SY486K MICS Lecture 6

Ladder Logic

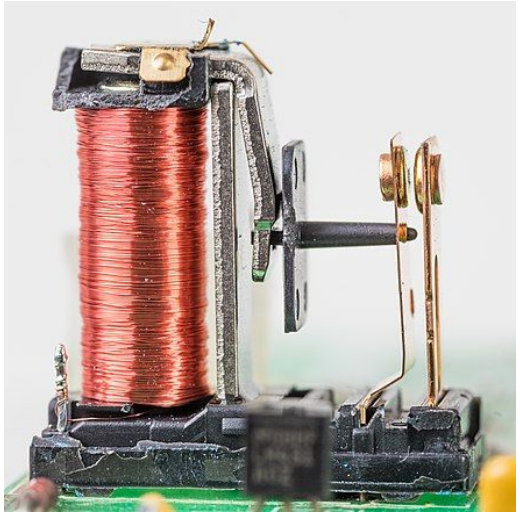
CDR Brien Croteau, USNA Cyber Science Department, February 2023

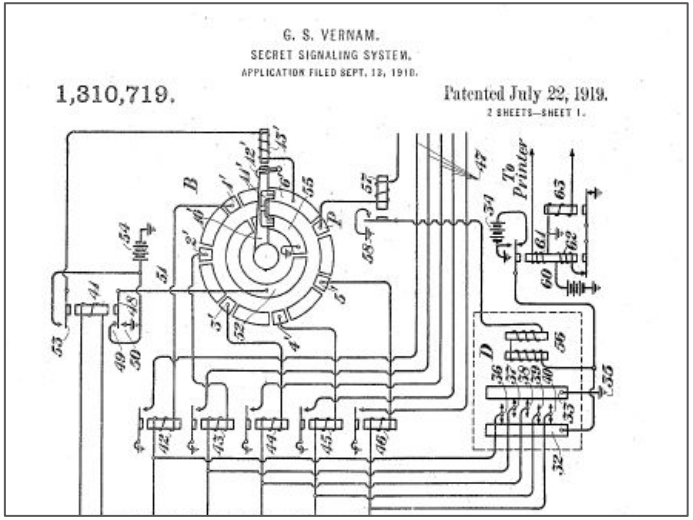
Outline

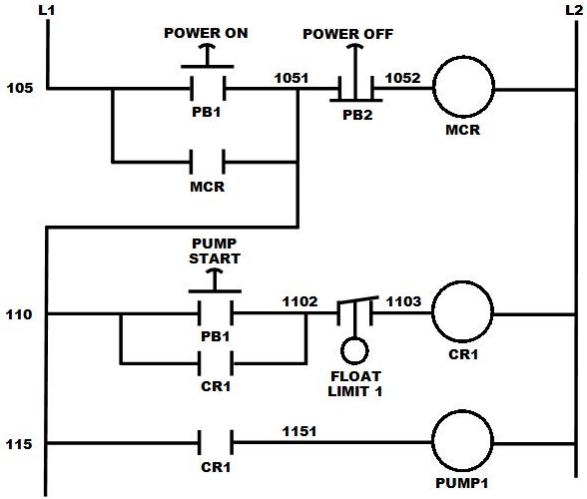
- History
- Conventions
- Examples
- Function Blocks

Where does LL come from?

Ladder logic was originally a written method to document the design and construction of relay racks as used in manufacturing and process control.[1] Each device in the relay rack would be represented by a symbol on the ladder diagram with connections between those devices shown. In addition, other items external to the relay rack such as pumps, heaters, and so forth would also be shown on the ladder diagram.

