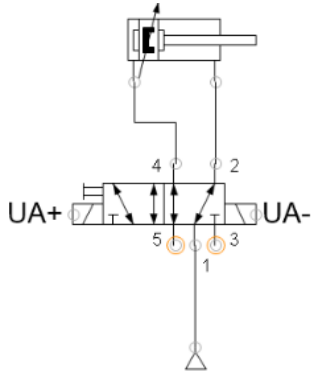
$$x_E = \begin{cases} 1 & \text{Cylinder extended} \\ 0 & \text{not extended} \end{cases}$$

Control signal

$u = \begin{bmatrix} u_1 & u_2 \end{bmatrix}^T$, with

$$u_1 = \begin{cases} 1 & \text{Activate UA+} \\ 0 & \text{Don't activate UA+} \end{cases}$$

$$u_2 = \begin{cases} 1 & \text{Activate UA-} \\ 0 & \text{Don't activate UA-} \end{cases}$$



Activating solenoid UA+ extends the cylinder, activating UA- retracts the cylinder.

Command signal

$$u_c = \begin{cases} 0 & \text{Button unpushed} \\ 1 & \text{Button pushed} \end{cases}.$$

Cheese pressing example - Plant dynamics

Plant dynamics $x_{k+1} = g(x_k, u_k)$

Input		Current state		Next state	
$u_{1,k}$	$u_{2,k}$	$x_{R,k}$	$x_{E,k}$	$x_{R,k+1}$	$x_{E,k+1}$
0	0	0	1	0	1
0	1	0	1	1	0
1	0	0	1	0	1
(1)	(1)	(0)	(1)	(0)	(1)
0	0	1	0	1	0
0	1	1	0	1	0
1	0	1	0	0	1
(1)	(1)	(1)	(0)	(1)	(0)

Cheese pressing example - Control law

The system is operating as long as the start button is pressed ($u_c = 1$). When the button is released, the cylinder should go to the retracted position.

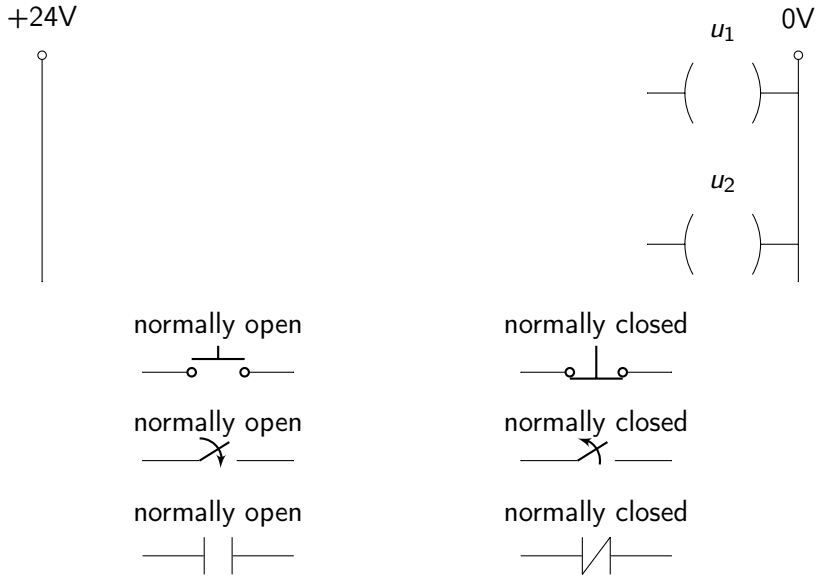
Control law $u_k = f(x, u_c)$

x_R	x_E	u_c	u_1	u_2
0	1	0	0	1
1	0	0	0	0
0	1	1	0	1
1	0	1	1	0
0	0	0	0	1
0	0	1	0	0

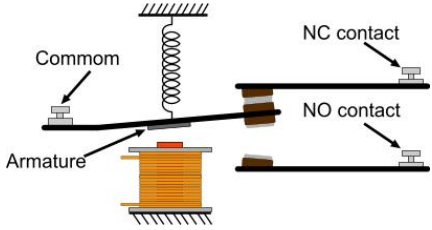
Activity: Write as boolen functions

$$u_1 = f_1(x_R, x_E, u_c) =$$
$$u_2 = f_2(x_R, x_E, u_c) =$$

Cheese pressing example - implementing the control law



An electrical circuit with memory



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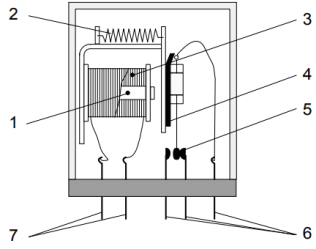

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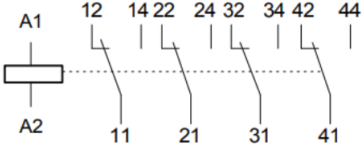

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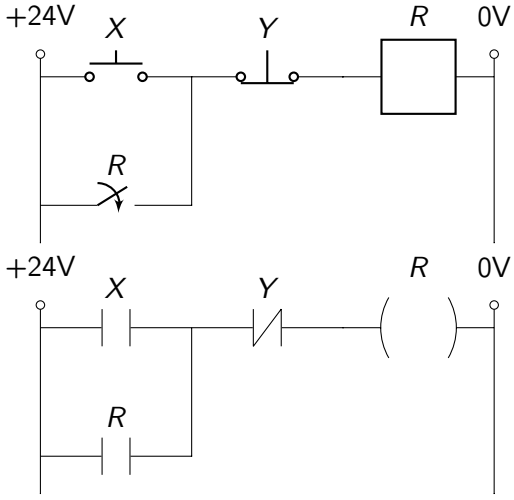
An electrical circuit with memory

Latching circuit



Truth table

X	Y	R_k	R_{k+1}
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Group activity: Implement the circuit in FluidSim and verify the truth table.