Benha University

Prof . Mohamed Ahmed Ebrahim

Benha University
Faculty of Engineering at Shoubra
Electrical Engineering Dept.

Industrial Controls (1)

By

Associate Prof. / Mohamed Ahmed Ebrahim Mohamed

E-mail: mohamedahmed_en@yahoo.com

mohamed.mohamed@feng.bu.edu.eg

Web site: http://bu.edu.eg/staff/mohamedmohamed033

Lecture (10)

05– 05 - 2019

Advanced PLC
Industrial applications

Prof . Mohamed Ahmed Ebrahim

EX:(3): PLC Program to Perform Pulse Width Modulation

- **Problem Description**

➢ Implement Pulse Width Modulation in PLC using Ladder Diagram programming language.

- **Problem Solution**

➢ To perform this two timers are used to Turn ON and OFF an output accord ing to the length of a pulse.

➢ Timer preset value should vary such that when preset of one timer is incr eased, preset value of other timer should decrease in order to maintain Turn ON and OFF time of output.

➢ Select input bits such that we can directly enter digits and place it into Preset value of a timer.

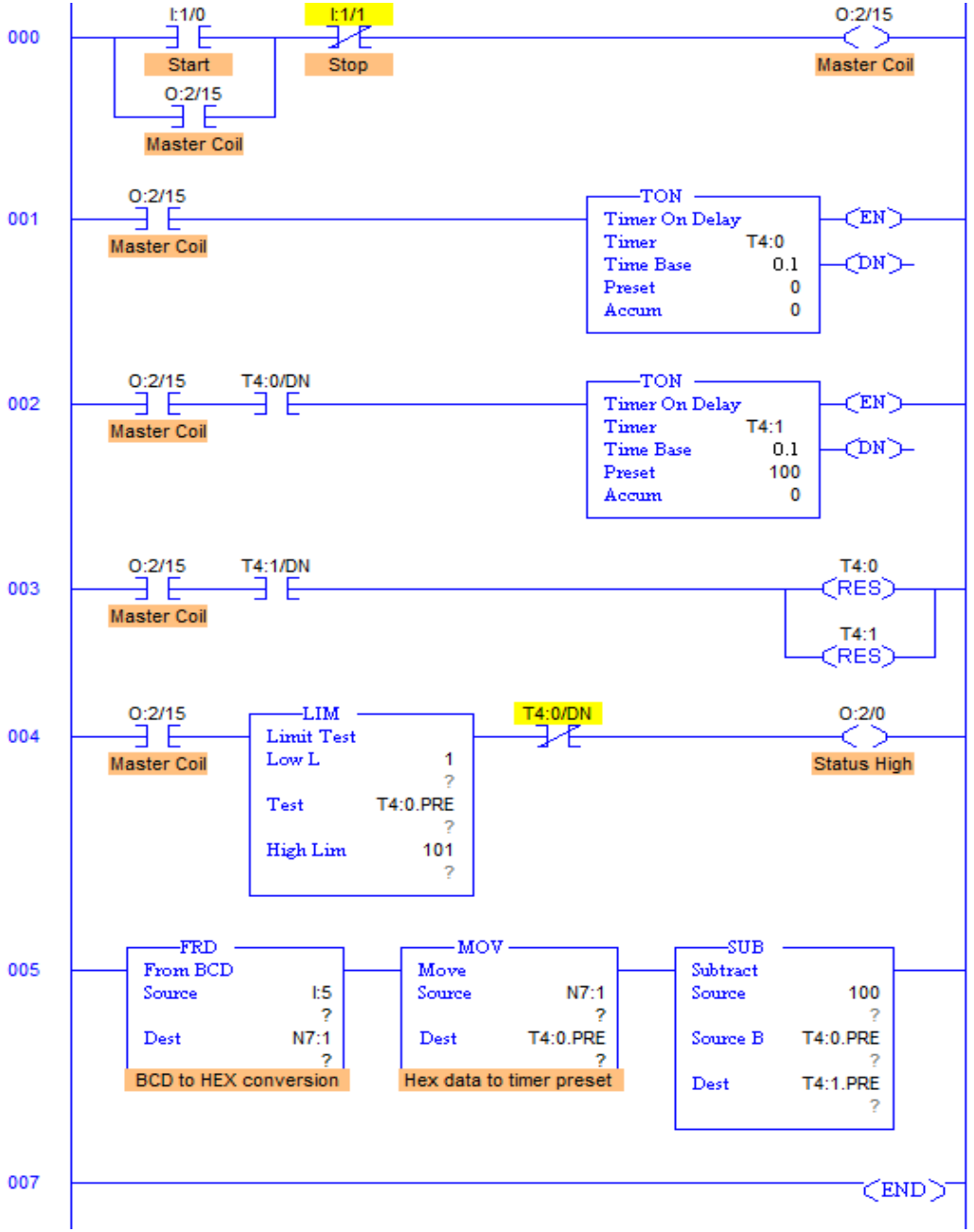
➢ This can be done by using a digital input device which generates 0-9 numerical digits.

- Output of this Digital device is always in BCD form and Timers pres et values store data in Hexadecimal, so whichever data are sent to preset register of a time, it has to be converted into Hexadecimal form.
- FRD instruction can be used to perform BCD to Hex conversion.
- Output of this conversion is directly moved to preset register of timer which can be performed by MOV instruction.

- **PLC Program**

```
List of Inputs and Outputs
 I:1/0    = Master Start PB                        (Input)
 I:1/1    = Master Stop PB                         (Input)
 O:2/15   = Master Coil                            (Output)
 T4:0     = Timer 0, ON time                       (Timer)
 T4:0.PRE = Timer 0 Preset value address           (Timer)
 T4:1     = Timer 1, OFF time                      (Timer)
 T4:1.PRE = Timer 1 Preset value address           (Timer)
 -(RES)-  = Timer reset coil                       (Output)
 I:5      = 0-100 BCD input                        (Input)
 N7:1     = BCD-Hex conversion storing register (Register)
```

- **Ladder Diagram to perform PWM operation**



EX:(4): PLC Program to Control Lights in a Sequence

- **Problem Description**

Implement controlling of various lights in PLC using Ladder Diagra m programming language using timers. Retentive Timer is suggested to use.

- **Problem Solution**

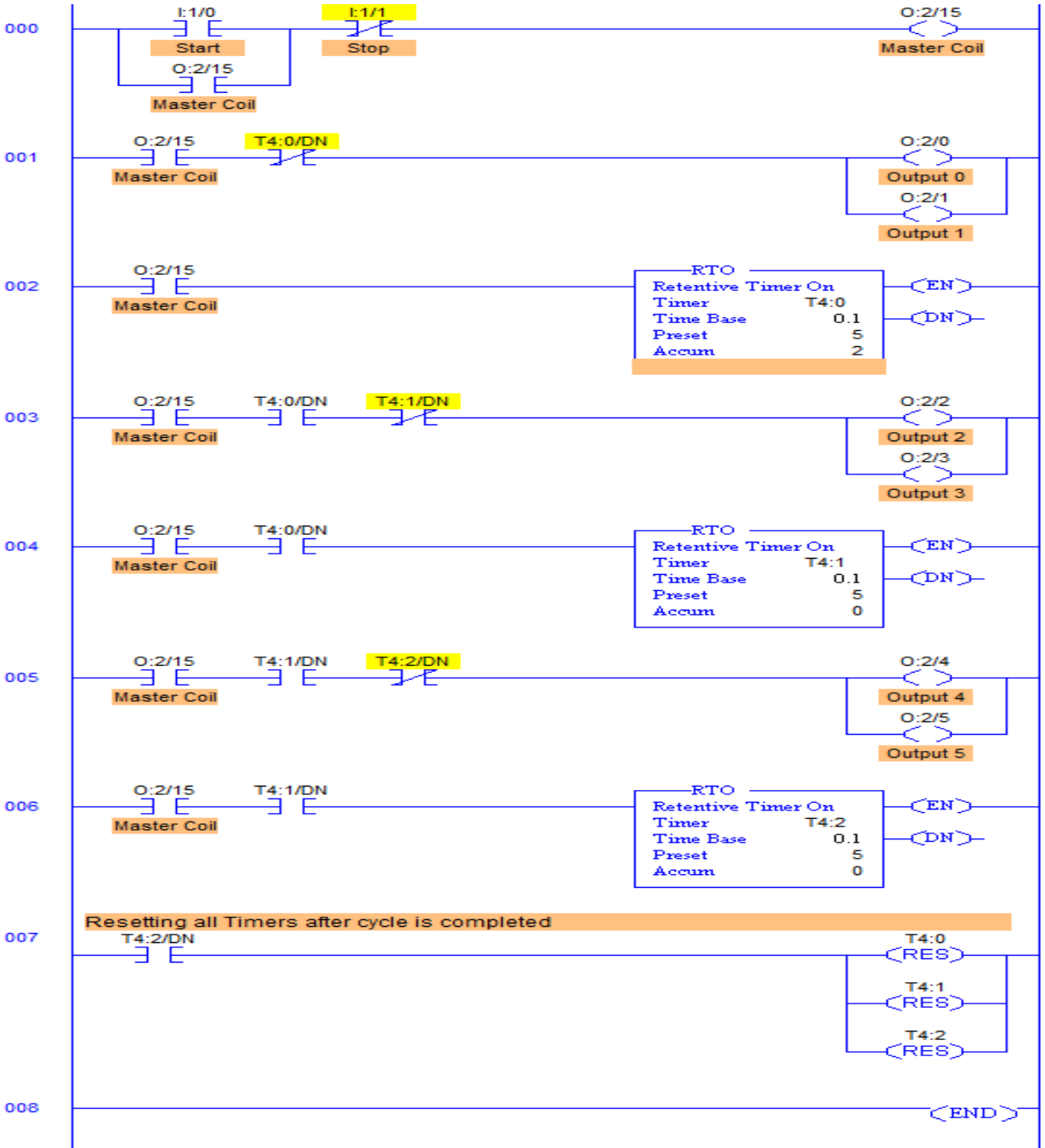
➢ Define order of lights.
➢ Provide timers to lights, to each individually if necessary.
➢ Reset timers automatically or use reset coil to reset timers.
➢ Double check if the order of light is made correctly and connections are made properly.
➢ Use latching coil for Master Start and Stop for prevention against malfunctioning.