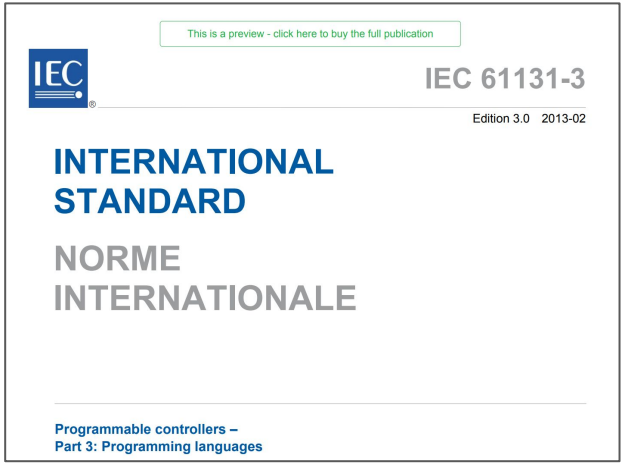






Where is it defined? = IEC 61131-3

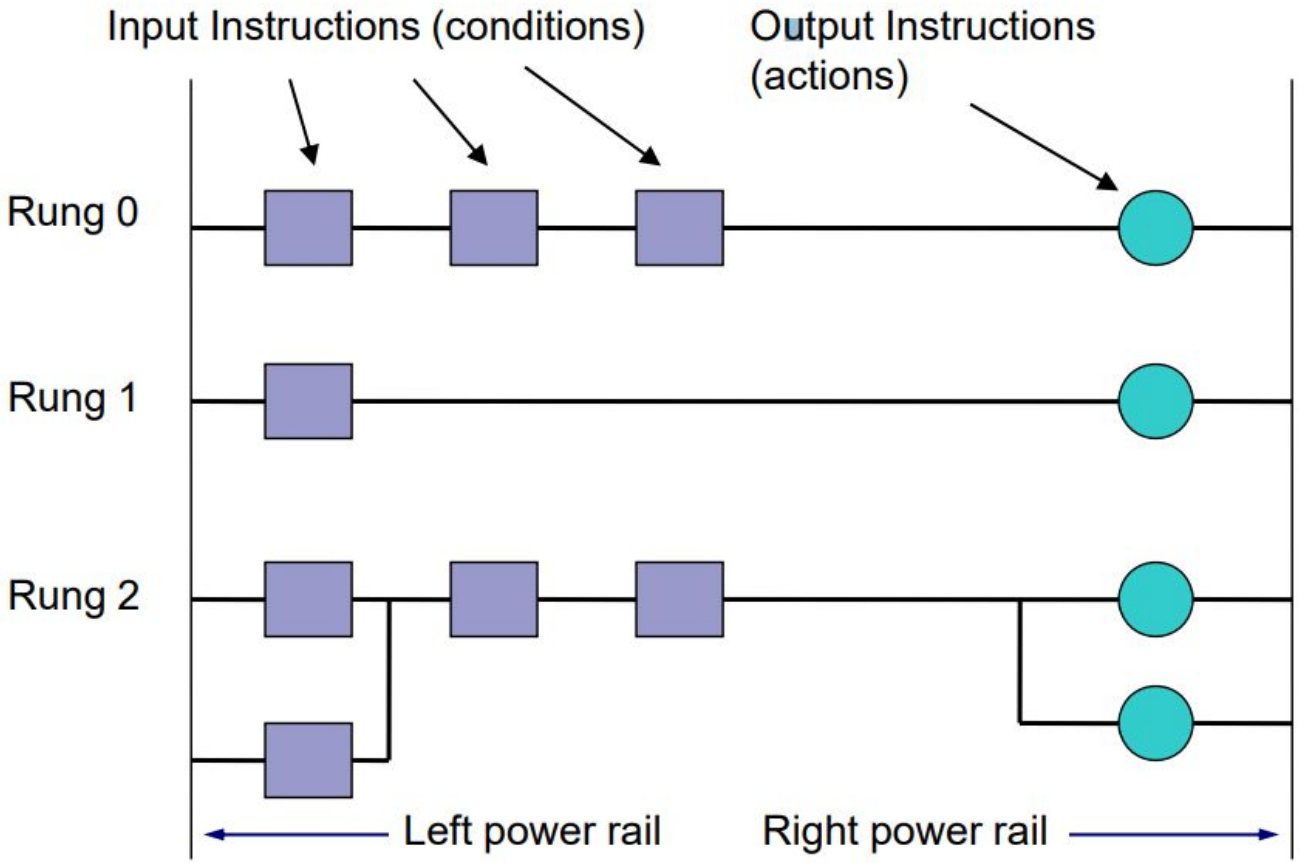
IEC 61131-3 is the third part (of 10) of the open international standard IEC 61131 for programmable logic controllers. It was first published in December 1993 by the IEC; the current (third) edition was published in February 2013.



