3/26/19 Notes

* What is a PLC?
  + If is a special purpose industrial computer designed for use in the control of a wide variety of manufacturing machines and systems.
  + 20% growth and 6.5-billion-dollar industry per year
* PLC Components
  + Processor
    - Actively making decisions and thinking. Memory is also stored here. Used to be program memory and data memory but lots of flaws with that so now memory is tag-based memory
  + Input Module
    - Accepts analog or digital inputs from devices
  + Output Module
    - Sends analog or digital data to devices
  + Power Supply
    - Provides power to CPU, modules, and external devices
  + Programming Device
    - A device, such as a PC, that allows for reconfiguration of a PLC
* Six methods for programming PLCs
  + International Electro-technical commission established standards
  + Ladder Diagram (LD)
    - Most common, relay logic
  + Function Block Diagram (FBD)
    - LabVIEW or Lego Minestorms
  + Structured Text (ST)
    - Text based like Java or C++
  + Instruction Lists (IL)
  + Sequential Function Charts (SFC)
  + Last two are more uncommon
* Relay Ladder Logic Diagram
  + Sometimes referred to as a Two-wire diagram
  + Basically fancy circuit diagram
  + Power is usually coming from the left, flowing to the right
  + Each “rung” is usually one or two tasks such as lamp, heater, etc.
* An input device is any device that provides a signal or other forms of data to a system
* Switch
  + A device that provides an On or Off signal
  + Can be manually or mechanically operated
    - Manual would be like a button or a physical switch
    - Mechanically operated would be like a pressure sensor or something
* Three basic components of a switch
  + Pole
    - Internal conductor in the switch that s moved by the operator
  + Operator
    - The mechanism in the switch that is moved to cause a change in the switch contact
  + Throw
    - The number of states a pole can operate
* Types of manual operated switches
  + Toggle switch
    - Moved from one position to another, like a light switch
  + Selector switch
    - Rotary switch, multiple selector like a heater, think heater selection on my car
  + Pushbutton switch
    - Lots of different types
  + Mechanically operated switches
    - Limit switch
      * Lever or plunger that detects a process element through direct contact
    - Flow switch
      * A switch used to detect a change in flow of a liquid or gas
    - Float switch
      * A switch used to detect liquid or other materials
    - Temperature switch
      * A switch used to detect temperature
* Electro-Mechanical Relay
  + An electrical device developed by Joseph Henry in 1921 that uses an electrical signal to energize an electromagnet, which then moves a switching element into an alternate ‘active’ position
  + Relays are often used to remotely switch electrical devices to limit safety concerns
  + Three main components
    - Contacts
      * Provides a path of conduction
    - Armature
      * Hinged arm that is attracted to the electromagnet when energized
    - Electromagnet
      * The actual electromagnet
  + Coil voltage
    - Voltage necessary to energize the electromagnet
    - Determined by electromagnet impedance
  + Rated load
    - Characteristic of the contact
    - Voltage rating is determined by max separation between contacts
* Normally Open contacts are the same symbol as a basic capacitor
  + Normally Open means that the default position is open circuit until something happens (pushbutton is a good example)
* Normally Closed contacts are the same symbol as a variable capacitor
  + Normally Closed means the default position is closed
* Logic elements are different in a latter
  + And
    - Elements in series both need to be closed to complete circuit
  + Or
    - One element out of two in parallel need to be closed to complete circuit
  + Not
    - Normally Closed element needs to be active to be open and have an incomplete circuit
* Latching
  + The ability of a circuit to ‘remember’ a previous state
  + Basic Latch
    - The input contact activates the output and the output changes the state of a third thing. The state is stored in the third thing and cannot be reset until something like unplugging the system from the wall is done
  + Resettable Latch
    - A resettable latch uses a Normally Closed contact in series with the input that can break the circuit when it becomes active
* NFPA Wiring Color Codes
  + Green – Ground
  + White – AC Neutral/DC Ground
  + Black – Single Phase AC Line Voltage
  + Red – Switched AC Line Voltage
  + Blue – +24V input to PLC
  + Orange – +24V output from PLC
  + Brown
  + Yellow

4/2/2019

* 110101 to decimal
  + 1\*2^5+1\*2^4+0\*2^3+1\*2^2+0\*2^1+1\*2^0
  + 2^5+2^4+2^2+1
  + 32+16+4+1
  + 53
* 16 to decimal
  + 1\*7^1 + 6\*7^0
  + 7 + 6
  + 13
* 101101 to base 8
  + 101 101
  + 5 5
  + 55 in base 8
* 1452 base 8 to base 10
  + 1\*8^3+4\*8^2+5\*8^1+2\*8^0
  + 810
* ACE base 16 to base 2
  + A C E
  + 10 12 14
  + 1010 1100 1110
  + 101011001110