- 0.1 Time Base function availability is useful to turn ON and OFF a light.
- By using this, we can make lights blink.
- This is one method to solve this problem by using timers.
- Retentive Timers have a capability of storing the previous values at which timer was stopped or input was withdrawn.
- Hence Retentive Timer RTO can be used here so that in case of power fail ure, program can be restarted from where it was left previously.

PLC Program

```
List of Inputs and Outputs
 I:1/0   = Master Start                    (Input)
 I:1/1   = Master Stop                     (Input)
 O:2/15  = Master Coil                     (Output)
 O:2/0   = Output 0                        (Output)
 O:2/1   = Output 1                        (Output)
 O:2/2   = Output 2                        (Output)
 O:2/3   = Output 3                        (Output)
 O:2/4   = Output 4                        (Output)
 O:2/5   = Output 5                        (Output)
 T4:0    = Timer for Outputs 0 & 1         (Timer)
 T4:1    = Timer for Outputs 2 & 3         (Timer)
 T4:2    = Timer for Outputs 4 & 5         (Timer)
 -(Res)-= Reset coil to reset timers       (Output)
```

Ladder Diagram to Control Lights in a Sequence



EX:(5):PLC Program to Implement an Automatic Car-Wash Process

- **Problem Description**

➢ When a Car enters the hall, a certain sequence is to be followed automatically. Steps are:

1) Soaping, 2) Washing, 3) Rinsing, and 4) Drying.

➢ Implement this process sequence in PLC using Ladder Diagram programming language.

- **Problem Solution**

➢ To detect the car automatically, load cells can be used, or any other sensor such as Infrared Sensor can also be used.

➢ Soaping, Washing, Rinsing and Drying are performed for a particular time, hence to generate time delay for these outputs become mandatory.

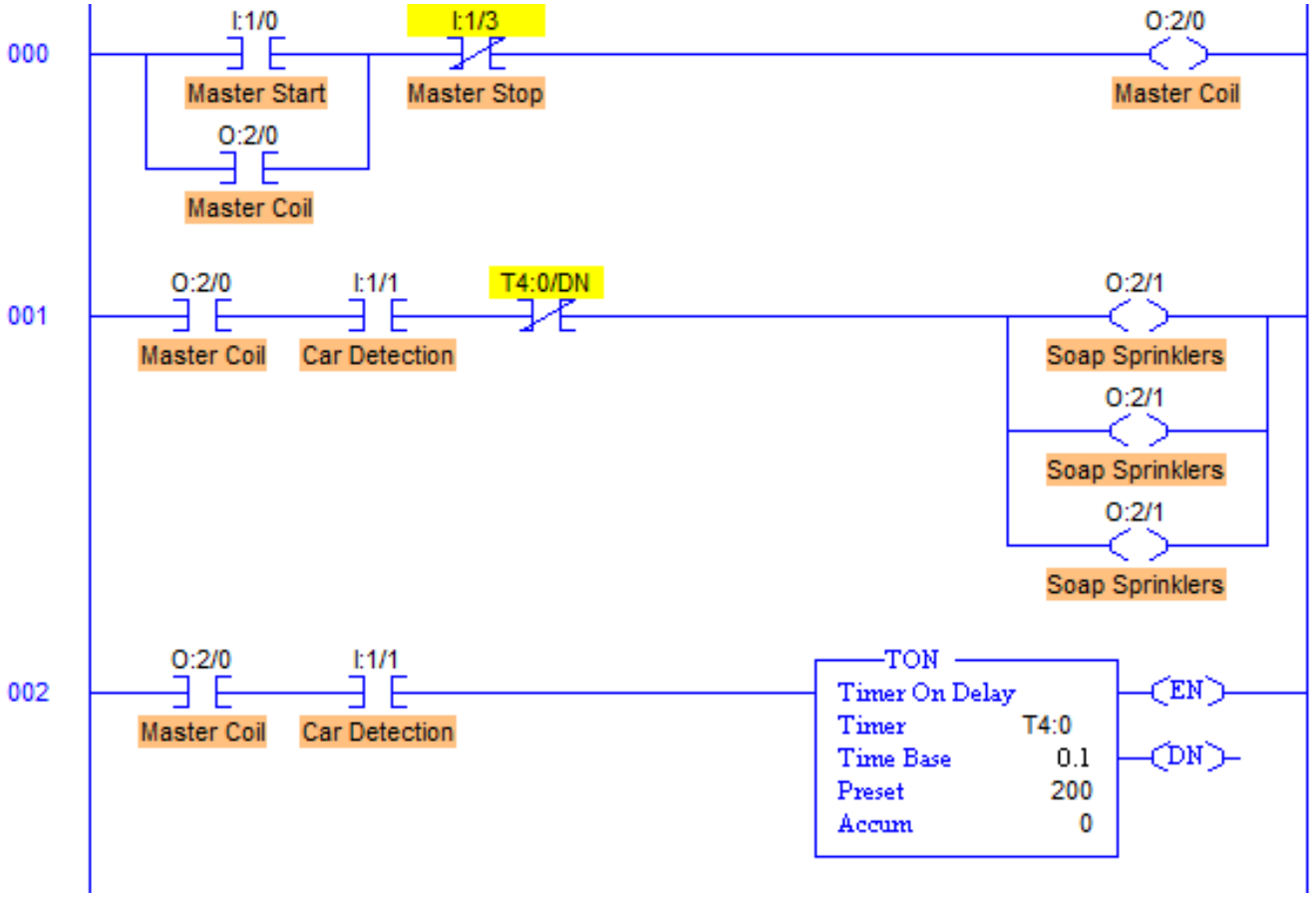
➢ To operate this process, for soaping, washing, and drying, four different timers are used.

➢ IR sensor detects everything whatever restricts the signal but in load cell, particular Low Level and High Level can be set to detect heavily weighted cars only. Load Cell can be here more effective here than IR sensors.

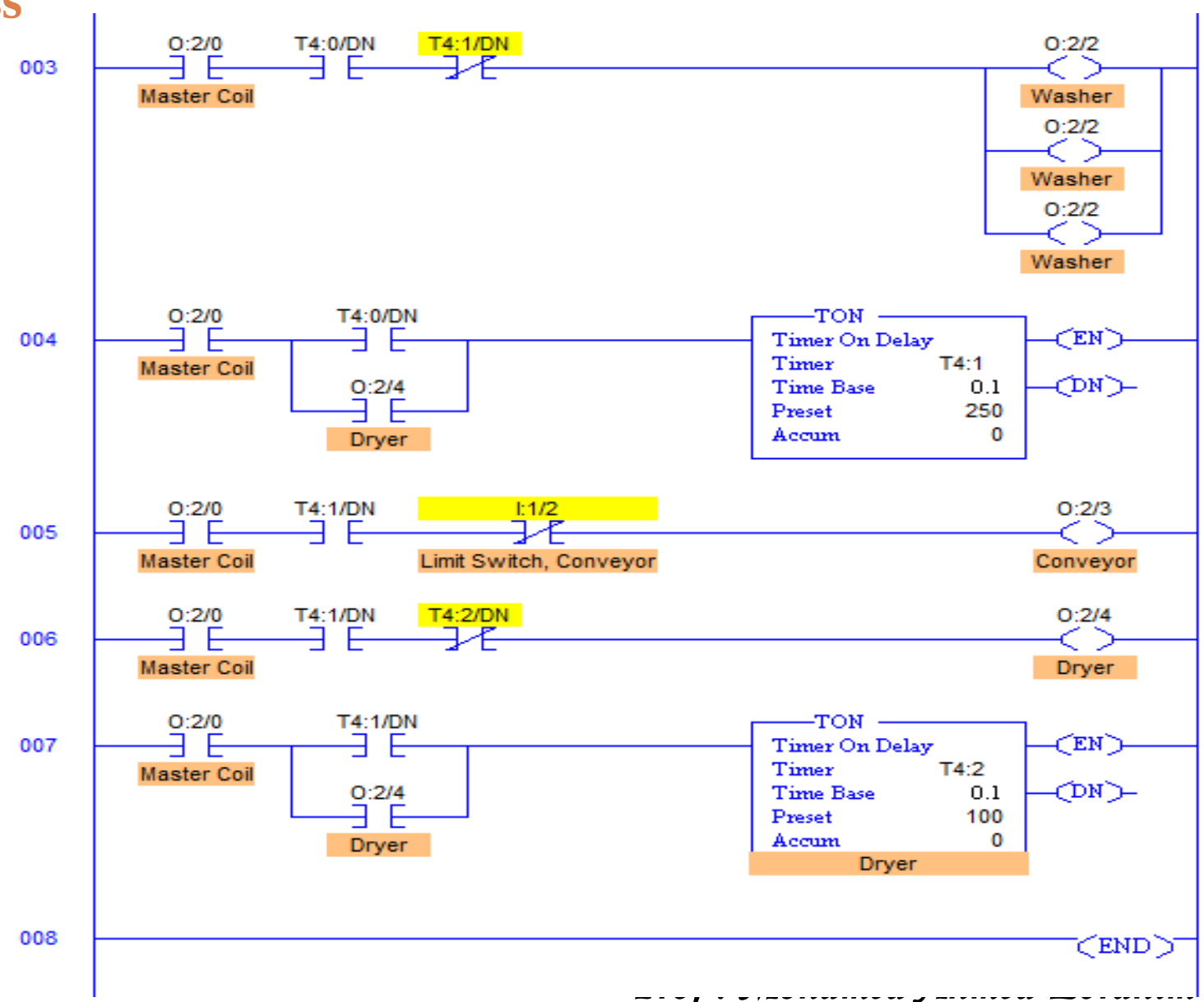
- **PLC Program**

```
List of Inputs and Outputs
 I:1/0  = Master Start                    (Input)
 I:1/1  =  Car Detection                  (Input)
 I:1/2  = Limit Switch, Conveyor          (Input)
 I:1/3  =  Master Stop                    (Input)
 O:2/0  = Master Coil                     (Output)
 O:2/1  = Soap Sprinkler                  (Output)
 O:2/2  = Washer                          (Output)
 O:2/3  = Conveyor                        (Output)
 O:2/4  = Dryer                           (Output)
 T4:0   = Soaping Time                    (Timer)
 T4:1   = Washing Time                    (Timer)
 T4:2   = Drying Time                     (Timer)
```

- **Ladder Diagram (1) for Automatic Car Wash Process**



- **Cont. Ladder Diagram (2) for Automatic Car Wash Process**



EX:(6):PLC Program to Store Data of Various Process Sequentially

- **Problem Solutions**

➢ There are total two parameters to be monitored of a tank. Display level and temperature of this tank for 5secs each.