Part 3 of *IEC 61131* deals with basic software architecture and programming languages of the control program within PLC. It defines three graphical and two textual programming language standards:

- Ladder diagram (LD), graphical
- Function block diagram (FBD), graphical
- Structured text (ST), textual
- Instruction list (IL), textual (deprecated in 3rd edition of the standard[3])
- Sequential function chart (SFC), has elements to organize programs for sequential and parallel control processing, graphical

Anatomy of a Ladder Program



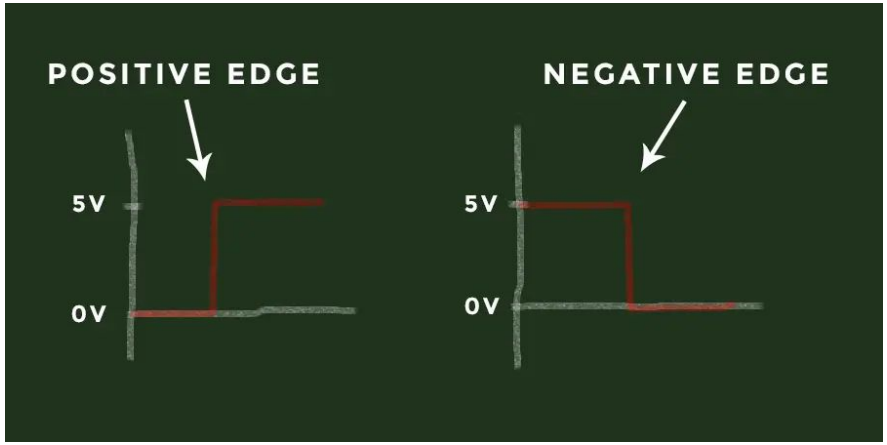
Typical Symbols

NO Contact

Positive Transition-Sensing Contact

NC Contact

Negative Transition-Sensing Contact