4/9/2019

* Digital input and output module selections
  + Module selection criteria is task and process specific
  + Need to consider the following questions
    - How many inputs and outputs are needed?
      * The system in our lab requires 12 inputs and 7 outputs
        + Allen Bradley inputs and outputs generally have 8, 16, or 32 points per module
        + Do you select a single 16-point input or 2 8-point input modules?
        + Do you select a single 8-point output module?
    - What are the voltages and current requirements of inputs and outputs?
      * The inputs are operated using 120 VA
    - Do the inputs and outputs need to be isolated?
      * The output module will need to have isolated relay outputs
    - How are the field devices connected?
      * All connected in a sinking configuration
        + Switching ground instead of switching power
    - Are there any environmental constraints?
      * The PLC System will need to operate under standard conditions
  + Input module selection: 1769-IA16
    - 16 points provide four spare inputs allows for expansion or reconfiguration
    - Sinking input with common connection
  + Output module selection 1769-OW8I
    - Isolated relay outputs
      * Allows either sinking or sourcing
      * Allows for AC or DC device interfacing
    - Limitations
      * Only allow for one spare output
      * Relay life limited to approximately 500,000 cycles
      * Depends on the voltage and current specifications of the load connected to the relay
* Truth tables (math260)
  + 0 is off
  + 1 is on
  + 2^n possible combinations (math330)
  + A or B 🡪 A + B
  + A and B 🡪 A \* B
  + Not A 🡪 !A
  + Zero property
    - A + 0 = A
    - A \* 0 = 0
  + Commutative property
    - A + B = B + A
    - A \* B = B \* A
  + Associative property
    - A + (B + C) = (A + B) + C
    - A \* (B \* C) = (A \* B) \* C
  + Distributive property
    - A \* (B + C) = A \* B + A \* C
  + Inverse property
    - A + !A = 1
    - A \* !A = 0
  + Ones property
    - A + 1 = 1
  + Other properties
    - A + A = A
    - A \* A = A
* Sum of products or product of sums to write an algebraic expression from a truth table
  + Will use sum of products only in class
    - A | B
    - 0 | 0 = 0
    - 0 | 1 = 1
    - 1 | 0 = 0
    - 1 | 1 = 1
      * First 1 = !A\*B
      * Second 1 = A\*B
      * !A \* B + A \* B = B
    - Algebraic statement for the truth table above is Out = B
  + !A \* !B \* !C + !A \* B \* !C + A \* !B \* !C
  + = !A \* !C \* (B + !B) + A \* !B \* !C
  + = !A \* !C + A \* !B \* !C
  + = !C(!A + A\*!B)
  + = !C(!A + !B)
    - If there is !A and A together, one of them will always be true, so we can ignore the regular A
  + = !A \* !C + !B \* !C = !C(!A + !B)
* A \* (B \* !C \* D + C \* (!B \* D + B \* !D))
  + (!B \* D + B \* !D) is XOr

4/16/2019

* Karnaugh Maps
  + A method for organizing a truth table so that adjacent outputs can be cancelled if active
  + Can be useful, but requires practice
  + Only really useful for logic circuits with three or four inputs
* A three input Karnaugh map is organized into a 4 row by 2 column matrix
  + The zeros and ones are transferred from the truth table to the Karnaugh Map
  + The row and column designation refers to whether the input is on or off. For example, 00 in the first row indicates that A and B are both off.
  + When the table is completed, ones are grouped together in powers of two and the corresponding portion of the table is cancelled out
* Introduce Karnaugh Maps
  + A method for organizing a truth table so that adjacent outputs can be cancelled if active

|  |  |  |  |
| --- | --- | --- | --- |
| A | B | C | Y |
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 |

|  |  |  |
| --- | --- | --- |
| AB/C | 0 | 1 |
| 00 | 1 | 0 |
| 01 | 0 | 1 |
| 11 | 0 | 1 |
| 10 | 1 | 1 |

* Row 01 and 11, column 1 combines to B\*C because A doesn’t matter, but C and B do matter.
* Row 10 and column 0 and 1 reduces to A\*!B because C does not change the output, but the output is true if A and !B
* Row 00 and 10, column 0 reduces to !B\*!C because A does not change the output, and B and C are both 0 for both input. Therefore it needs to be !B\*!C
* The reduced form of this table is BC+A!B+!B!C
* A program tag is considered a local variable
* A controller tag is considered a global variable
* Timing
  + Mechanical timing relays are often pneumatic
    - As air flows, pressure against diaphragm increases until contact is made
    - Time delays range between 50 milliseconds to 180 seconds with a +/- 10% error
  + Electronic timers use internal oscillators as a clock
    - Commonly referred to as a Mono-stable Multi-Vibrator
    - Timer adjustment through hardware or software and can be programmable
    - Time delays range determined by circuit typically between 50 milliseconds to 60 hours
    - Significantly better accuracy +/- 1%