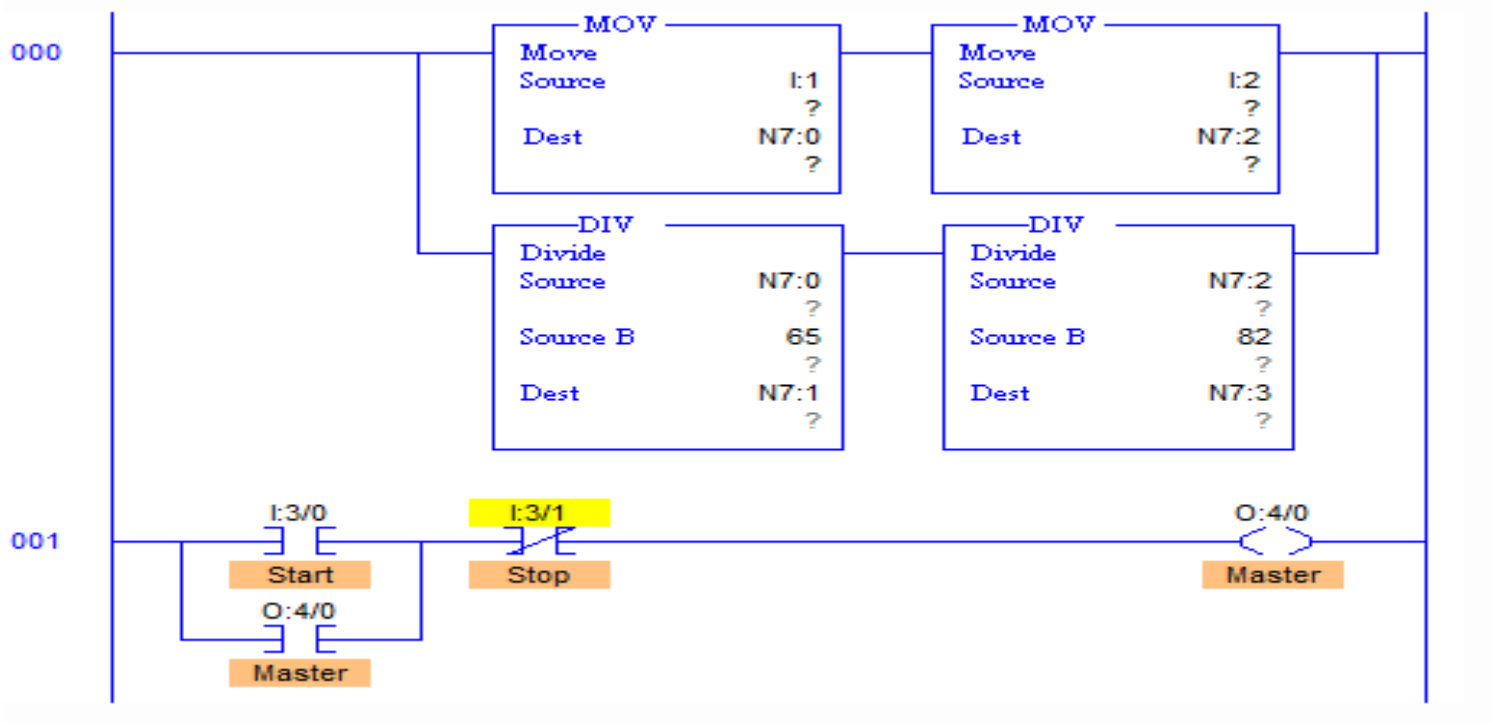
- **Problem Solution**

➢ Continuous measurement is necessary in this case.
➢ Continuous level measuring devices such as Ultrasonic or Pressure level sensor can be used and for temperature, RTD or Thermocouple can be used.
➢ Output of these sensors are in analog form, so to deal with such analog data, analog modules are used in PLC.
➢ Analog modules convert analog signal into equivalent hex form.
➢ Convert this into Temperature in degree centigrade and level in height in cm.
➢ Generate time base to MOV output storing register value to display address after converting into BCD equivalent.
➢ Use either number of timers or Sequential Output instruction to solve this problem.

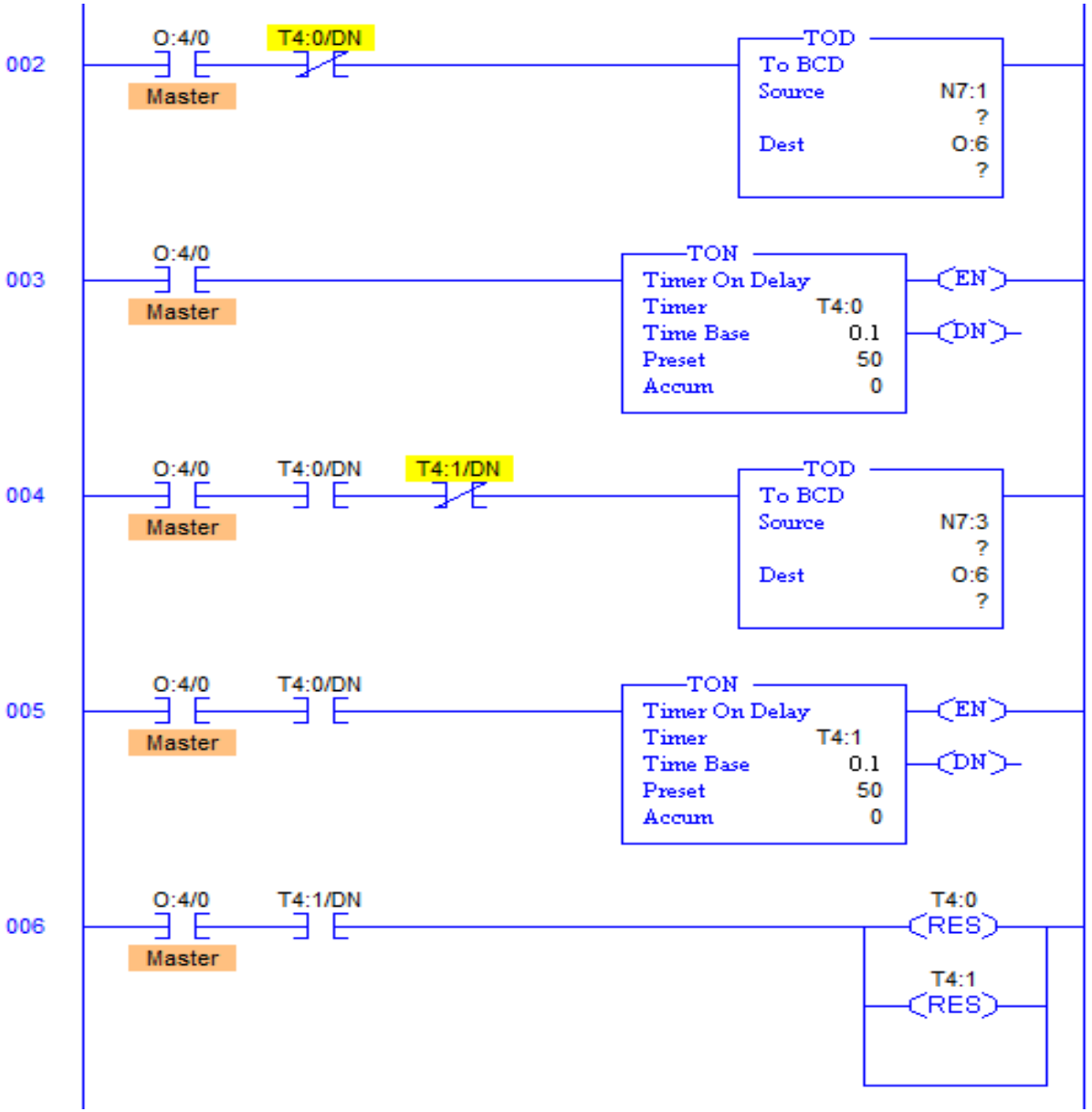
- **PLC program**

```
List of Inputs and Outputs
 I:1              = Level Input from Tank                          (Input)
 I:2              = Temperature Input from of the Tank              (Input)
 N7:0 and N7:1    = Store and  process data of tank level           (Register)
 N7:2 and N7:3    = Store and process data of tank Temperature      (Register)
 T4:0, T4:1       = Timers to switch display data every 5secs       (Timers)
```

- **Ladder diagram showing conversion of inputs**



- **Ladder diagram to display level and temperature**



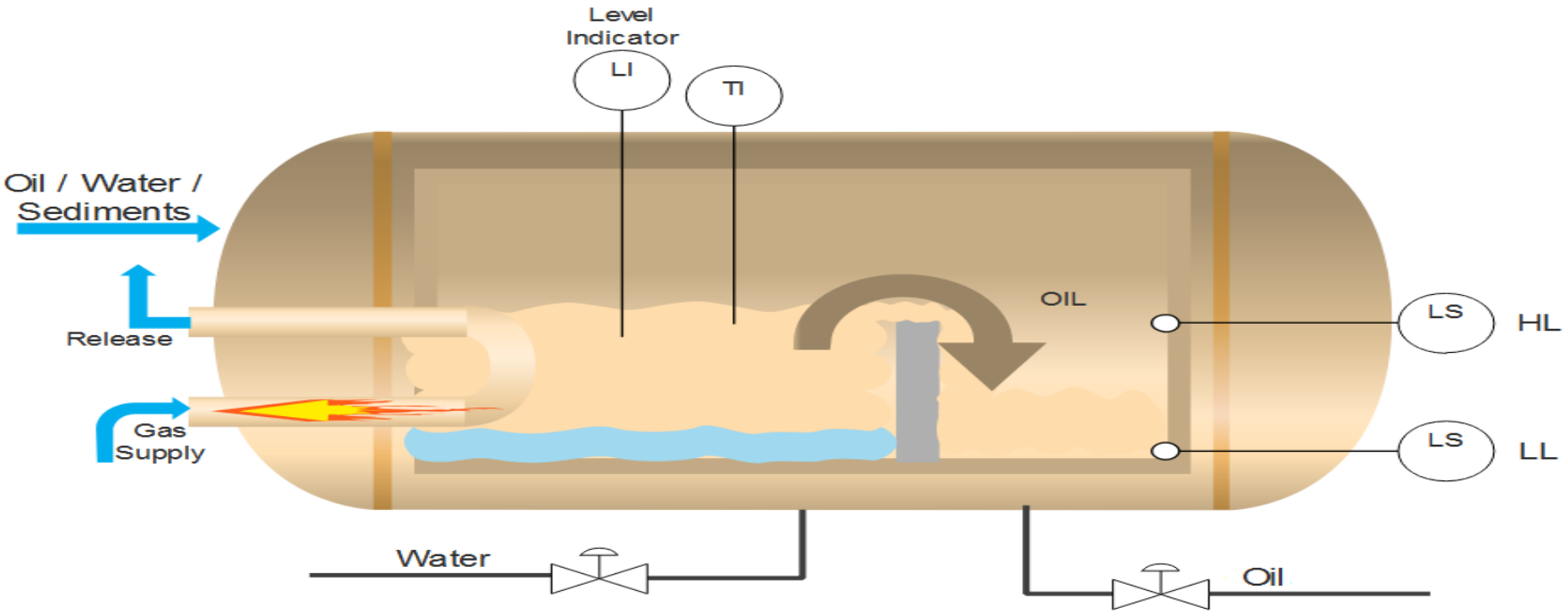
Prof . Mohamed Ahmed Ebrahim

EX:(7): PLC Program for Oil and Water Separation Process

- **Problem Description**

➢ Implement programming of Oil and Water separation process in PLC using Ladder Diagram programming language.

