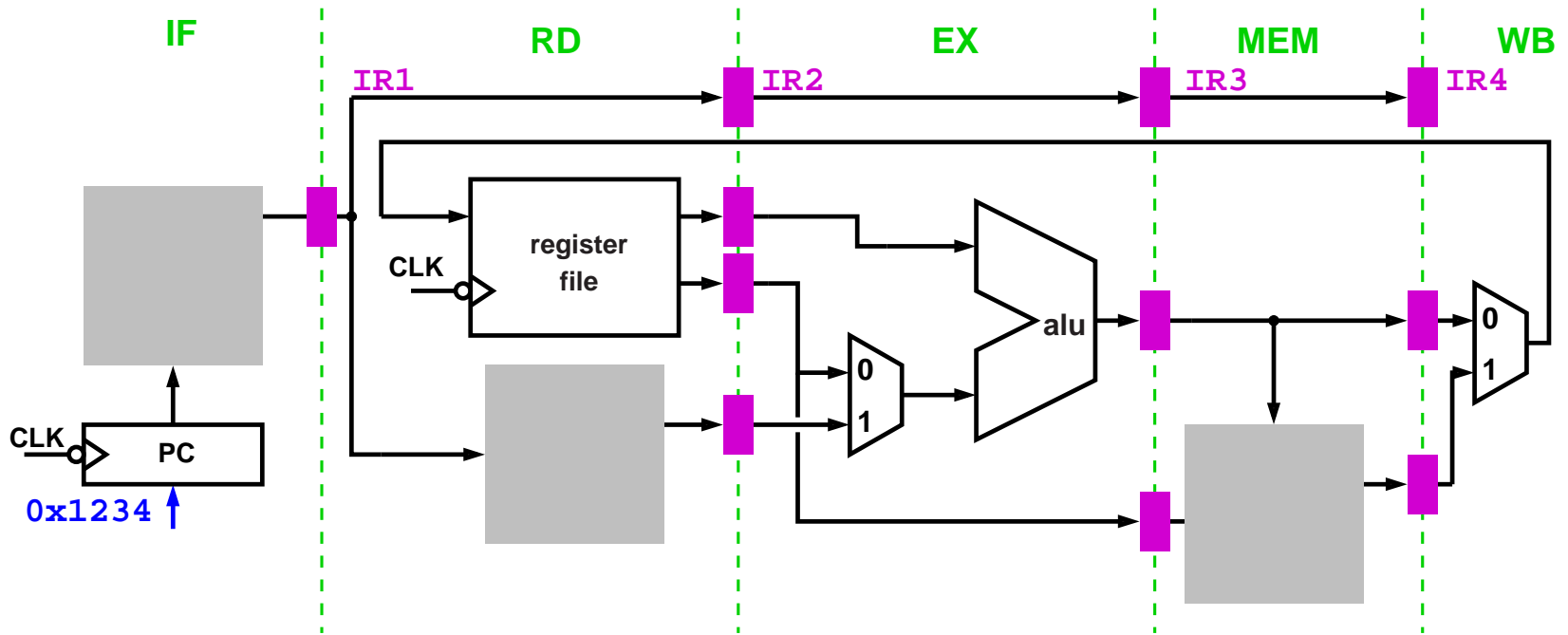
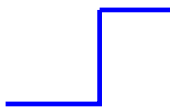


