**Objective:** Integrate interlocking Bit commands, timers, program control, & memory management ladder logic elements to control an automated process using an Allen-Bradley Micrologix1200C microcontroller with RSLogix500 programming software. The lab utilizes a number of control and data manipulation aspects of Chapters 9, 10, & 11 in one process; as well as using bit, timer, and counter operations from Chapters 1-8.

**OVERVIEW:**

PLC’s are commonly used to operate electric motors using electromagnetic motor starters in process control systems. Some process systems use two motors in a critical application. This is commonly referred to as a ‘Duplex” control system. The two motors (or units if the motor is part of something else, like a pump) can be referred to as a main and a backup, or sometimes they are called a ‘lead’ and a ‘lag.’ Terminology can vary greatly from application to application.

The Duplex control method provides three advantages: (1) in ordinary situations the main unit will do all the work, and will wear out, or fail, first. When a duplex system is used it ALTERNATES between the two units each time the system is activated. So motor A is turned on, then the next time the system activates motor B is turned on. And then it alternates back to motor A on the next call. (2) Extra system capacity is already built in. If one motor cannot maintain the needs of the system then the backup can be activated to help out till only one motor is needed again. (3) Redundant systems mean that the emergency backup is already in place. If Motor A is running and experiences a failure then Motor B automatically takes its place.

Automated systems not only provide control but often gather operational data from a process for various business and engineering purposes as the system is in operation. In addition to controlling the operation your design will do real time data collection, monitoring, and storage in PLC memory for maintenance and quality control purposes through the creation of several subroutines attached to the main project file.

**ASSIGNMENT: The Swamp Cooler Warehouse**

A fresh produce supplier has a bulk storage area which uses a dual fan ventilation (two fan motors) and an evaporative, or “Swamp,” cooler system to maintain stable temperature air flow over fruits and vegetables awaiting loading and shipment to area restaurants and smaller vendors. To prevent excessive temperature from damaging the produce, if area temperature exceeds 70º F then one fan of the two fans comes on to pull cooling air across the produce. The fans alternate between uses as to which is activated (FAN\_MTR\_1 or FAN\_MTR\_2). If the temperature exceeds 80º F then both fans come on to increase volume.

Design a PLC program to operate the system that meets all of the following requirements:

1. The system is operated using one NO PB (I:1). The PB is configured to toggle the entire system on and off with each push. (The same pushbutton turns the system on and off, so if the system is Off, pushing the button turns it ON, if it is already ON then pushing the same button turns it OFF. This means you need to design a way for the system to always know which mode it is currently in and then do the other when pushed.) As an indicator that the system is turned on & operational we will use O:0 as an indicator. NOTE: there is no pilot light on the trainer for Output 0-3, but there are LED indicators on the PLC unit itself that show if that output is true or false. So just use the PLC LED for O:0-3.

2. When the control circuit is active, it will alternately operate the two fan motors (FAN\_MTR\_1 & FAN\_MTR\_2) when the temperature in the warehouse exceeds 70º F as determined by Temperature Switch #1 (TS\_1). (NOTE: This means that you also have to create a way for the circuit to “remember” which fan ran the last time, and then turn on the other one when the temp is greater than 70º F the next time.) The green indicator lights (O:8 & O:9) are used to represent the fans to show which is running (or if both are active if required).

3. If the warehouse temperature exceeds 80º F as determined by Temperature Switch #2 (TS\_2), then BOTH fans turn on and continue to run until 10 seconds after the temperature falls below 80º F, with the one motor that was originally determined to run in the duplex resuming the run alone until the temperature falls below 70º F. So you will need to incorporate a timer with the second temperature switch operation.

4. TS\_1 (Temp>70º F) will be simulated by the first two-position switch (I:4); TS\_2 (Temp>80º F) will be simulated by the first two-position switch (I:5). Outputs O:6 & O:7 will serve as visual indicators of the temperature range. NOTE: In an actual application we would probably have more than one temperature sensor in place in case one failed, but for this case we will assume the sensors always work correctly. Logically, this means that the temperature cannot be above 80º F and below 70º F at the same time (so, if I:5 is true then I:4 must already be true).