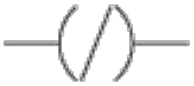


Coil

SET Latch Coil

Positive Transition-Sensing Coil

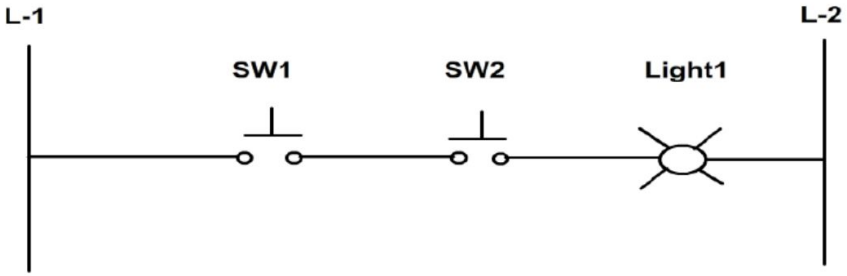
Negated Coil

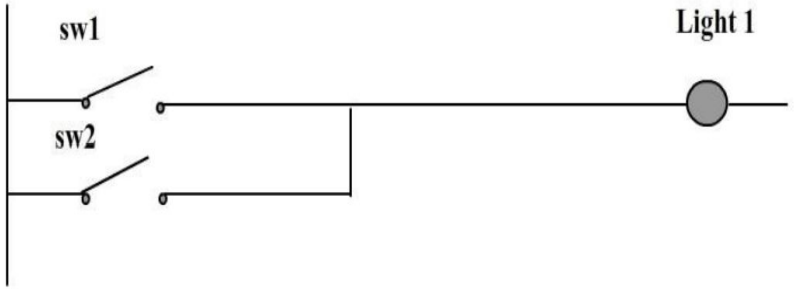


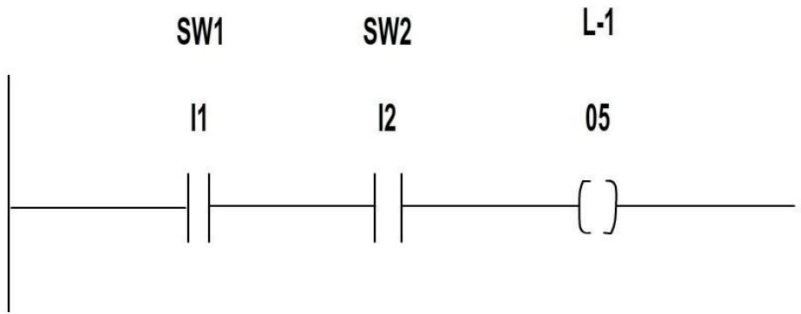
RESET Latch Coil

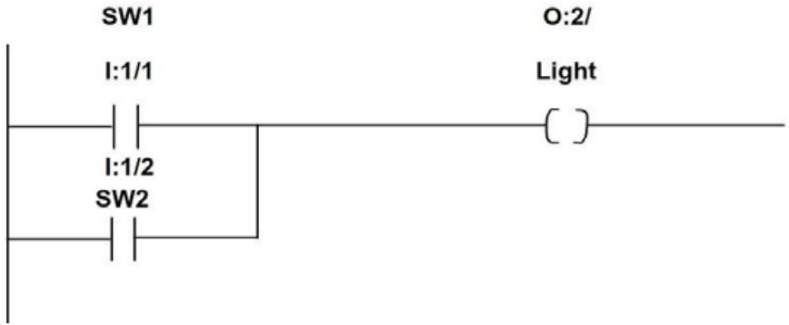
Negative Transition-Sensing Coil

Basic Logic


L-1
SW1
SW2
Light1
L-2


sw1
Light 1
sw2


SW1
SW2
L-1
I1
I2
05


SW1
O:2/
I:1/1
Light
I:1/2
SW2

The Scanning Process

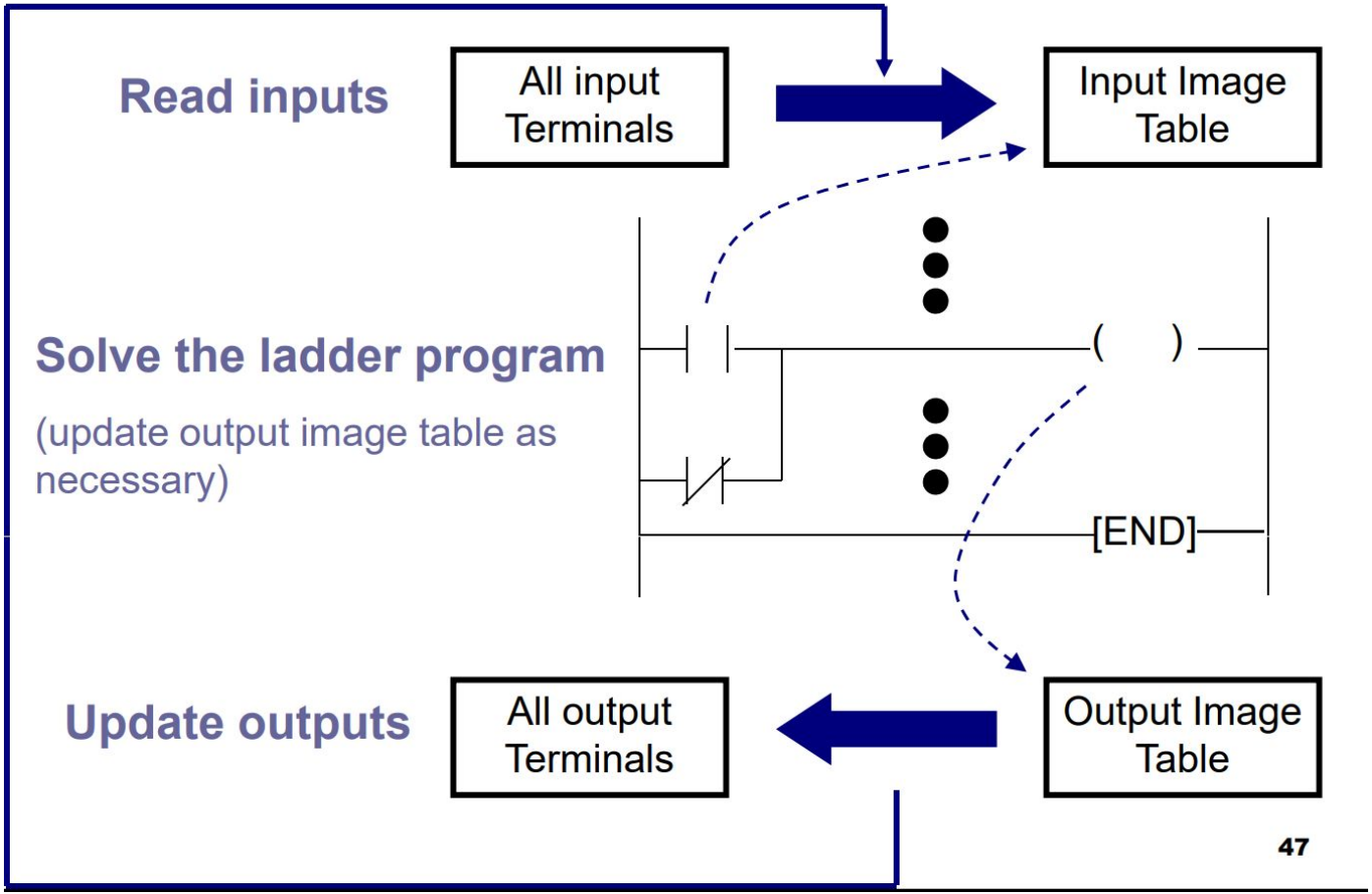
- The scan sequence can be broken into two functional parts:
  - The **Program Scan**
    - Scan the ladder program
  - The **I/O Update Scan**
    - Write outputs, Read inputs