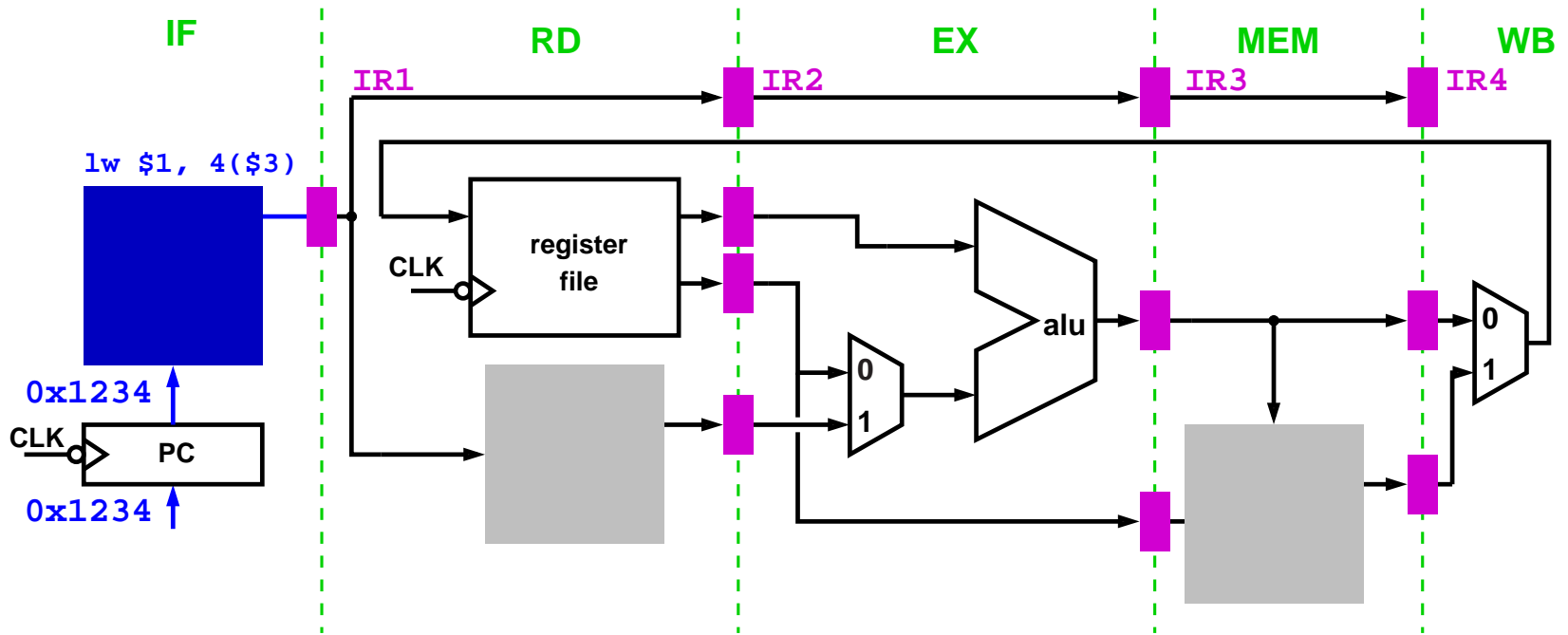
# Executing Multiple Instructions



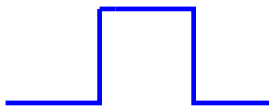
CLK



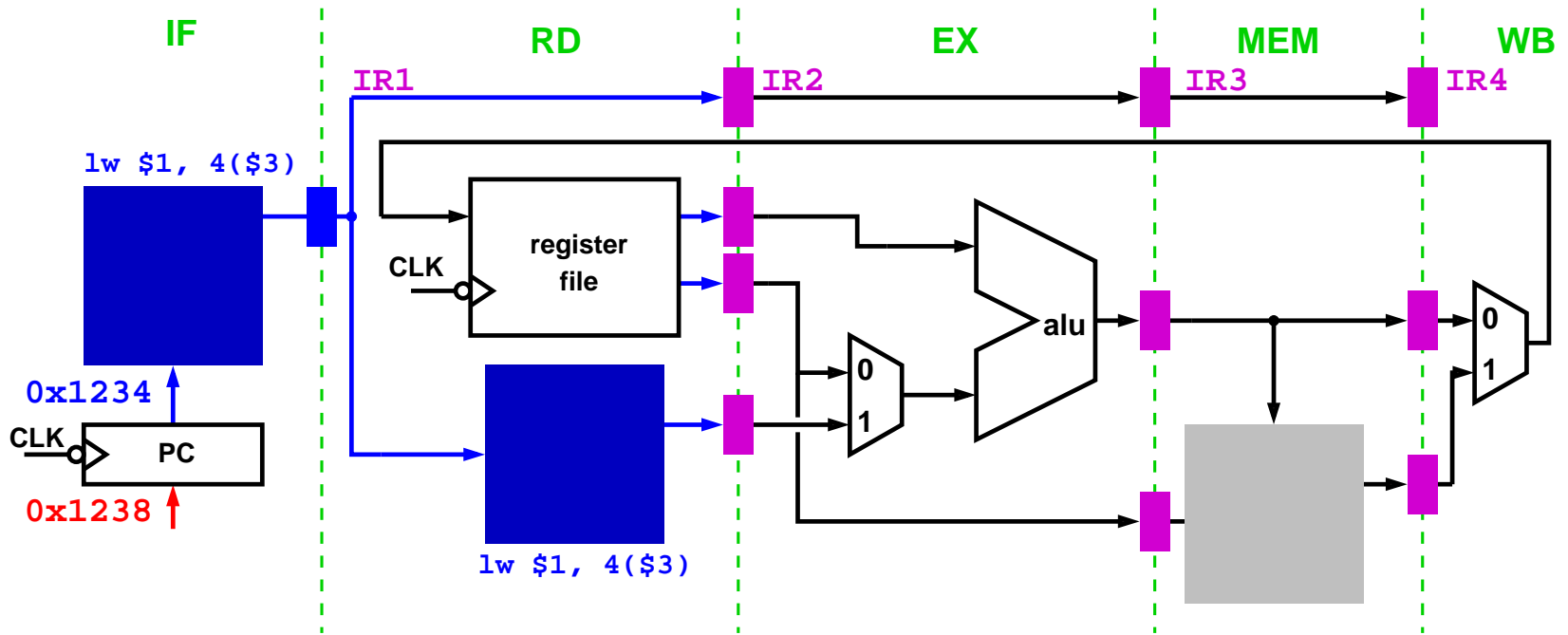
# Executing Multiple Instructions



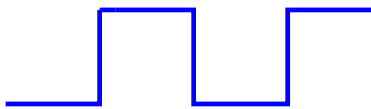