- **Problem Diagram**



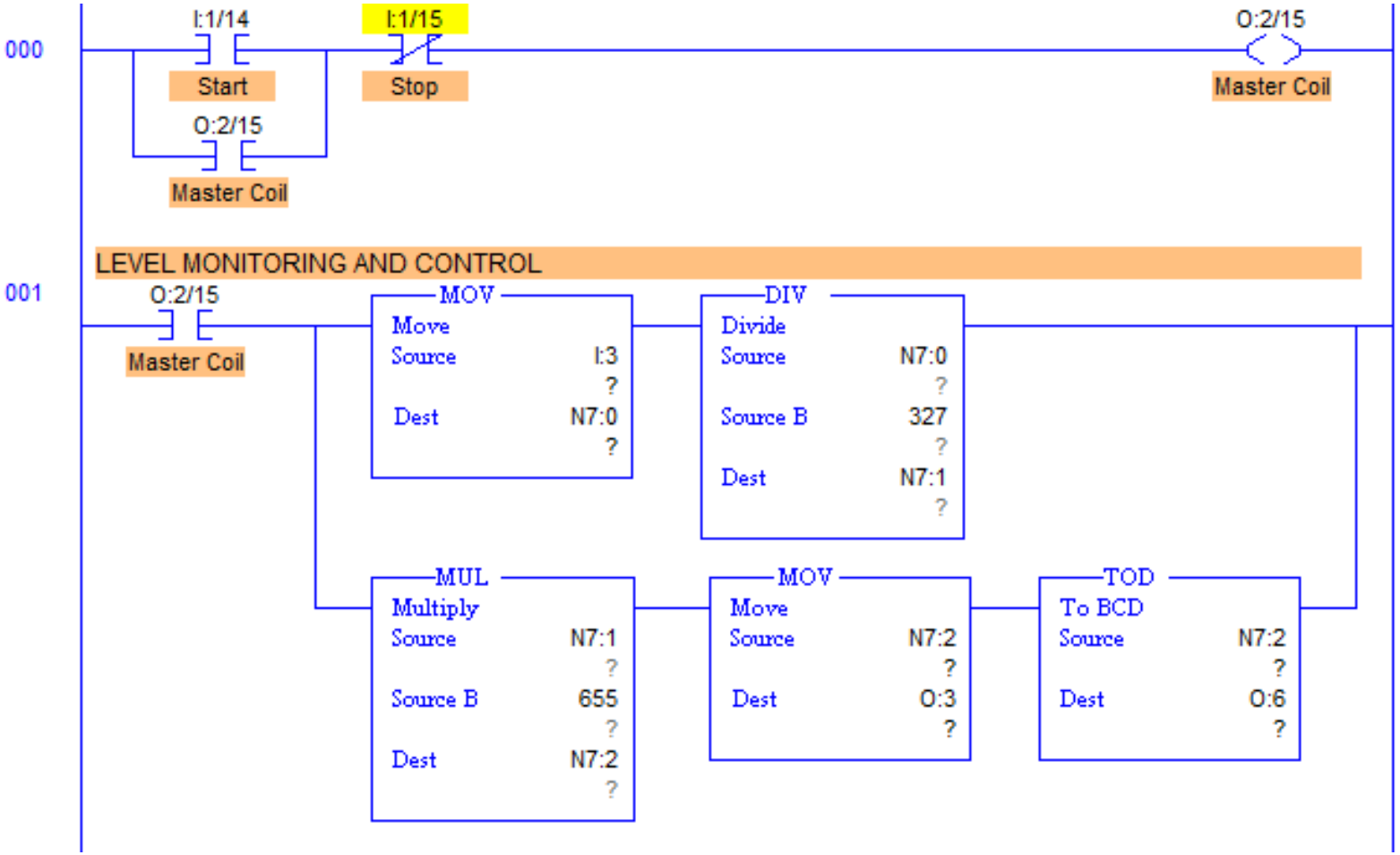
- **Problem solution**

- Due to the gravitational force and different liquid density of Water and Oil, when water and oil both are present in the liquid, oil always reside on top of the liquid. By following this theory and making an arrangement shown in the diagram above, Oil and Water can be separated.
- However, this process does not completely remove water particles but only less than 10% of water contents are present after passing through this process.
- Level of the tank is monitored using level sensor. To control level of the system Inlet is controlled.
- To control the temperature of this system, ignition is to be controlled. Temperature sensor is used and gas supply flow is controlled to control temperature. Temperature set point here is 50 degree centigrade.
- Oil outlet is controlled by control valve which is operated by two level switches.

- **PLC Program & Program Description**

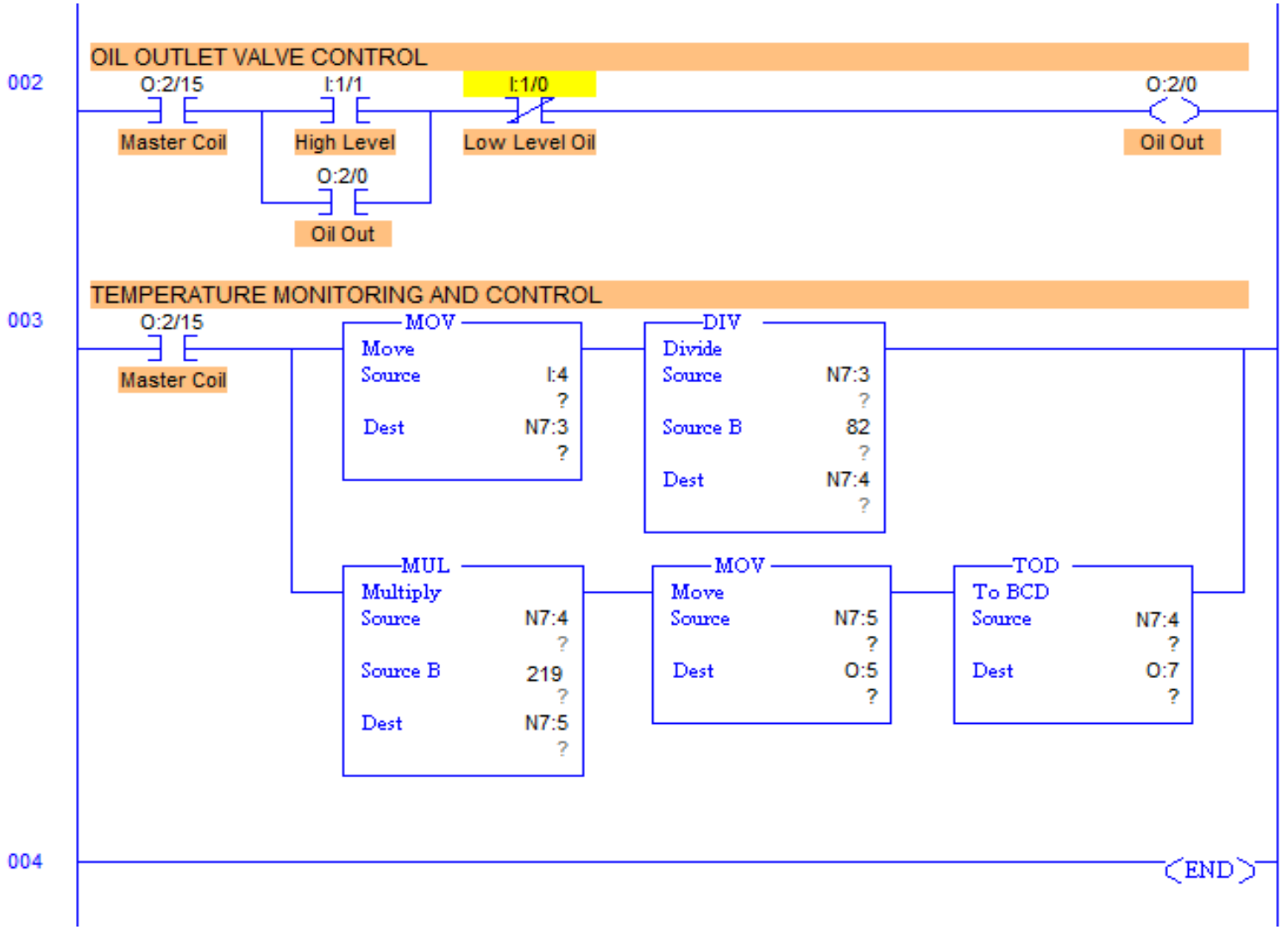
```
List of Inputs and Outputs
 I:1/14          = Start                                          (Input)
 I:1/15          = Stop                                           (Input)
 O:2/15          = Master Coil                                    (Output)
 I:3             = Level sensor output                            (Input)
 N7:0-N7:2       = Level monitoring and controlling registers     (Registers)
 O:3             = Inlet controlling valve                        (Output)
 O:6             = Level Display                                  (Output)
 I:1/1           = High level (Oil)                               (Input)
 I:1/0           = Low level (Oil)                                (Input)
 O:2/0           = Oil output valve (Single actuating)            (Output)
 I:4             = Temperature output from sensor                 (Input)
 N7:3 to N7:5    = Temperature monitoring and controlling registers (Registers)
 O:5             = Gas supply controlling valve                   (Output)
 O:7             = Temperature Display                            (Output)
```