- **The Program Scan**:
  - For each rung executed, the PLC processor will:
    - Examine the status of the input image table bits,
    - Solve the ladder logic in order to determine logical continuity (is the rung true?),
    - Update the appropriate output image table bits, if necessary.

      Note: The output will not actually be energized until the I/O update part of the scan.

- **The I/O Update Scan**:
  - Copy the output image table status to the ALL of the output terminals (discrete output circuits)
    - Power is applied to the output device if it's output image table bit has been previously set to a 1.
  - Copy the status of ALL of the input terminals to the input image table
    - If an input is active (i.e., there is electrical continuity), the corresponding bit in the input image table will be set to a 1.

The Scanning Process

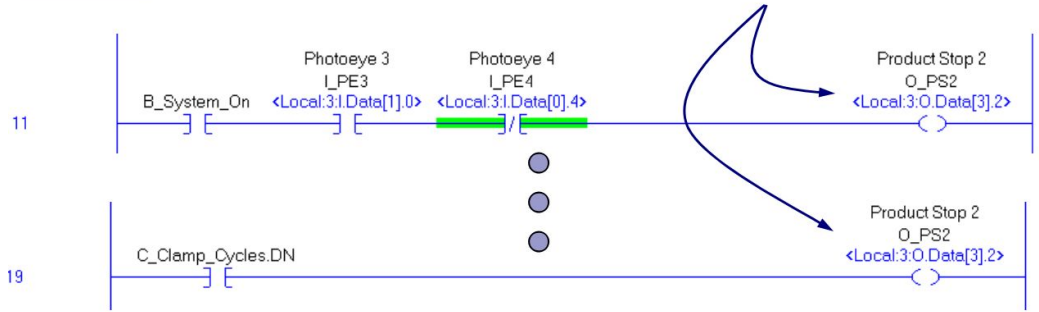


Duplicate Coils

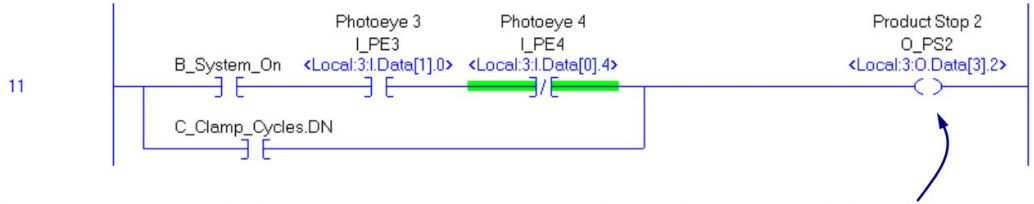
In a ladder program, a specific output address (e.g., O:013/02) should NOT be referenced on more than one rung!