CLK



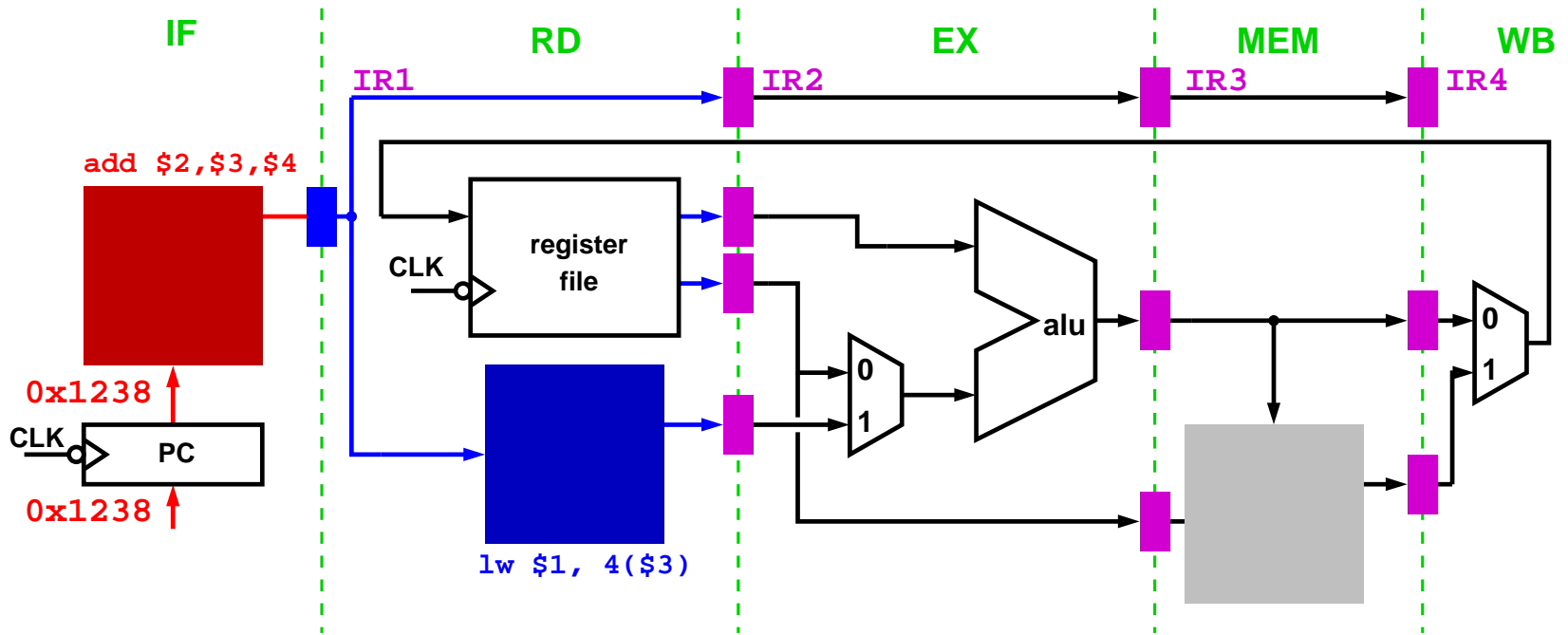
# Executing Multiple Instructions



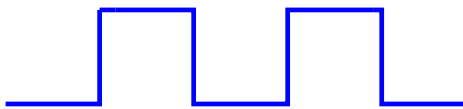
CLK



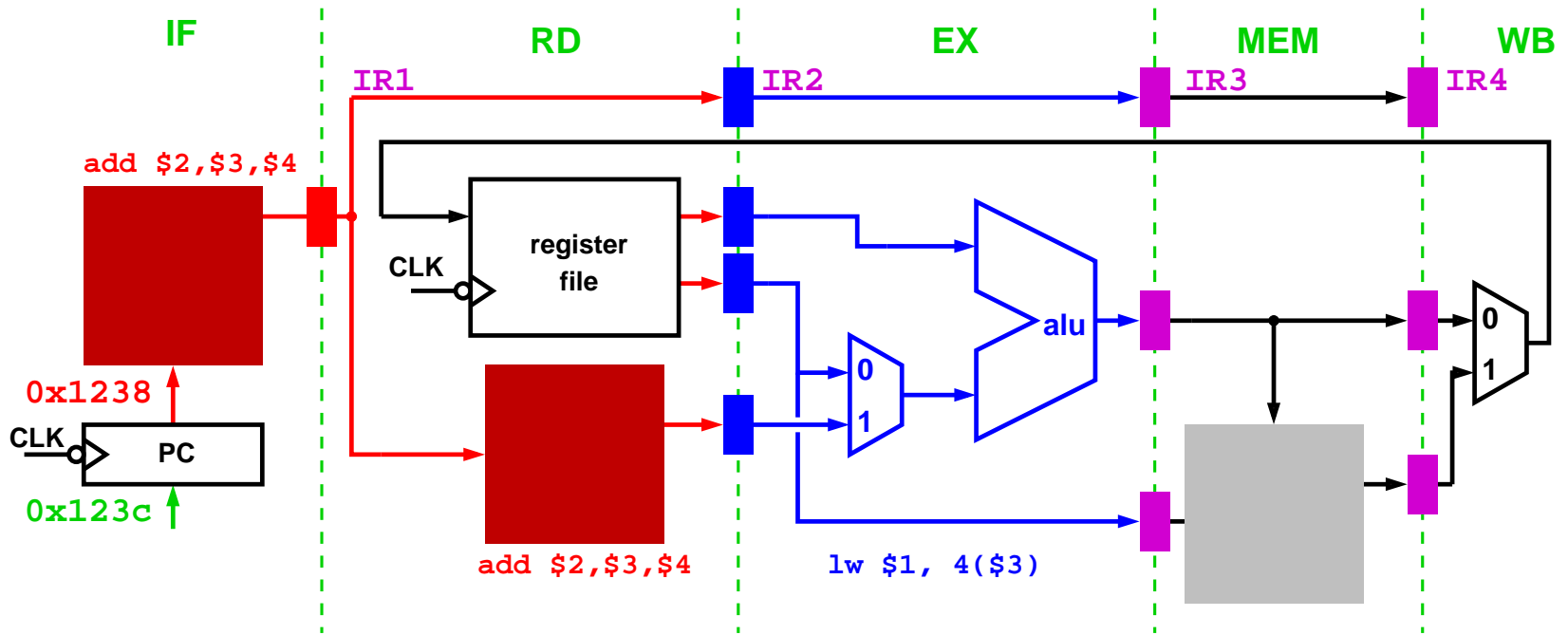
# Executing Multiple Instructions



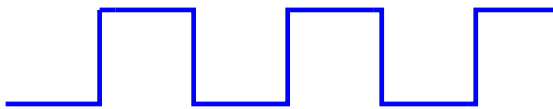
