Logic Control (Example)

Reservoir

\[ \text{tank}_1 \]
\[ \text{tank}_2 \]

\[ V_1 \]
\[ V_2 \]
\[ h_1 \]
\[ h_2 \]
\[ b_1 \]
\[ b_2 \]
\[ W_1 \]
\[ W_2 \]

* State aggregation:
  \[ \text{height}_i < b_i \Rightarrow \text{low}_i \]
  \[ \text{height}_i > h_i \Rightarrow \text{high}_i \]
  \[ \text{otherwise} \Rightarrow \text{medium}_i \]

* Level sensors:
  \[ \text{low}_i \Leftrightarrow b_i = 0 \]
  \[ \text{high}_i \Leftrightarrow h_i = 1 \]

* Valve actuators:
  \[ V_i, W_i = \text{on} \] push button actuator: m

Control spec.

- Initially tanks low
  - m pushed \( \Rightarrow \) open both valves
  - \text{tank}_i \text{ full} \Rightarrow \text{close value } V_i, \text{ open value } W_i
  - \text{tank}_i \text{ low} \Rightarrow \text{close value } W_i
  - Tanks low, m pushed again \Rightarrow \text{resume filling both tanks}
Notation and Signals

\[ f(t) \]
\[ \uparrow f(t) \]
\[ \downarrow f(t) \]

\[ f : \text{boolean signal} \]
\[ \uparrow f, \downarrow f : \text{event signals} \]

Definition: \( \uparrow a \oplus \uparrow b, \quad a \uparrow b, \quad \uparrow a \uparrow b \) etc.

State machine/Automaton representation

- Each node represents a state:
  - \( w_2 = 1 \) node: tank 1 low, tank 2 medium or high
- Each arc represents a transition of state or event label
Relay Ladder logic. Description of Controller

RLL graphical language for encoding a logic/automaton in PLC
- Each "rung" corresponds to a Boolean equation
- Pair of vertical bars represent rung inputs; rung output represented by circled crossed bar represents Boolean complement (physical relays)
- AND/OR by series/parallel placement of bars

\[ q_1 = b'_1 b'_2 \]
\[ v_1 = (q_1 m + v_1) h'_1 \]
\[ v'_1 w_1 = (v_1 h_1 + w_1) b_1 \]
\[ v_2 = (q_1 m + v_2) h'_2 \]
\[ v'_2 w_2 = (v_2 h_2 + w_2) b_2 \]

- Any automaton can be encoded by RLL
- Limited by limited descriptive power of automata
- RLL encoding may not be directly obvious from control spec.