- **Ladder diagram (1) to monitor and control Oil and Water separation process**



Prof . Mohamed Ahmed Ebrahim

- **Cont. Ladder diagram (2) to monitor and control Oil and Water separation process**

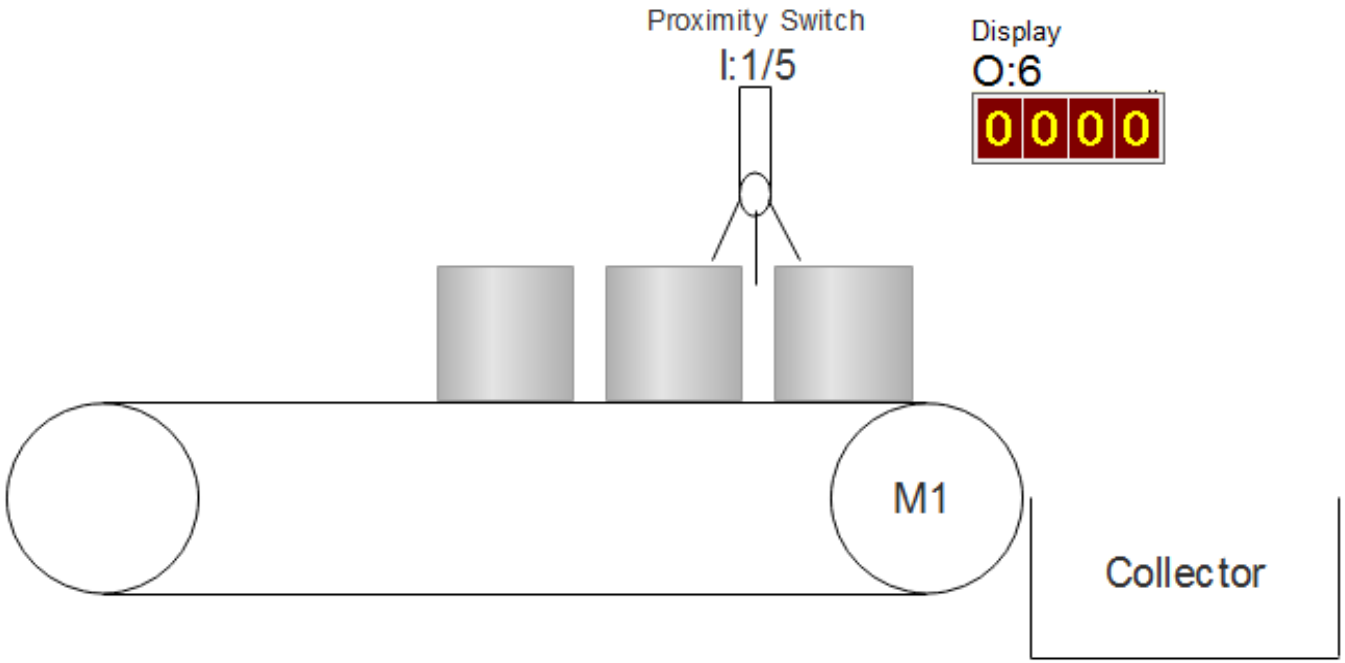


EX:(8): PLC Program for Counting of Parts from Conveyor

- **Problem Description**

➢ Parts are moved on the conveyor. Count the number of parts collected at the end of the conveyor and display it on the display in PLC using Ladder Diagram programming language.

- **Problem Diagram**



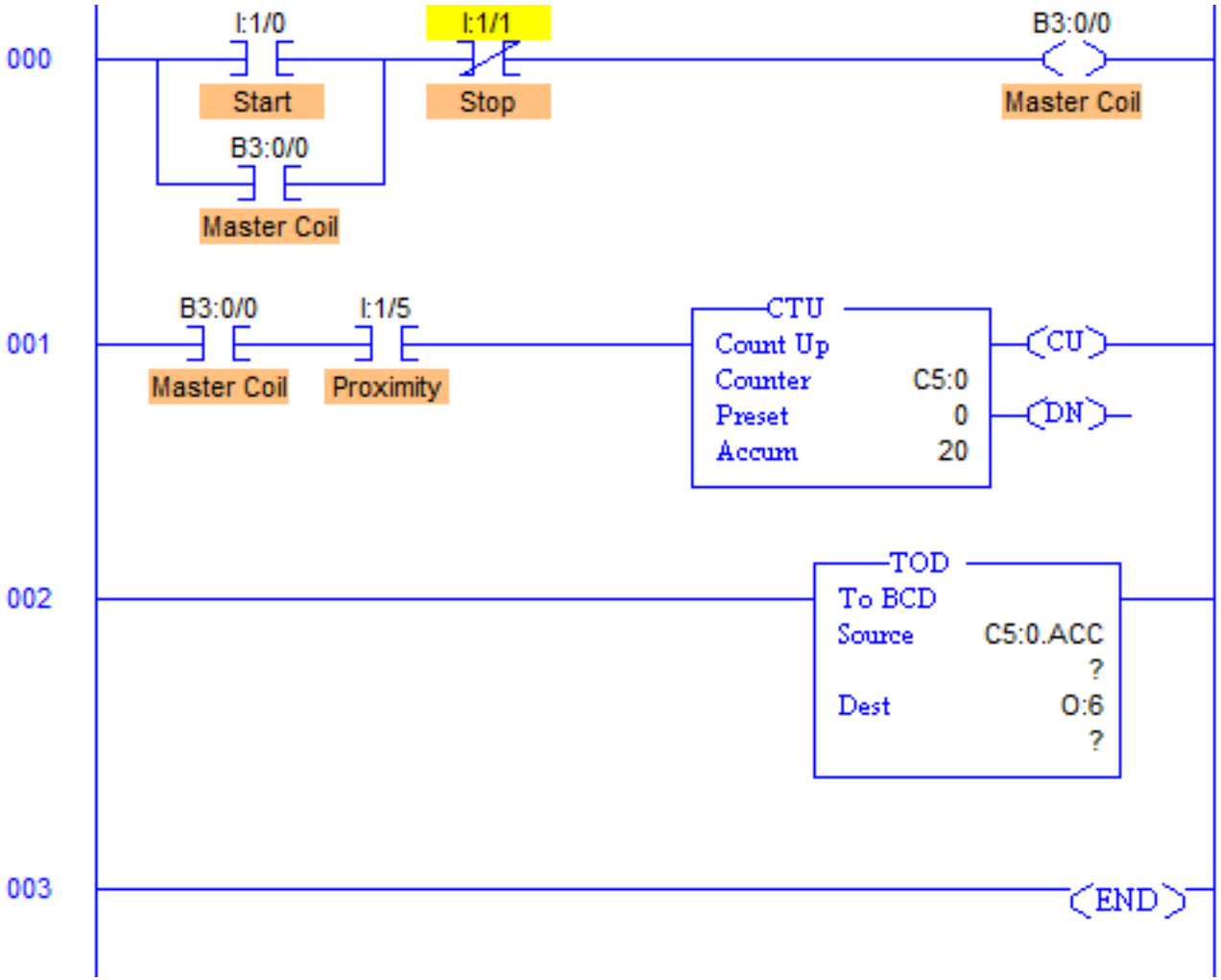
• Problem solution

- Mount Proximity Switch to detect the parts.
- Use output of proximity to counter as an input to increment data.
- Convert this number into appropriate numerical and show number of parts collected.
- Most widely Inductive and Capacitive Proximity switches are used to detect parts.
- Inductive Proximity are used to detect metal objects while to detect other objects, Capacitive Proximity Switch is most widely used.
- Capacitive Proximity detection capability ranges from 1 to 25mm distance.
- Mount this sensor according to the size of parts present on the conveyor and width of conveyor so that this sensor can detect parts easily.
- CUP is used to increment the number of parts collected.

• PLC Program

```
List of Inputs and Outputs
 I:1/0  = Start                                          (Input)
 I:1/1  = Stop                                           (Input)
 I:1/5  = Proximity (Part detection)                     (Input)
 C5:0   = Counter Up                                     (Counter)
 O:6    = Display address                                (Output)
 TOD    = Hexadecimal to BCD conversion instruction      (Compute)
 B3:0/0 = Latching Bit                                   (Bit)
```

- **Ladder Diagram to count and display number of parts**



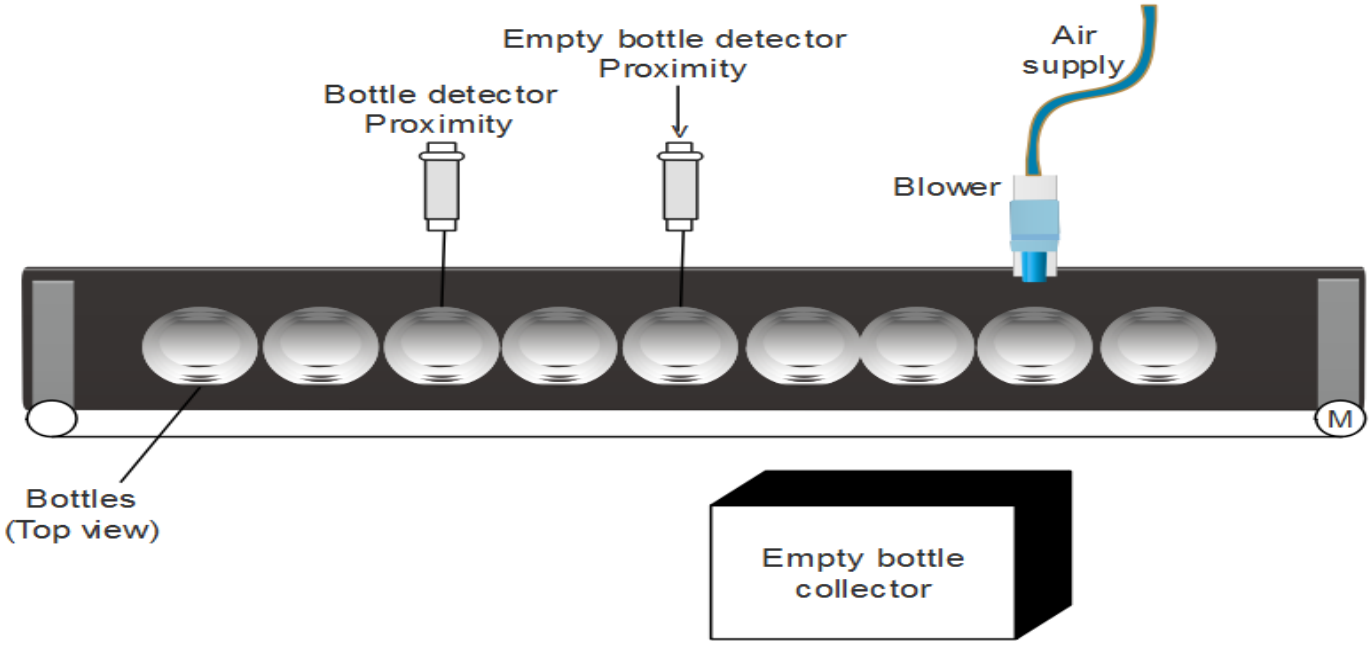
Prof . Mohamed Ahmed Ebrahim

EX:(8): PLC Program to Remove Empty Detected Bottle on Conveyor

- **Problem Description**

➢ After filling process, bottles are moved on the conveyor belt for packing process. Detect if any empty bottle is left on the conveyor and remove it from the conveyor