CLK



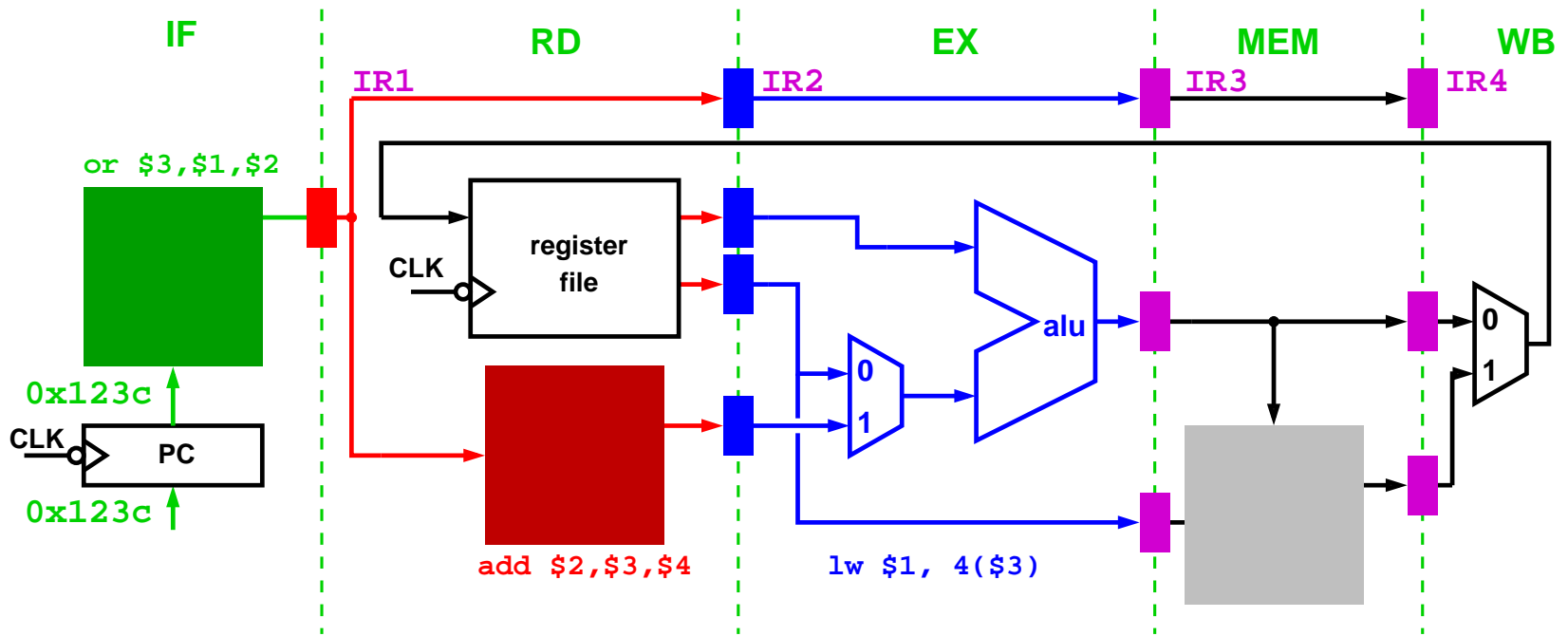
# Executing Multiple Instructions



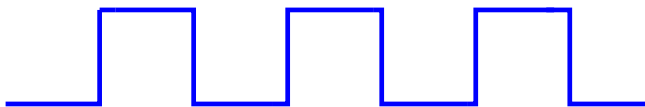
CLK



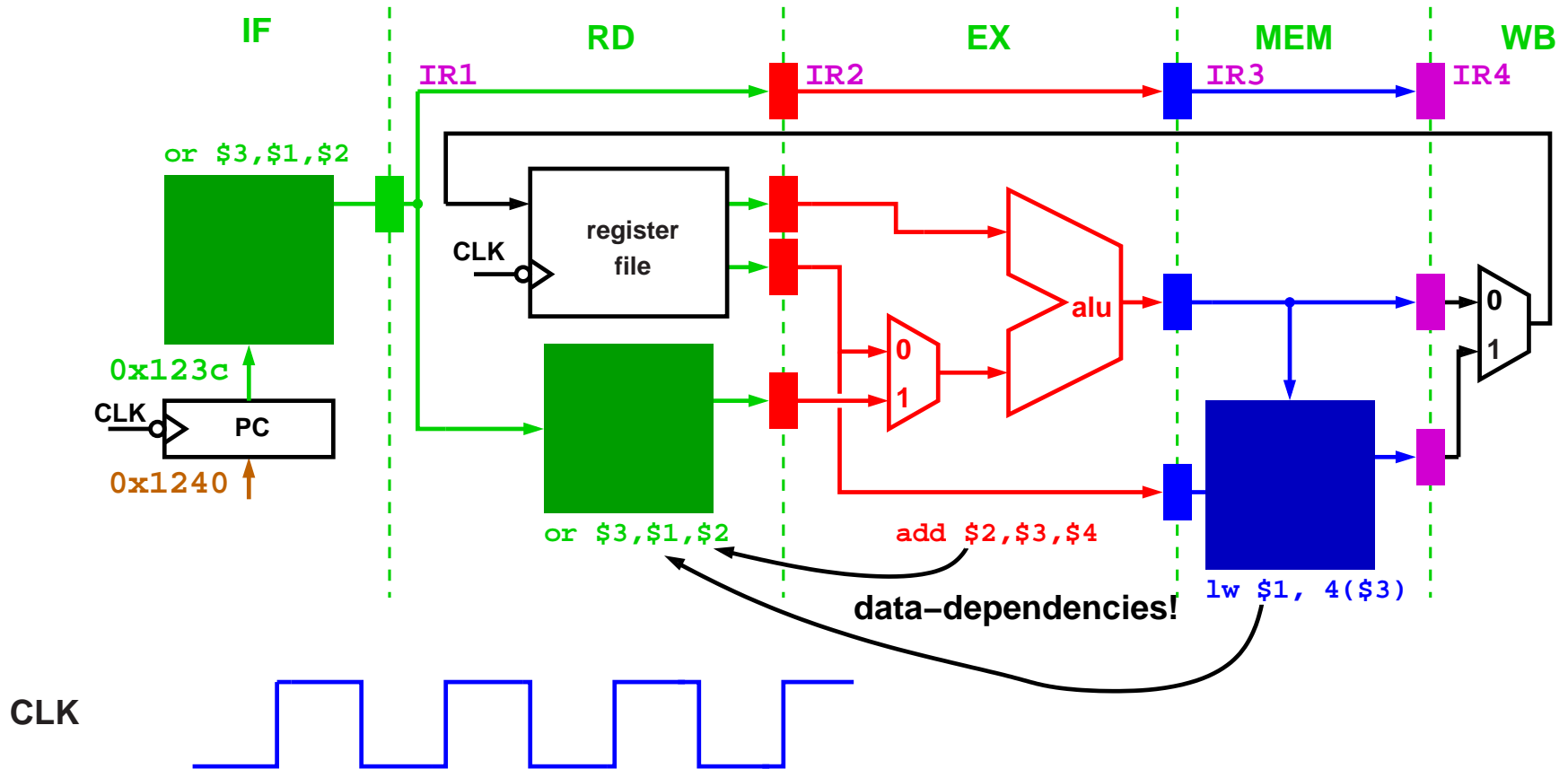
# Executing Multiple Instructions



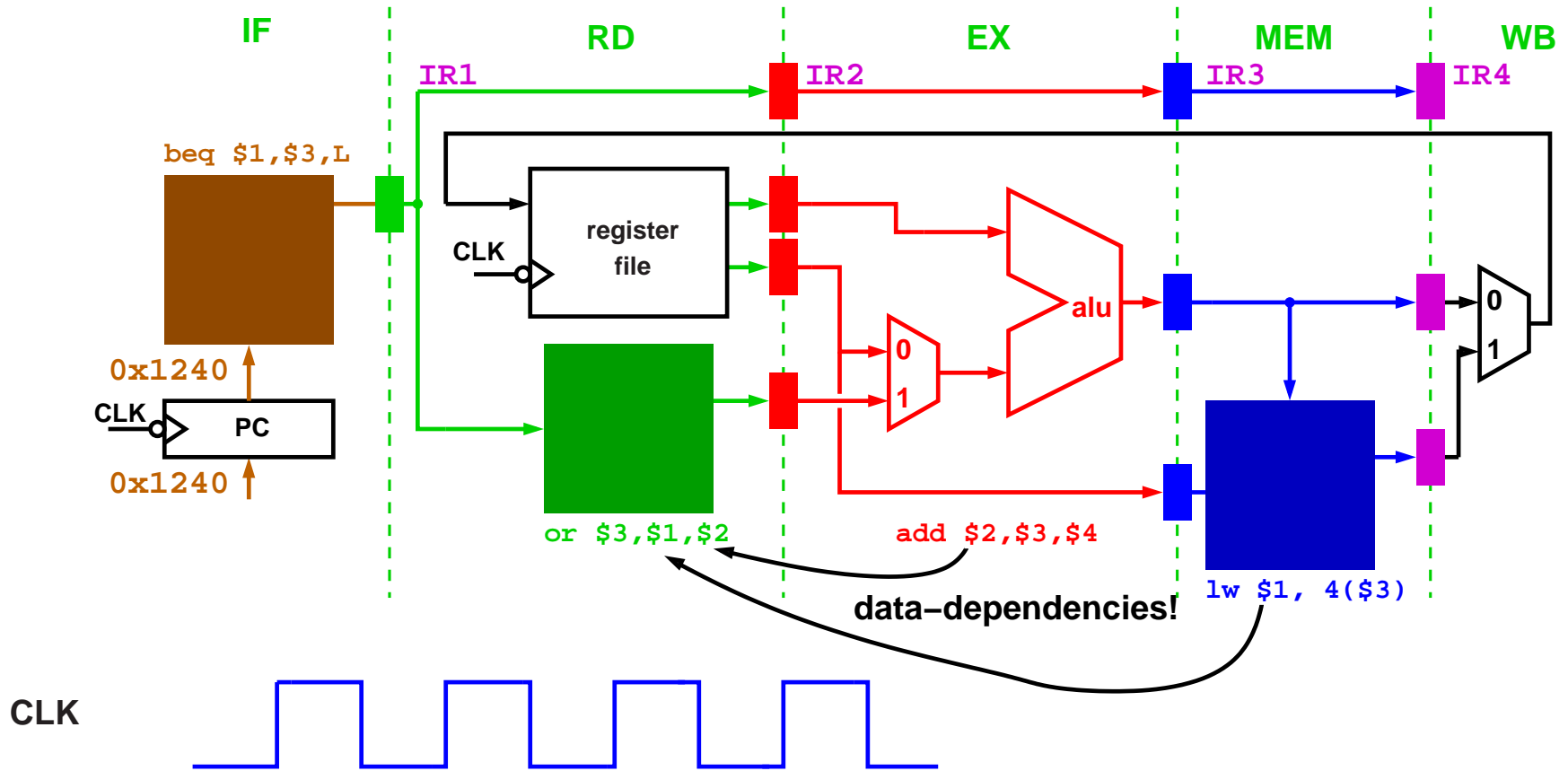
