I. Why Study?

1. Industrial processes often involve a sequence of operations to take place—for example:

   A. The lights in a traffic signal go through a sequence: green, yellow, red, green, yellow, red, etc.
   
   B. In a clothes washer, the tank has first to be filled with water, then the agitator is turned on to wash the clothes, then the water is drained out, then the tank is filled up again, etc.
   
   C. Others?

2. Need to know how to make the PLC generate such sequences

   A. “time driven” sequences, and
   
   B. “event driven” sequences

II. Time-Driven Sequences

1. These are sequences in which each operation takes a certain fixed amount of time

   A. For example, the traffic signals might be red for 30 seconds, green for 25 seconds, and yellow for 5 seconds

   B. Other examples?

2. Formerly done by electromechanical sequencers, as explained in the text (SHOW example sequencer)

   A. A clock motor would drive a set of cams

   B. The cams would activate contacts that would turn different loads on and off as the common shaft would slowly turn around

3. The PLC can generate these sequences using special sequencing instruction, but it is complicated and confusing, so it’s easier and just as effective to do it with time delays we have already learned
4. An example will illustrate the process

   A. Purpose: (traffic signal controller) when an ON/OFF switch is turned on and a START button is momentarily pressed, the red signal (R) lights for 20 seconds, then turns off and the green (G) lights for 15 seconds, then turns off and the yellow (Y) turns on for 5 seconds, and then off and back to the red. On the opposing street, the red light (R’) is on during the time the light on the other street is either green or yellow.

   B. timing diagram (Fig. 1)

      i) draw it as first step toward designing sequencer

      ii) each horizontal division = 5 seconds

      
      Fig. 1—Timing diagram for traffic light sequencer

   C. design steps

      i) examine the timing diagram and mark the times where something changes state (turns on or off) (SHOW)

         (a) in this case, something changes at 0 (seconds), 20, 35, and 40 (same as 0, as the cycle repeats after that)

         (b) NOTE: had we included the green and yellow signals in the opposing direction, there may have been other changes to be marked

         (c) these changes divide the complete cycle into three time intervals
• 0 – 20

• 20 - 35

• 35 - 40

ii) now design a ladder circuit that closes a different logic relay during each of these intervals (start Fig. 2)
Fig. 2--Ladder diagram for traffic lights sequencer

(a) one rung for each interval

(b) each rung is a monostable
(c) the monostable on the top line is triggered by the START button

(d) we use the timer contacts of the monostable as the trigger to start the next timing interval on the next branch—these contacts are closed for only a brief moment

(e) after the last delay (35 – 40s), we retrigger the first delay using the timer contacts of the last delay, since we want a repeating cycle

iii) now go back to the timing diagram and determine when each of the outputs is supposed to be on, then add output relays to your ladder accordingly

(a) the R output should be on from 0 – 20s, so connect its output relay (0500) to contacts from logic relay 1000

(b) G should be on from 20 – 35s, so it goes with 1001

(c) Y is from 35 – 40s, so connect to 1002

(d) R’ is from 20 – 40s, so need to combine two of the intervals—20 – 35s (1001) and 35 – 40s (1002), so OR (parallel) these two together

D. show operation using the PLC simulator program (TRSIG1)

III. Event-Driven Sequences

1. These are sequences in which one or more of the sequential operations is triggered—not by the passage of time—but by an event that occurs during the previous operation

   A. For example, the clothes washer—what triggers the agitation cycle?

   B. Other examples?

2. The PLC can handle these sequences, and combine them with time-driven sequences

3. Example—the clothes washer
A. Task: after the master switch is turned on and a start button is pressed, a water valve opens, allowing water to run into the tub; after the water reaches a certain level, a NO float switch closes, turning off the water valve and triggering the next operation, agitation for 15 minutes, after which the sequence ends (does not repeat)

B. Timing diagram (Fig. 3)

C. Ladder diagram (Fig. 4, explain each rung)
i) First rung: after the master switch is closed, pressing the START button latches on the load, which is the fill valve, so that it allows the water to fill up the tank—how long does this last?

ii) When the water reaches the float switch, it closes, unlatching the first rung and stopping the water flow into the tank, because the tank is now full

iii) At this point, we need to trigger the agitate motor to start washing the clothes, but how?

(a) We want it to happen when the float switch closes, so why not use NO float switch contacts to trigger the next branch?

(b) Problem: this rung will always be triggered so long as the tank is full, so we will be unable to stop the agitation
(c) Solution: we use a monostable to energize the agitate motor, because a monostable is *edge* triggered

- means the 15-minute delay of the monostable is triggered by the *transition* of the float switch input relay from off to on (rising edge)

- not by the *state* of this switch

- so after the 15-minute delay is over, the monostable will not be retriggered by the float switch being closed at that time (tank still full)

D. Show operation using the PLC simulator program (CLWSHR)

IV. Single Event Driven Sequences

1. Means a single event, such as an operator pushing a button, initiates the next operation in the sequence

   A. Not a fixed time interval (as in a time-driven sequencer)—operator can push the button whenever he or she wants to

   B. Not an event that occurred during the previous operation

   C. Sort of a combination time/event-driven sequence, or a manual override of a time or event-driven sequence

2. Examples?

3. Timing diagram
A. Each time the trigger button is pressed, the sequencer moves to the next operation in order

B. A reset button sets it back to the start

4. Ladder program
A. Uses up/down counter, count sequence is 0, 1, 2, 0, 1, 2,….

B. Each count is decoded using LDA and CMP instructions
   i) When count = 0, 0500 is activated
   ii) When count = 1, 0501 is activated
   iii) When count = 2, 0502 is activated

5. Simulate using PLC simulator program (MANSQ)

6. Can also use this circuit to do time-driven sequence
   A. change the trigger to special utility relay contacts 2006
B. 2006 opens and closes automatically once every second

C. like a clock built into the PLC (SHOW by substituting 2006 for 0001 in MANSQ program)

V. Introduction to the laboratory exercises

1. go over examples from the lab exercises (timing diagram for second lab project)

2. student should look over the assignments in advance, prepare ladder and hookup diagrams, and test them out on the PLC simulator program

VI. MATERIALS

1. sample electromechanical sequencer(s)

2. Ladder Builder software

3. computer

4. data projector