5/14/2019

* Write a program that will convert degrees to radians. The degrees measured are stored in a tag labeled Degrees and the resulting radian measure should be stored in a tag labeled Radian
  + Pi/180
* Variable Frequency Drive
  + VFD is a subset of an AC drive. All VFDs are AC drives, but not all AC drives are VFDs
  + VFDs control the speed of an AC motor without damaging or burning out the motor
    - They slowly speed up and slow down the AC motor
  + Controls AC motor by varying its frequency
    - Angular velocity is directly proportional to frequency
      * w = 2(pi)(f)
    - A change in frequency will result in a change in speed
* VFD Electrical Characteristics
  + Single phase or three phase input
  + Single phase or three phase output
  + Power can range from fractional horse power to 2000 hp
  + AC input 🡪 AC to DC conversion 🡪 Energy storage 🡪 DC to AC Conversion
* VFD Construction
  + Single or three phase input is rectified and converted to DC
  + The DC is filtered and stored
  + The CD is converted back to AC using controller data that controls the electrical characteristics of the required output
  + The output is connected to the motor
* Negative parts of the sine wave are flipped over time axis to make 1.5 waves out if 1 wave, the average of the absolute value of the wave is turned into DC, then a switch rapidly turns on and off to make a square wave form that averages to the output sine wave (pulse wave modulation)
* PowerFlex 4 Characteristics
  + Input characteristics
    - Input voltage: 120 VAC
    - Input current: 6 Amp
    - Phase: single
  + Output characteristics
    - Output voltage: 0-230 VAC
    - Output Current: 1.5 Amp (max)
    - Phase: Three
    - Output frequency: 0-240 hertz
  + Rated efficiency: 97.5%
* PowerFlex 4 Power Connections
  + Single Phase Input
    - Line voltage: R/L1
    - Common: S/L2
  + Three Phase Input
    - Phase A: R/L1
    - Phase B: S/L2
    - Phase C: T/L3
  + Output
    - Phase A: U/T1
    - Phase B: V/T2
    - Phase C: W/T3
  + Cover on the controller, then a second cover that protects the terminal screws.
    - You REALLY don’t want to accidentally touch the terminal screws
* PowerFlex 4 Control Connections
  + Stop (1)
  + Start/Forward (2)
  + Reverse (3)
  + +24 V DC (11)
  + +10 V DC (12)
  + Analog Input (13)
  + Analog Common (14)
  + Page 23 of user manual lists parameters that control each of these inputs
  + Generally, other control inputs are not used
* DO NOT PLUG IN AN ETHERNET CABLE TO THE RS485 JACK OF THE CONTROLLER
* PowerFlex 4 Interface and Control Parameters
  + 4 Common groups of parameters
    - Fault (read only)
      * Displays warnings/errors
    - Display (read only)
      * Displays general operational parameters
    - Program (read/write)
      * User modifiable operational parameters
    - Advanced (read/write)
      * User modifiable operational parameters
* PowerFlex 4 Common Control Parameters
  + Display Group
    - D001: Output Frequency
    - D003: Output Current
    - D004: Output Voltage
  + Program Group
    - P031: Motor Nameplate Voltage
      * Generally, 110/220 V
    - P032: Motor Nameplate Frequency
      * Generally, 60 Hz
    - P033: Motor Overload Current
      * Generally, 10-20% below fuse rating
    - P034: Minimum Frequency
      * 50% of NP frequency
    - P035: Max frequency
      * 150% of NP frequency
    - P036: Start source
      * Default keypad (0)
    - P038: Speed reference
      * Default keypad (0)
* **Reminder: Lab 7 introduces HAZARDOUS voltages. It is vital that you follow proper lab procedures. Sloppy wiring is dangerous. If you are uncertain about anything, ask a TA before you power your cabinet.**
* Motor characteristics
  + 208-230 V/460 V
  + 1.3-1.3/0.65 A (Normal)
  + 1.5-1.5/0.8 A (Overload)
  + 0.25 Horsepower
  + 1725 RPM @ 60 Hz
  + Power Factor (PF) of 50
  + 56% Efficiency
* Wiring Color Code Specified by the NFPA
  + Green/Bare Wire/Green-Yellow – Ground
  + White/Gray – AC Neutral/DC Ground
  + Black – Single Phase AC Line Voltage
  + Red – Single Phase AC Line Voltage (2nd hot)
  + Three Phase (L1) 120/208/240 V – Black
  + Three Phase (L2) 120/208/240 V – Red
  + Three Phase (L3) 120/208/240 V – Blue (NOT 24 V DC INPUT ANY MORE)
* PowerFlex 4 Control Parameters for Lab 7
  + Display Group
    - D001: Output Frequency
    - D003: Output Current
    - D004: Output Voltage
  + Program Group
    - P031: Motor Nameplate Voltage
      * 230 V
    - P032: Motor Nameplate Frequency
      * 60 Hz
    - P033: Motor Overload Current
      * 15 A
    - P034: Minimum Frequency
      * 30 Hz
    - P035: Max frequency
      * 90 Hz
    - P036: Start source
      * 2-Wire (2)
    - P038: Speed reference
      * Analog 0-10 V Input (2)
* Auxiliary Contact
  + Used in Lab 1 to “latch” the motor starter relay
  + Can also be used to control items in parallel with motor
  + Will be used in Lab 7 to control VFD “Motor Enable”