5. If either fan is running and fails because its overload (OL) trips (FAN\_MTR\_1\_OL and FAN\_MTR\_2\_OL) then the other motor automatically begins operation to maintain temperature. The Overloads are NC contacts placed in Series with the fan motor starter coil they are monitoring to properly protect them. (HINT: Remember that contacts in a PLC program can exist in several places in the program, and be configured as NO in some places & NC in others!) Use the two NC wired pushbutton (the RED stop PBs, I:2 & I:3)) to act as the Overload contacts. The Red indicator lights (O:4 & O:5) are used to show the human operator when a motor OL is tripped and its fan is offline until reset or repaired. (NOTE: The motor will “trip” OL when you push the PB and will reset when you release the PB)

6. “Swamp” coolers work in areas of low humidity (they were used by the ancient Egyptians) to cool air by drawing it through wet burlap, or wool, layers. As the warm dry air passes through the fabric the water evaporates, cooling the air. Actually the one place a swamp cooler is totally ineffective is in a real swamp that has 100% humidity saturated air. When (a) the system is activated, and (b) either fan motor is running a water spray pump (O:1) is engaged to mist water onto the layers, (c) if both fans are called then a second water spray pump (O:2) is on to inject additional liquid on the layers.

The sprayers jets can become clogged, or the filter dirty, or low water levels, so flow sensors are included with each spray pump (I:6 & I:7), if water flow in either pump is blocked while a fan is running then a warning output (O:3) blinks in 0.5 second pulses until the problem is fixed and flow is restored to alert operators to check the pumps.

7. Create three subroutines files. (Right-Click on the Program Files folder in the project tree; select ‘New’ to create new ladder files.) Give the subroutines the following number and name: File #3: FAN\_MTR\_1 (Operational data for Fan Motor #1) File #4: FAN\_MTR\_2 (Operational data for Fan Motor #2) File #5: TOTALS (Excessive Temperature in Process & longest Run time) The subroutines should be called on each scan to update the data gathered.

8. Using the subroutines for the two fan motors: (A). a counter will be established for each motor which records how many times each fan was activated. (B.) a timer will be set up to record in seconds how long total each fan motor has run.

9. Using the totals subroutine for the excess temperate recording: (A). a counter will be established to record how many times the temperature in the warehouse exceeded 90º F; (B) a timer will record in seconds the total amount of how long the temperature remained above 90º F, and (C) What is the longest period, in seconds, that any of the two fans has run continuously since the last reset was made.

10. Data gathered from the process will be stored in processor memory as follows where it can be viewed & monitored as needed: N7:0 = Motor\_1\_OL The number of times Fan Motor 1 Tripped out N7:1 = Motor\_2\_OL The number of times Fan Motor 2 Tripped out

N7:2 = Motor\_1\_ON The number of times Fan Motor 1 was activated N7:3 = Motor\_1\_RunTime The total amount of time Fan Motor 1 was activated N7:4 = Motor\_2\_ON The number of times Fan Motor 2 was activated N7:5 = Motor\_2\_RunTime The total amount of time Fan Motor 2 was activated N7:6 = Above\_90 The number of times the temperature exceeded 90º F

N7:7 = Above\_90\_Time The amount of time the temperature exceeded 90º F

N7:8 = Longest\_Run The longest continuous period either motor was required to run

11. Data from subroutine Fan\_Motor\_1 is reset (count and time) using I:8 Data from subroutine Fan\_Motor\_2 is reset (count and time) using I:9 Data from Totals subroutine (count and time above 90º F, & longest continuous run time for any fan motor) is reset using I:0

12. During testing of the circuit the N7 Integer Data Folder can be monitored to confirm that process data is being properly gathered during the circuit run & stored in the correct memory locations. Also that the resets work as expected.

See the data table on the last page for a summary of I/O assignment

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| --- | --- | --- | --- |
| Assign addresses in your PLC program according to the table shown below. Input Description  | Address  | Output Description  | Address  |
| Reset Totals data  | I1:0/0  | System in Operation  | O0:0/0  |
| Start & Stop the system  | I1:0/1  | Main Water Spray Pump  | O0:0/1  |
| Fan\_Motor\_1 OL  | I1:0/2  | Backup Water Spray Pump  | O0:0/2  |
| Fan\_Motor\_2 OL  | I1:0/3  | Flow Pump Sensor Error  | O0:0/3  |
| TS\_1 (temp>70)  | I1:0/4  | FAN\_MTR\_1\_OL Trip  | O0:0/4  |
| TS\_2 (temp>80)  | I1:0/5  | FAN\_MTR\_2\_OL Trip  | O0:0/5  |
| Pump 1 Flow Sensor  | I1:0/6  | Temperature >70  | O0:0/6  |
| Pump 2 Flow Sensor  | I1:0/7  | Temperature >80  | O0:0/7  |
| Reset Fan\_Motor\_1 Data  | I1:0/8  | FAN\_MTR\_1 Running  | O0:0/8  |
| Reset Fan\_Motor\_2 Data  | I1:0/9  | FAN\_MTR\_2 Running  | O0:0/9  |