- **Problem Diagram**



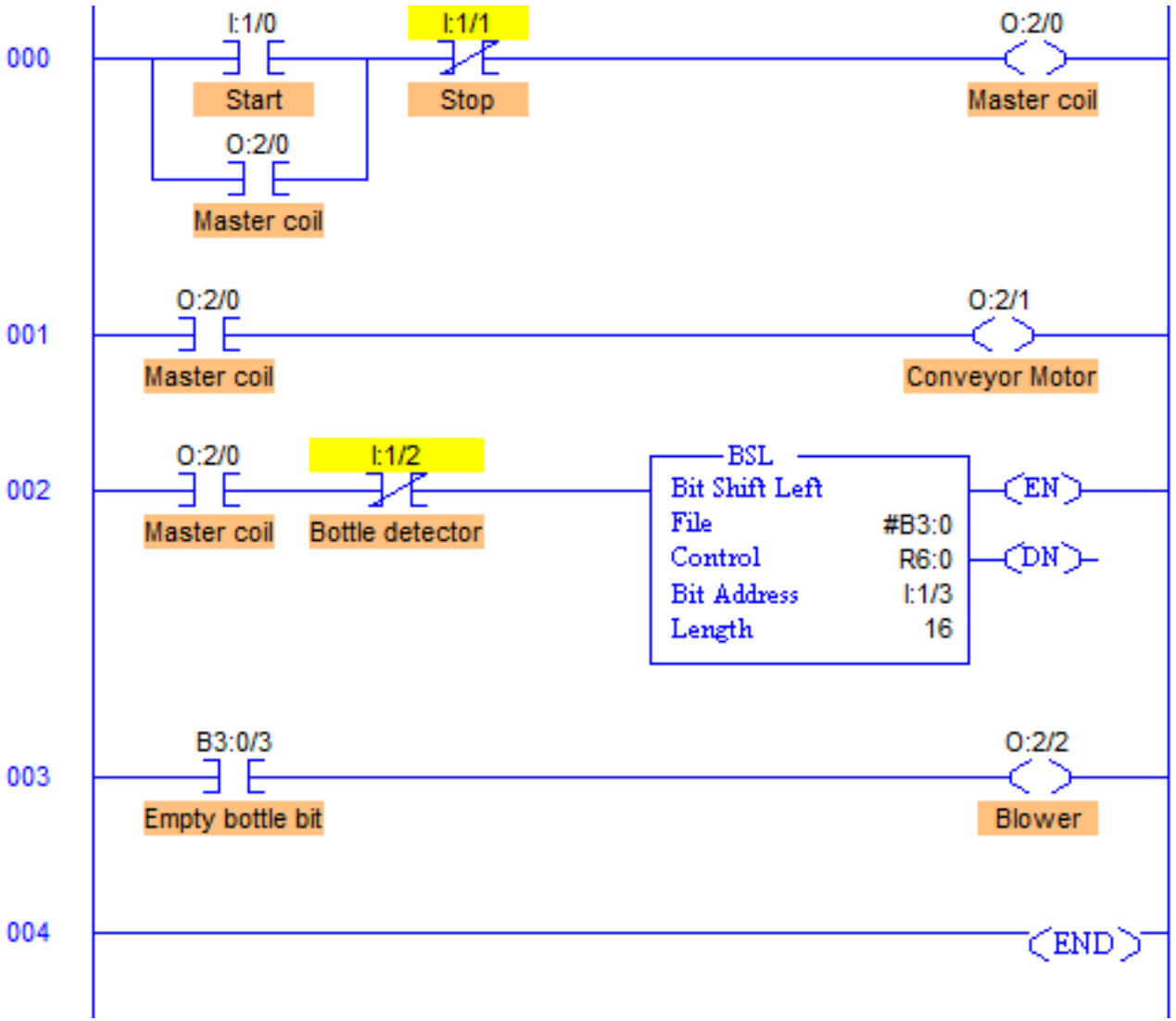
• Problem solution

- Proximity sensors are used to detect bottles.
- One proximity is calibrated such that it detects all the bottles passing on the conveyor. And other proximity is used such that it detects only empty bottle.
- Use Bit Shift Register to shift a bit which is set when an empty bottle is detected.
- Use a piston or blower is used to throw an empty bottle out of the conveyor.

• PLC Program

```
List of Inputs and Outputs
 I:1/0   = Start                                (Input)
 I:1/1   = Stop                                 (Input)
 I:1/2   = Bottle Proximity                     (Input)
 I:1/3   = Empty bottle proximity               (Input)
 O:2/0   = Master coil / Run                    (Output)
 O:2/1   = Conveyor motor                       (Output)
 O:2/2   = Blower                               (Output)
 BSL     = Bit shift left instruction           (Logical)
 B3:0    = Bit shift Register                   (Register)
 B3:0/3  = Bit to energize capping machine      (Bit)
 R6:0    = Control register                     (Register)
```

- **Ladder Diagram to accomplish removing of empty bottle**



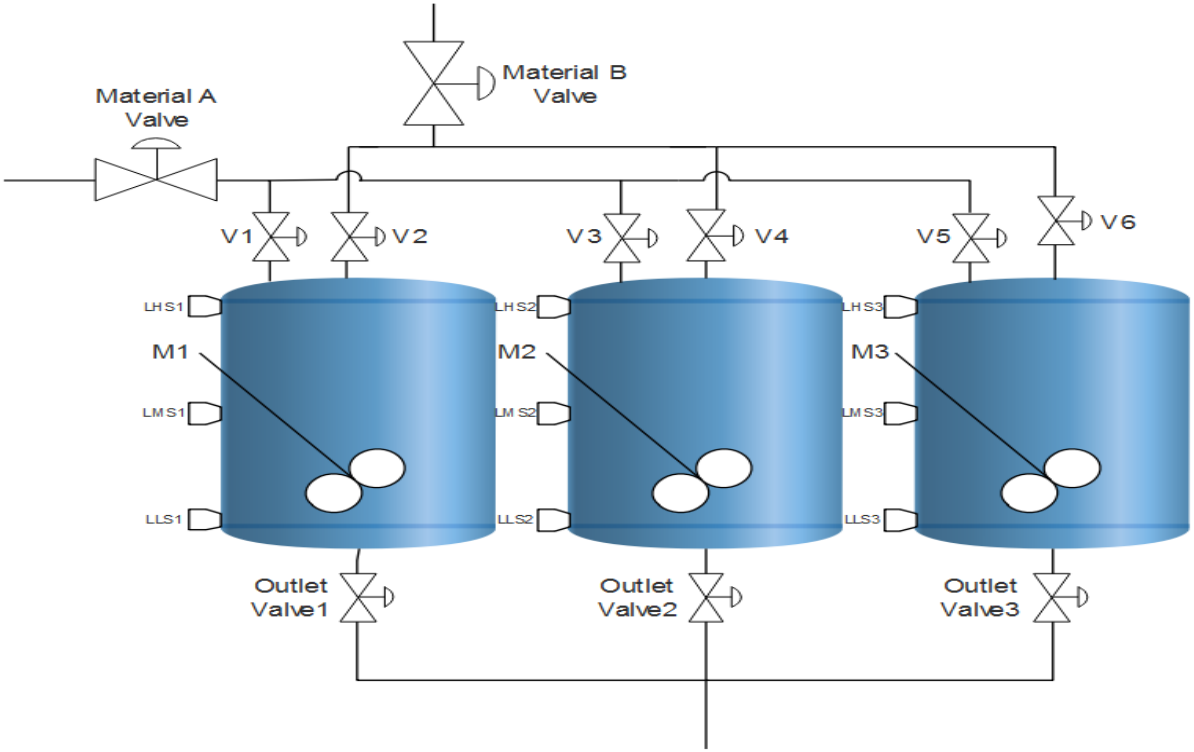
Prof . Mohamed Ahmed Ebrahim

EX:(9): PLC Program to Control Three Mixing Devices in a Processing Line

- **Problem Description**

➢ Control three mixing devices in a process line. Two mixing devices are running in the parallel to each other. When any one of the mixing process stops, individual stop switches turn the third mixing device ON and the device operated by the stop button is stopped.