CLK



# Data Hazards

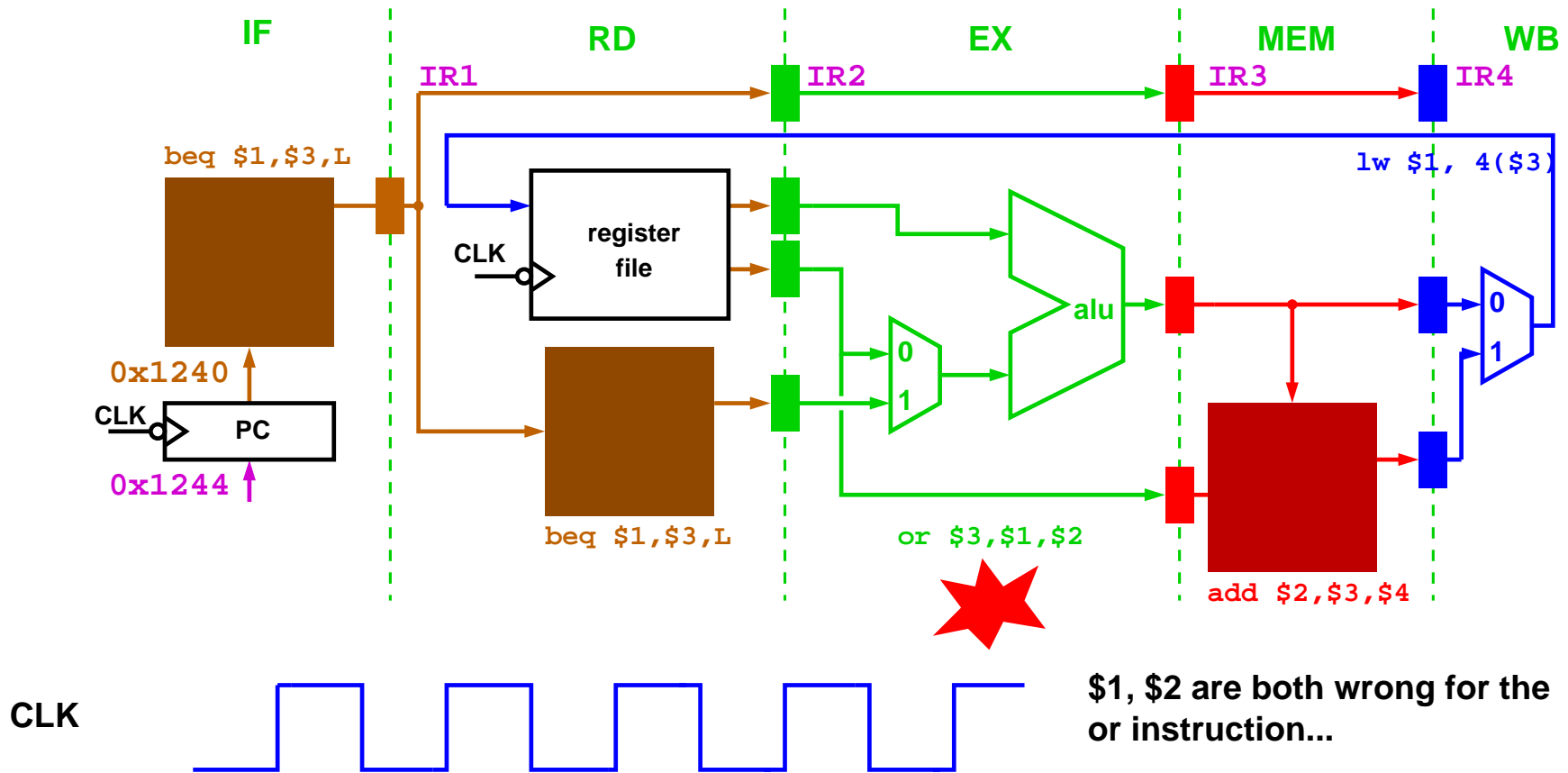


# Data Hazards

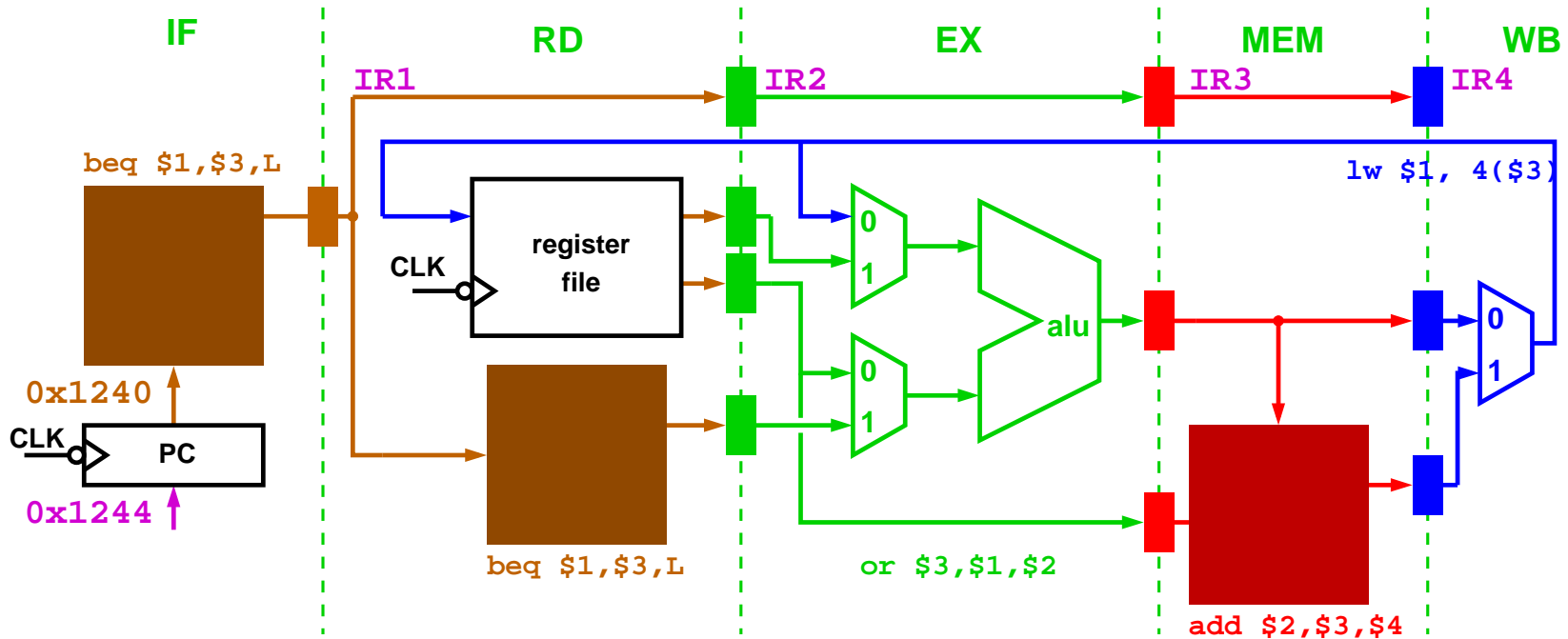




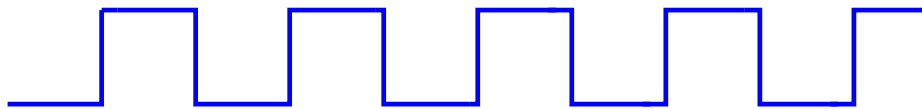
# Data Hazards



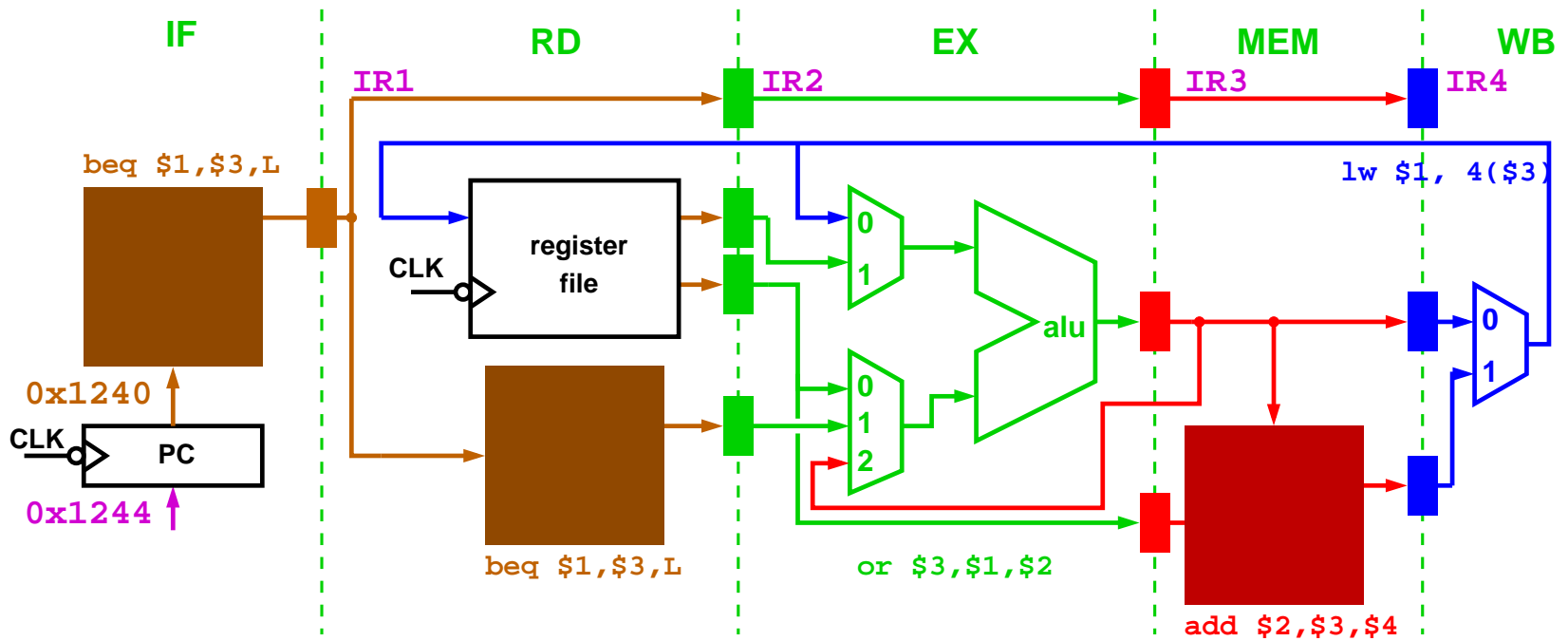
