Programmable Logic Controllers

PLC Basics

Operating systems and application programs

- A PLC contains a basic operating system that allows for:
  - Downloading and executing user (ladder logic) programs
  - Communicating with devices
    - I/O modules
    - Other PLCs on a network
  - Holding configuration data such as
    - Number and type of I/O modules present in the PLC system
    - Status information
Operating systems and application programs

- A PLC retains its operating system, user programs, and some data in retentive (nonvolatile) memory
  - While the PLC is off or is even disconnected from the power supply (given a battery backup)
- A PLC can then resume running a user program as soon as power is restored
  - The PLC may be programmed to require some operator action before resuming user program execution (for safety purposes)

User program execution

- A PLC executes an initialization step when placed in run mode, then *repeatedly executes a scan cycle sequence*
- The basic PLC scan cycle consists of three steps
  - An input scan
  - A user program scan
  - An output scan
- The total time for one complete program scan is a function of processor speed, I/O modules used, and length of user program
- Typically, hundreds of complete scans can take place in 1 second
Input scan

- During the input scan, data is taken from all input modules in the system and placed into an area of PLC memory referred to as the **input image area**

User program scan

- During the program scan, data in the input image area is applied to the user program, the user program is executed and the output image area is updated
Output scan

- During the output scan, data is taken from the output image area and sent to all output modules in the system.

PLC scanning considerations

- During the input scan, input terminals are read and the input image area is updated accordingly.
- During the program scan
  - data in the input image area is applied to the user program
  - the program is executed (instructions carried out in sequence)
  - the output image area is updated appropriately
- During the output scan, data associated with the output image area is transferred to output terminals.
PLC scanning considerations

- It is important to understand that the input, program, and output scans are separate, independent functions
  - Any changes in the status of input devices during the program or output scan are not recognized until the next input scan
- Furthermore, data changes in the output table are not transferred to the output terminals during the input and program scans
- The transfer affecting the output devices takes place only during the output scan

PLC scanning considerations

- With all PLCs, there are special processing considerations to note
- First, all PLCs take a specific amount of time to scan their operational programs completely
- Typically, the program scanning takes place left to right across each rung and from the top to bottom rungs, in order
- Usually, the complete ladder scan time is a few milliseconds
PLC scanning considerations

- Another scanning consideration involves proper operational sequencing of events
- An output might not go on immediately in sequence as it would in a relay logic system
- In a relay logic system, an event occurring anywhere in the ladder control system results in immediate action
- In a PLC ladder control diagram, however, no effect takes place until the rung is scanned
- In most cases, the PLC logic delay effect is inconsequential

PLC scanning considerations

- Program (ladder logic) scanning typically takes place left to right across each rung and from the top to bottom rungs, in order
  - Known as rung scanning, it is the method used, for example, by Allen-Bradley
- Another method, used by Modicon/Schneider Automation is known as column scanning
  - Here the processor "looks" at the first contact at the top left corner and reads the first column from top to bottom
  - It next reads the second column from top to bottom, and so on
- Either method, rung or column, is appropriate.
Rung scanning

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Column scanning

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Two-rung ladder logic program

On switch  Part sensor  Spray paint
Paint empty  Operator alarm
Conveyor stopped

Two-rung ladder logic program

CPU  Digital input module  Digital output module
Input Image  Part sensor  Spray painter
User program  Motor  Paint level sensor
Output image  Operator control switch  Zero speed sensor
Alarm light
Example Program (In LogixPro Simulator)
Example Program with Energized Inputs