- **Problem Diagram**



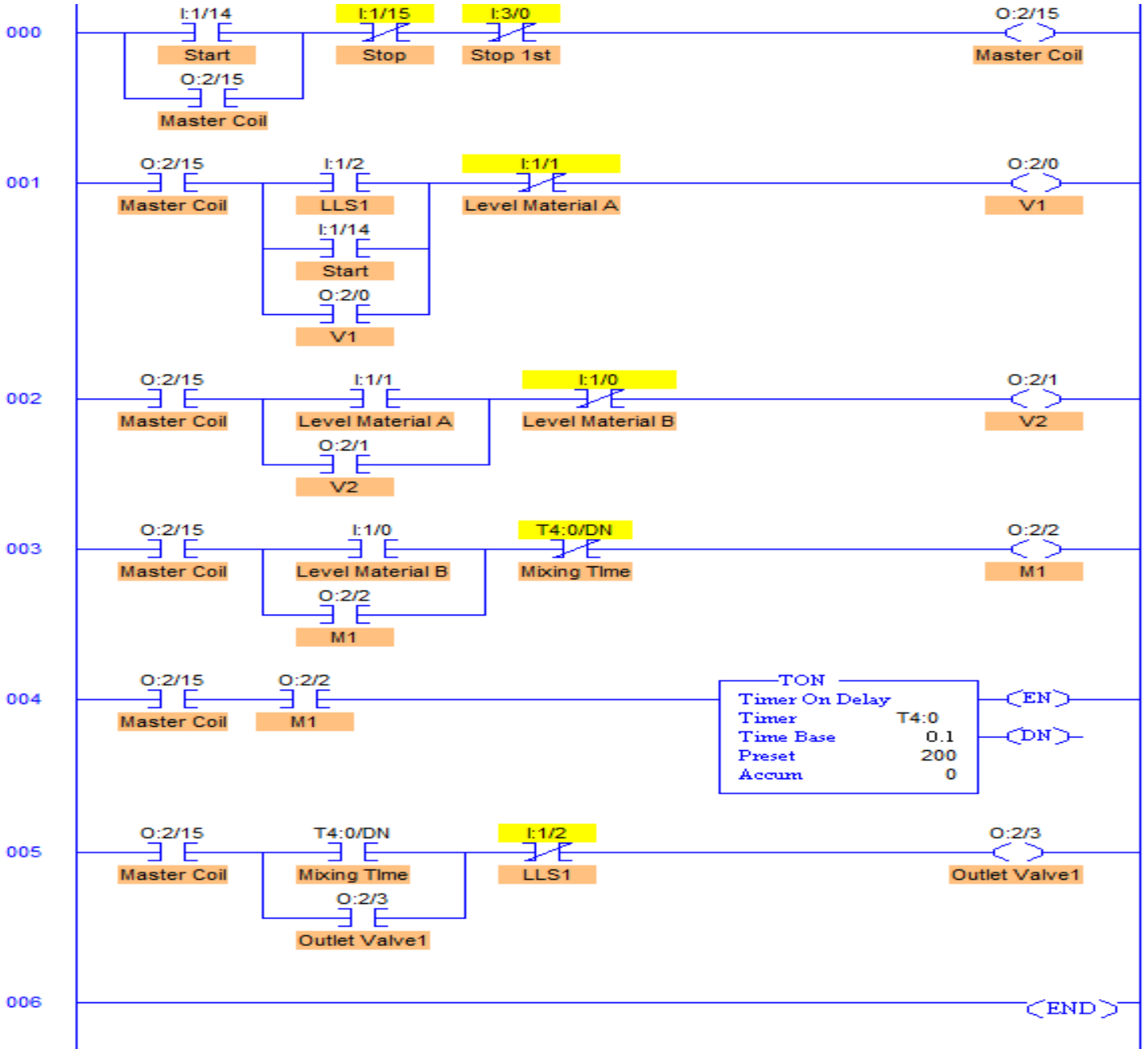
- **Problem solution**

- Use limit switches, control valves and motor agitators separately for all three mixing tanks.
- The only common input to all these tanks is Material feeding by two valves.
- Use separate timers for each tank for mixing.
- First two tanks are tagged as primary mixing tanks and the third one is said to be secondary mixing tank.
- Use switches of stop buttons of both Primary mixing processes as an input to start the tank third to enter into the process sequence.

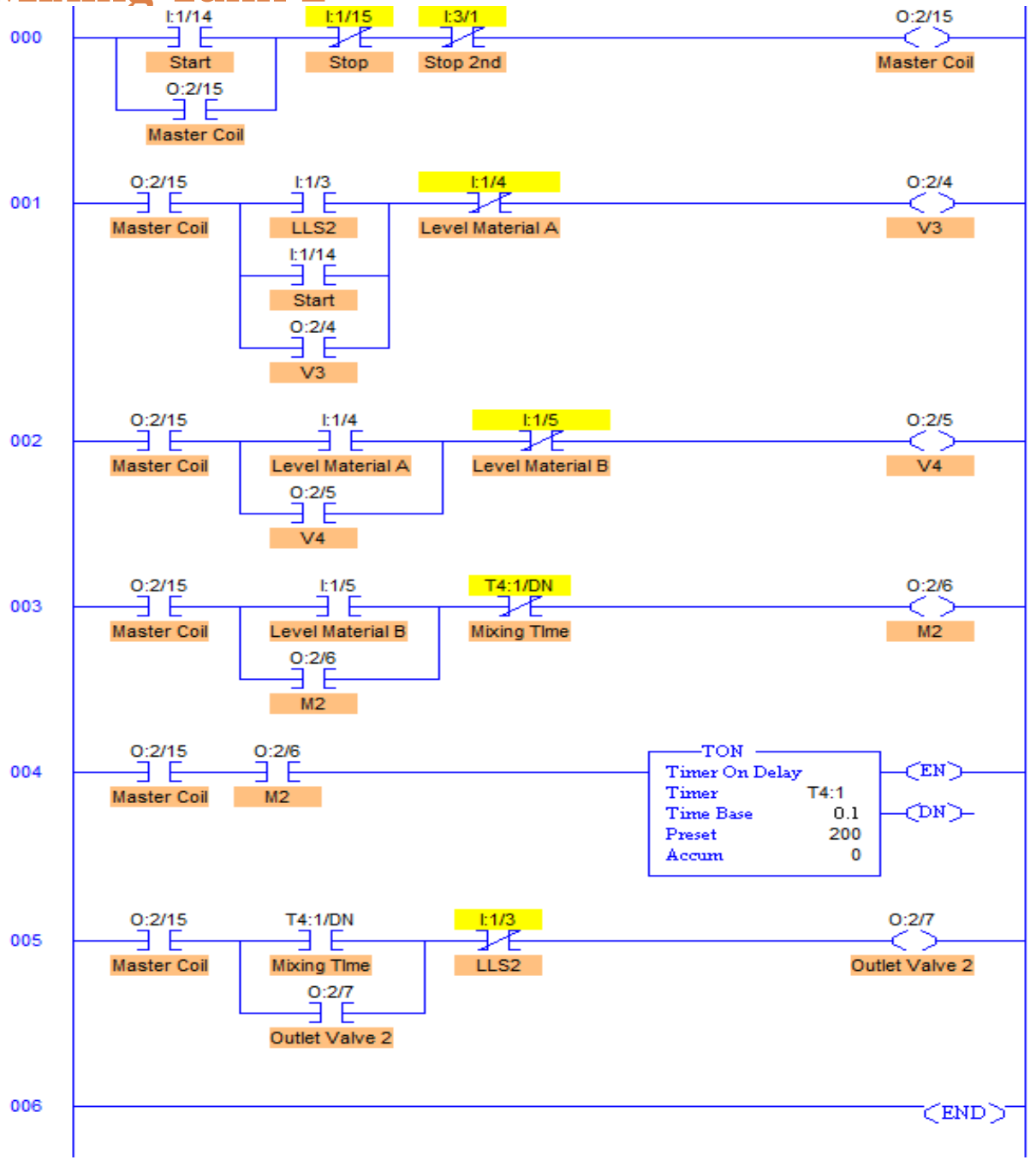
- **PLC Program**

```
List of Inputs and Outputs
 I:1/14                 = Start                                (Input)
 I:1/15                 = Stop                                 (Input)
 O:2/15                 = Master Coil                          (Output)
 I:1/0, I:1/5, I:1/7    = Level of Material B Switches         (Input)
 I:1/1, I:1/4, I:1/8    = Level of Material A switches         (Input)
 I:1/2, I:1/3, I:1/6    = Low Level Switch (empty tank)        (Input)
 O:2/0, O:2/4, O:2/8    = Inlet Valves to feed Material A      (Output)
 O:2/1, O:2/5, O:2/10   = Inlet Valves to feed Material B      (Output)
 O:2/2, O:2/6, O:2/9    = Agitator Motors M1, M2 and M3        (Output)
 O:2/3, O:2/7, O:2/11   = Outlet Valves for product outlet     (Output)
 T4:0, T4:1, T4:2       = Timers to mix materials              (Timer)
```

- # Ladder Diagram for Mixing Tank 1



- # Ladder Diagram for Mixing Tank 2



EX:(10): PLC Program to Maintain the Capacity of a Particular Classroom

- **Problem Description**

- A classroom has a capacity of maximum 120 students. There are two doors, one for Entry and the other for Exit.

- When number of students in the classroom is less than 120, Entry door has a Green light on it which remains ON.

- When number of students in the classroom is 120 or more than that, Red light goes ON turning OFF the Green light which indicates that the classroom has reached its maximum capacity and is full.