# Data Hazards: Memory to ALU



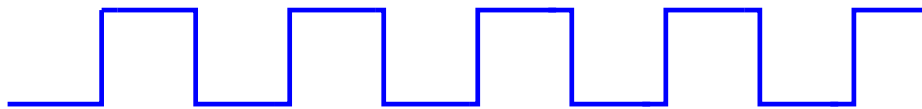
CLK



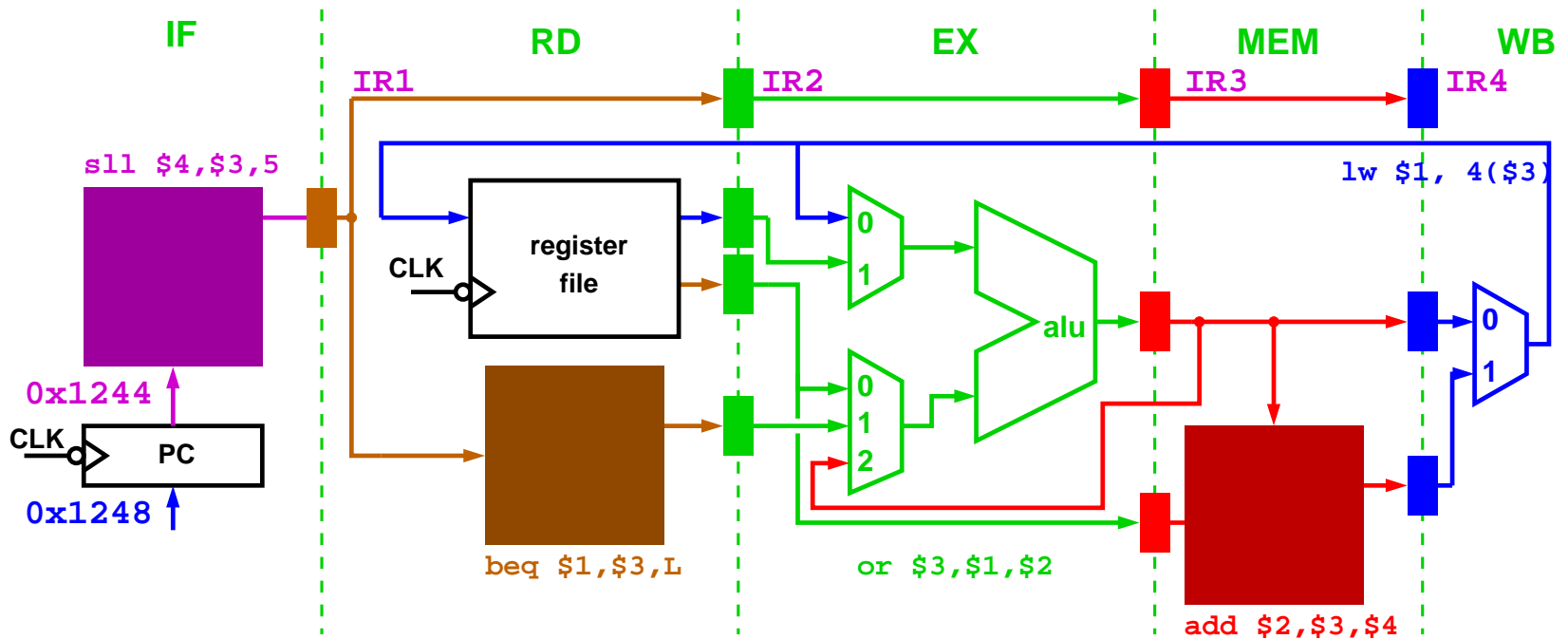
# Data Hazards: ALU to ALU



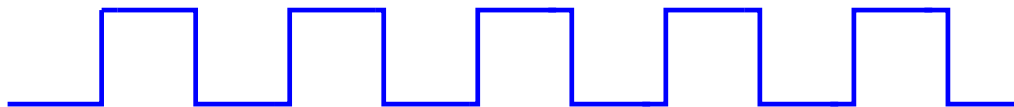
CLK