- This is sometimes called “duplicate coils”
- Using duplicate coils will cause unpredictable operation and should be avoided
- When using duplicate coils “the last rung wins”

Problem: Rungs 11 and 19 both reference the same output address:

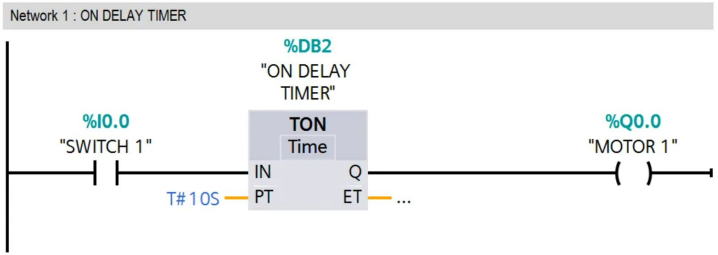


Solution: Edit the ladder program as follows:



Problem corrected, this output is only used once in the entire program

Timer Block

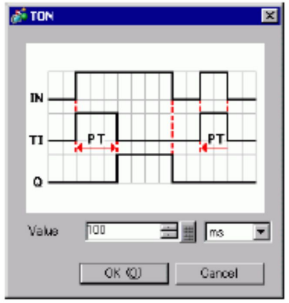


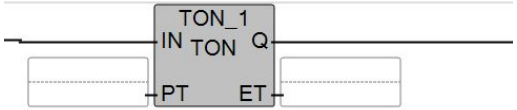
32.7.1.1 Explanation of the ON Delay Timer (TON) and OFF Delay Timer (TOF) Instructions

Timer variables used in TON and TOF instructions are structure variables. The following table lists the internal structures.

Timer Variable

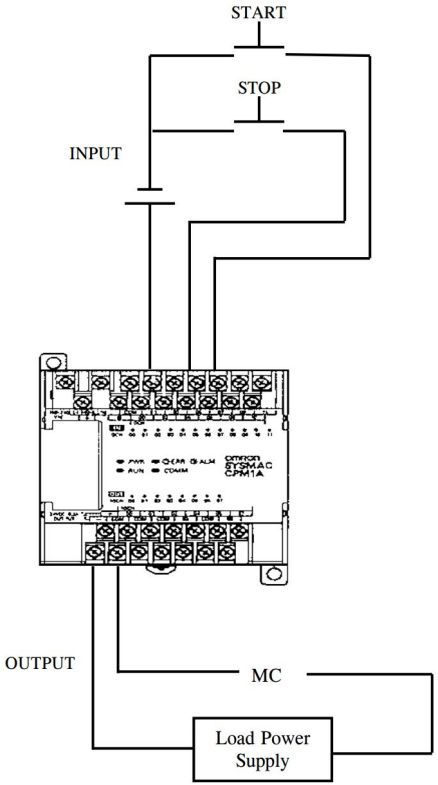
Timer Variable	Variables Settings	Description
VariableName.TI	Bit Variable	Turns ON when the timer begins.
VariableName.Q	Bit Variable	Turns ON upon completion of the timer.
VariableName.PT	Integer Variable	The value set on the timer
VariableName.ET	Integer Variable	The current value on the timer