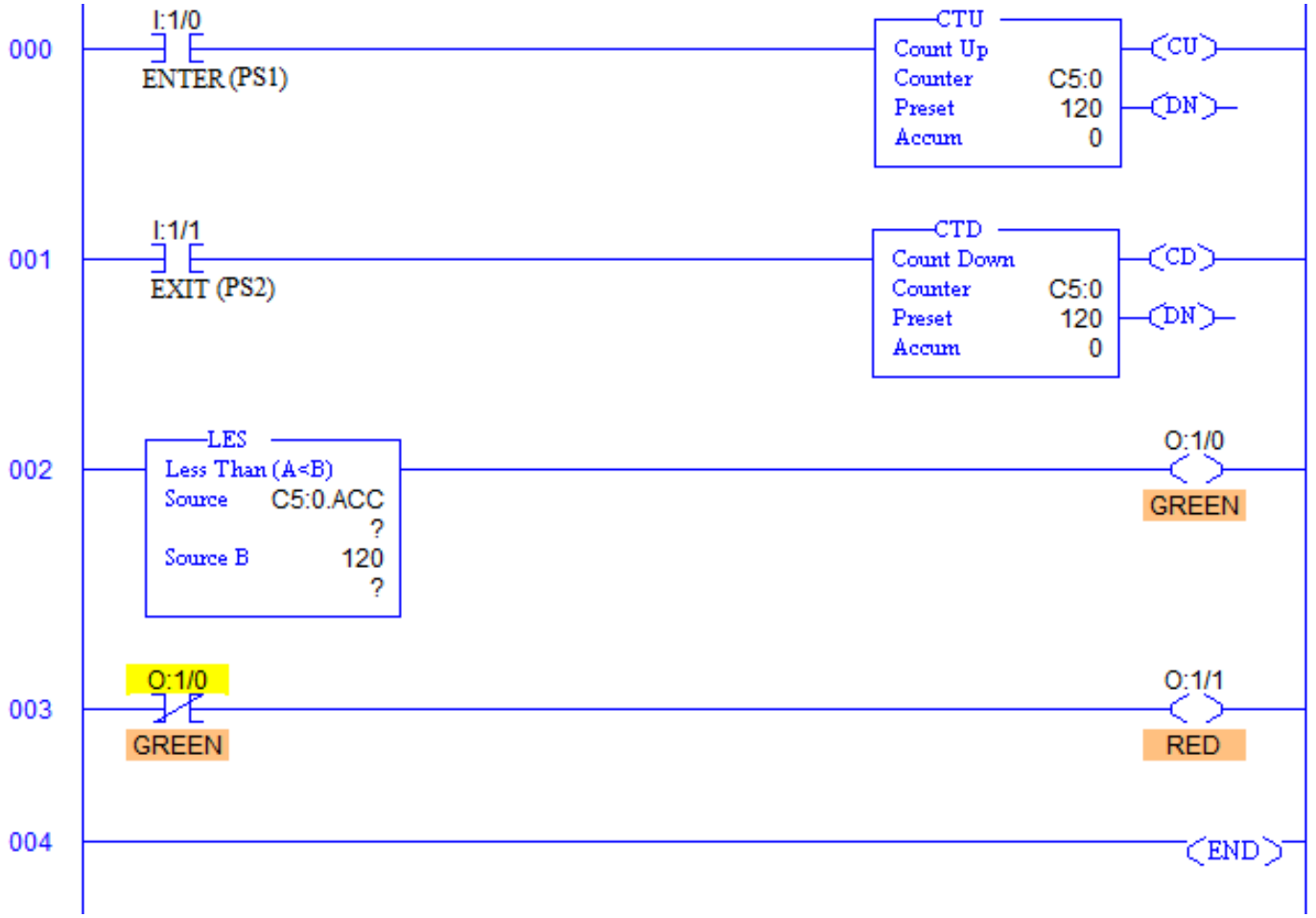
• Problem solution

- Considering the availability of two separate doors for Entry and Exit, two separate Proximity Switches can be used to detect entry and exit of students.
- One proximity switch is mounted at the Entry door and the other at the Exit door.
- Both the switches will generate two different outputs which can be then fed to PLC to operate the lights according to the Ladder Logic Program written in its memory.
- Counter must be used to count the number of students entering and exiting.
- Comparator must also be used to compare the count value with the given maximum capacity of 120.

• PLC Program

```
List of Inputs and Outputs
 I:1/0 = Proximity Switch to detect Entry of a student.          (Input)
 I:1/1 = Proximity Switch to detect Exit of a student.           (Input)
 O:1/1 = Red Light to indicate availability in the classroom     (Output)
 O:1/0 = Light to indicate classroom's maximum capacity.         (Output)
 C5:0  = Counter to count the number of students entering.       (Counter)
 C5:0  = Counter to count the number of students exiting.        (Counter)
 LES   = Comparator to compare the counter value
```

- **Ladder Diagram to solve this problem**



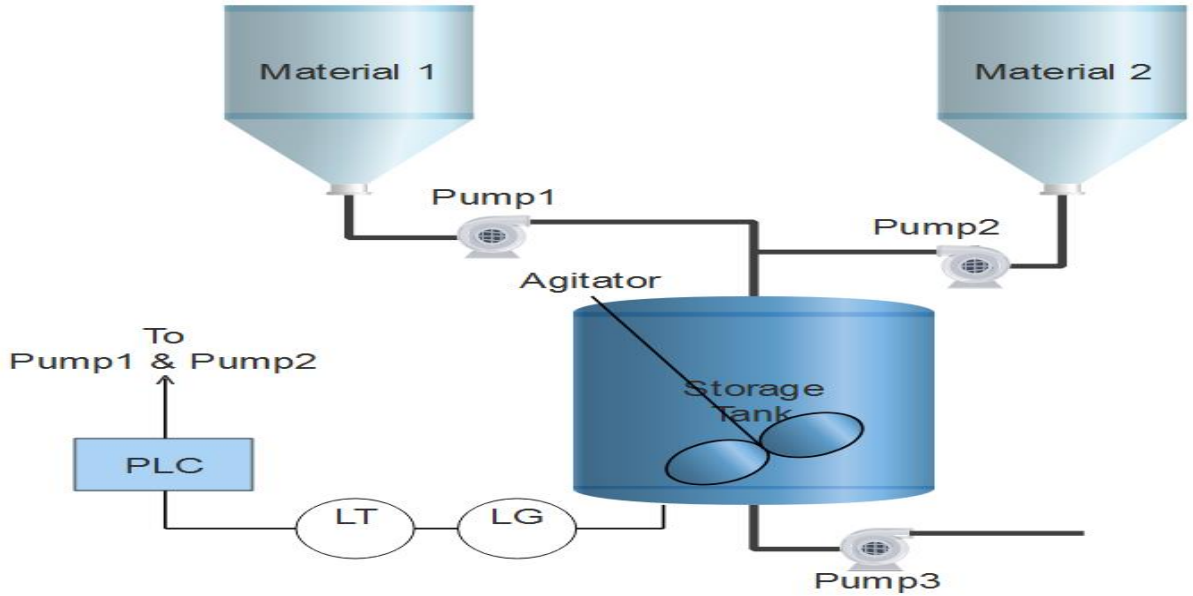
EX:(11): PLC Program to Drain Two Different Products from 2 Tanks

- **Problem Description**

- There two different tanks which are to be operated.
- Draining of these two materials are controlled.
- Mixing in the ratio of 2:1 is to be done.

- **Problem Diagram**

Diagram showing mixing of two materials continuously



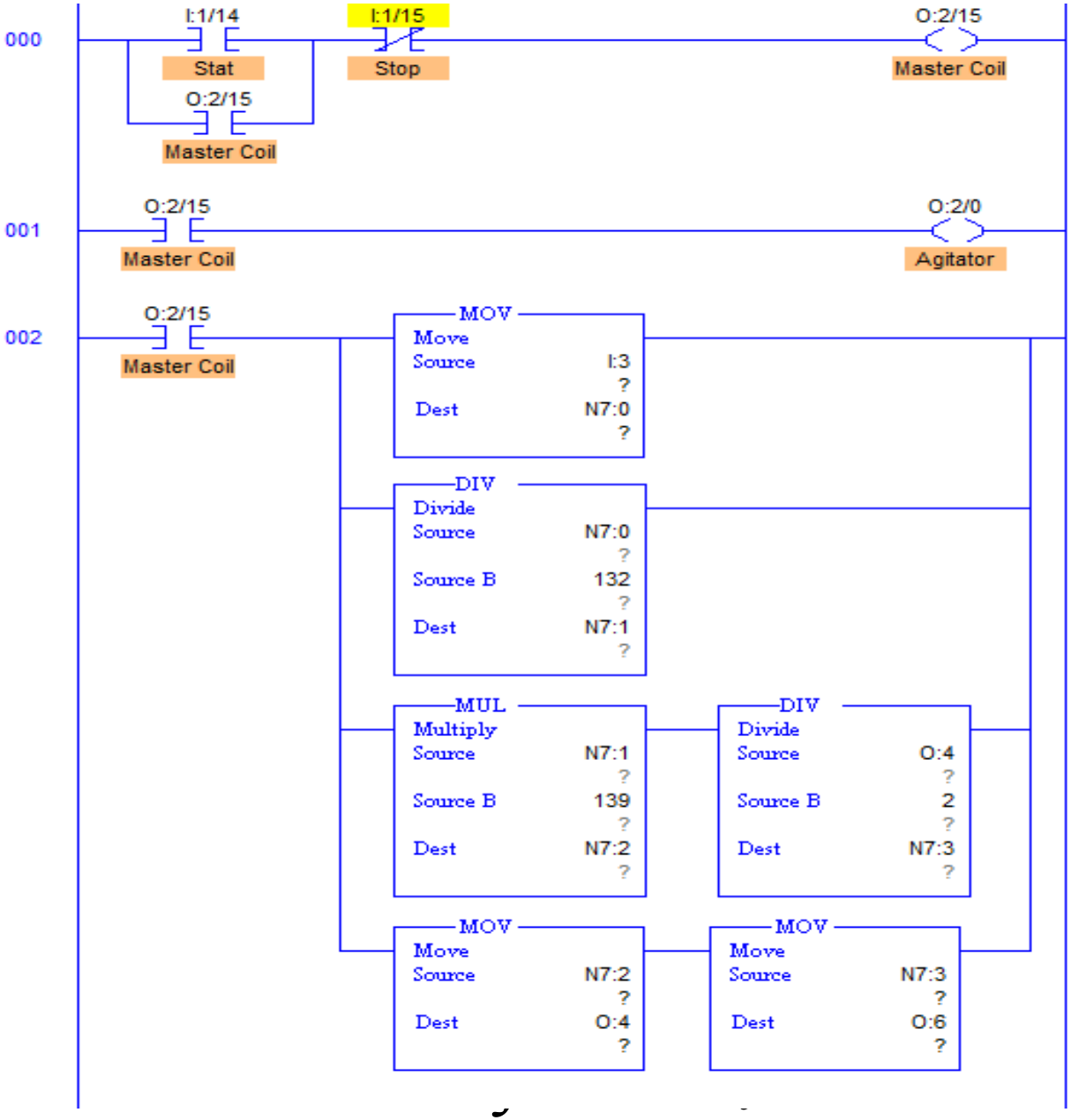
- **Problem solution**

- Level gauge is used to measure level of the storage tank continuously
- Level gauge is connected with Level Transmitter which converts corresponding level output in 4-20mA equivalent.
- Analog I/O Modules are chosen to deal with Analog signals.
- Centrifugal pumps are used to drain material from both the tanks at the same time.
- Height of storage tank is 5meters that is 500cm and the level which is to be maintained is 470cm.
- Calculate necessary conversions and use registers to store data and to do arithmetic operations.

- **PLC Program**

```
List of Inputs and Outputs
 I:1/14 = Start                                                  (Input)
 I:1/15 = Stop                                                   (Input)
 O:2/15 = Master Coil                                            (Output)
 O:4    = Output to I-V converter of Pump1                       (Output)
 O:6    = Output to I-V converter of Pump2                       (Output)
 O:2/0  = Agitator to mix                                        (Output)
 I:3    = Input to which transmitter is connected                (Input)
 N7:0   = Register to store input data                           (Register)
 N7:1   = answer of division by value change per centimeter      (Register)
 N7:2   = Multiplication answer                                  (Register)
 N7:3   = Division to obtain 2:1 ratio                           (Register)
```

- **Ladder Diagram to control this mixing process**



Thank You For Your Attention

Mohamed Ahmed Ebrahim