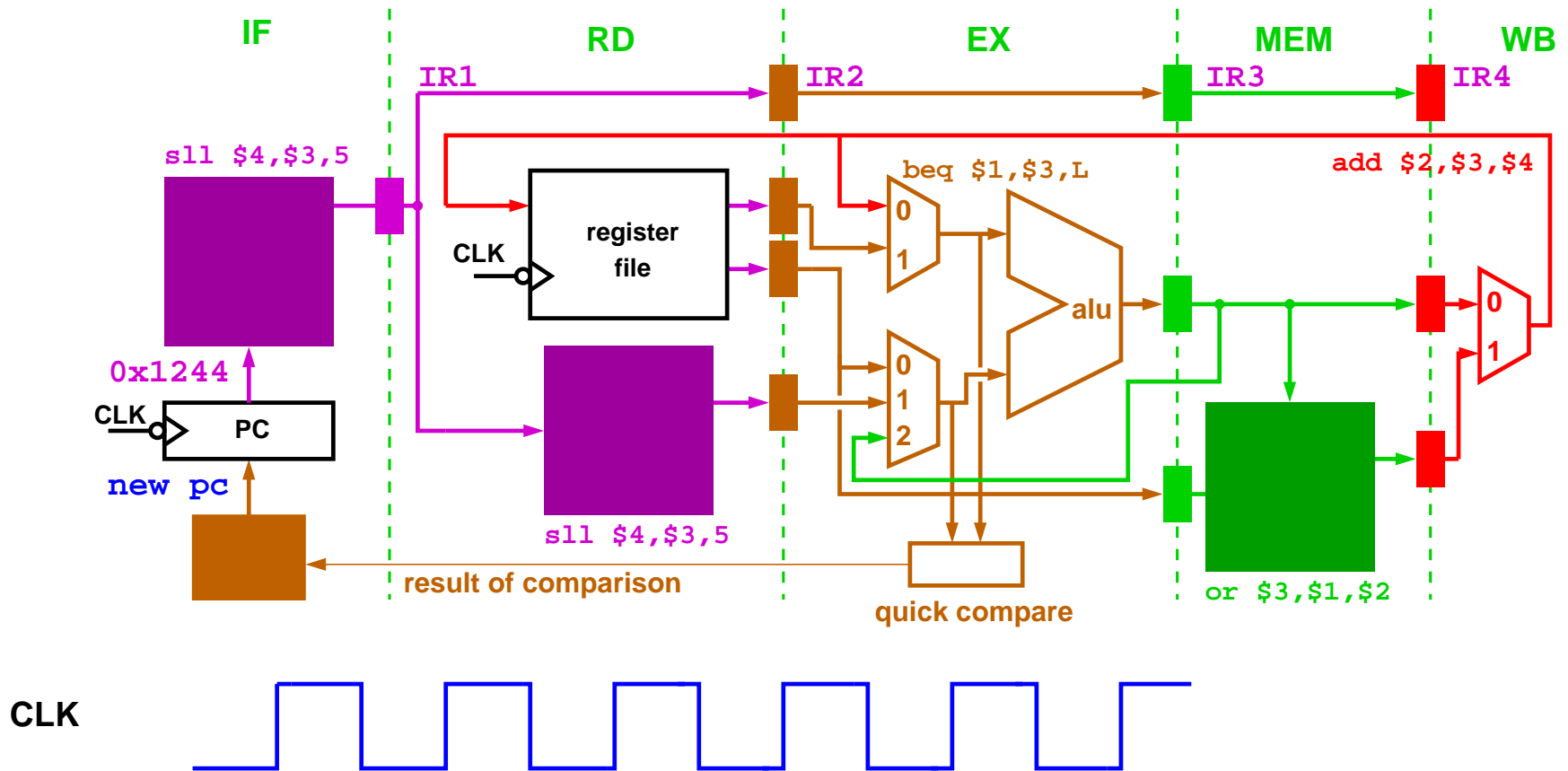
# Control Hazards: Delayed Branching



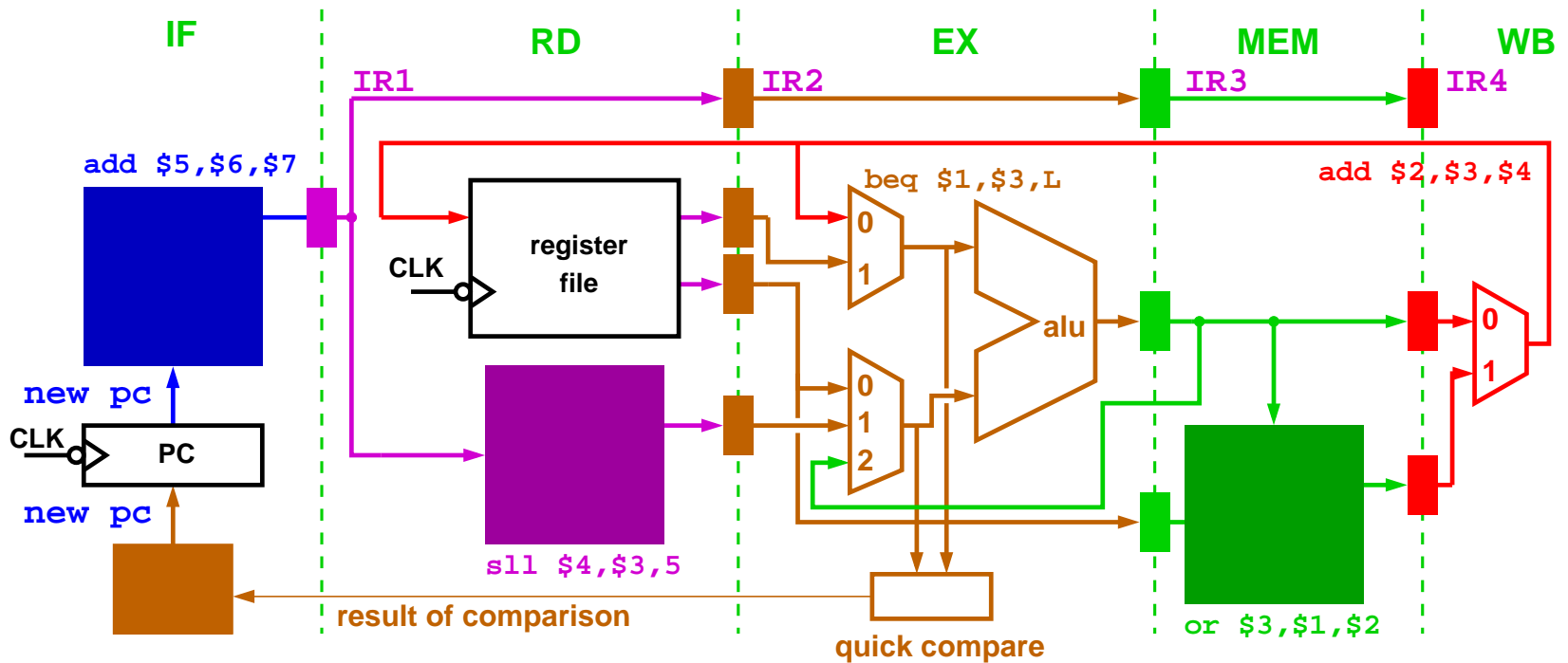
CLK



# Control Hazards: Delayed Branching



# Control Hazards: Delayed Branching



CLK



# Pipeline Hazards

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Three classes:

- **Data Hazards**
  - data-dependencies
  - read-after-write (RAW)
  - WAW, WAR?
- **Control Hazards**
  - determining the next PC
- **Structural Hazards**
  - hardware resource conflict