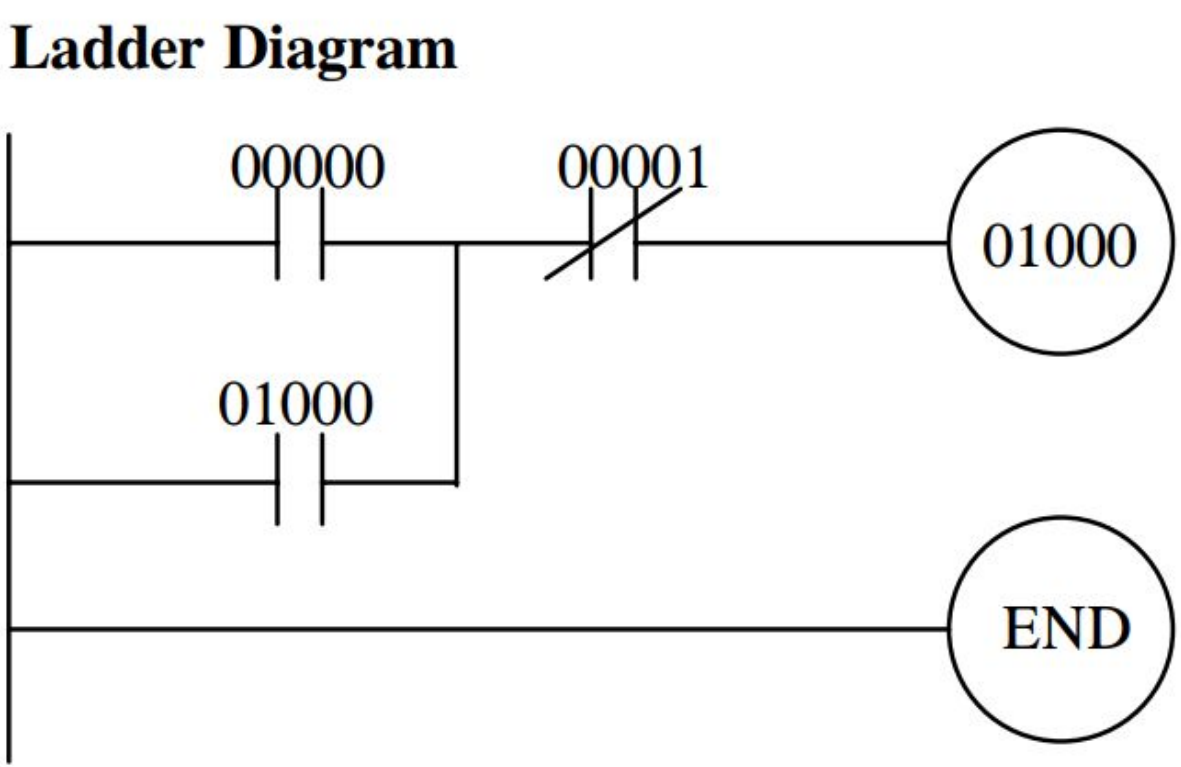




https://www.youtube.com/watch?v=QISbZC6uCvc

Latch / Self Holding Circuit

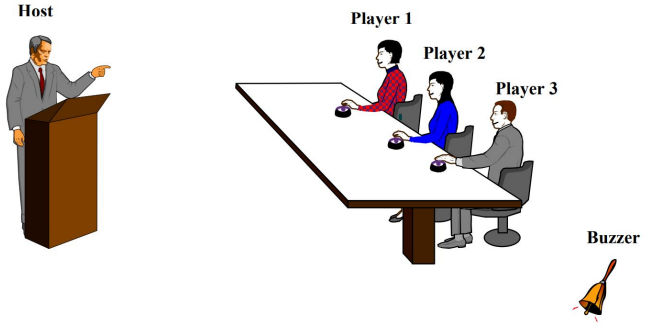




Example - Quiz Show

The game buzzer control requirement:

1. After the Host has finished with question.
2. The 3 players will press the switch in front of them to fight to be first to answer the question.
3. The buzzer will sound for 10 sec after any one of the players has touched the switch.
4. The light indicator in front of each player will light-up and only reset by the Host switch.



Input	Device
00000	PB1
00001	PB2
00002	PB3
00003	RST (reset)

Output	Device
01000	Buzzer
01001	Player 1 light
01002	Player 2 light
01003	Player 3 light