# Theory of Logic Circuits

# Laboratory manual

# Exercise 14

### Microprogrammable circuits

# 1. Introduction

Microprogrammable circuits are synchronous sequential logic circuits. Their operation is defined by the memory contents, called microprogram. Therefore they are more universal comparing to hard-wired logic circuits. Microprogram consists of microcommands. Microcommand on turn consists of a output part and address part. There exist several types of microprogrammable circuits differing on the way of determining the next microcommand address. The most common structures are:

- structure with D-register
- structure with D-register and the multiplexer(s) of condition

The second type is less universal, however it can reduce the number of address inputs of memory if the problem can be easily implemented with this structure. In practice, this is the case, when number of inputs that influence the operation of the circuit at given time is meaningfully less than total number of inputs of the circuit.

# 2. Tasks to be performed during laboratory

1. Implement as microprogrammable circuit in a chosen by the supervisor structure (with or without multiplexer of condition), a circuit controlling the switching of two pumps. The pumps $P_1$ and $P_2$ (see fig.1) should be switched on alternately (only one pump can work at a time) when water exceeds the level of the sensor $x_2$ (i.e. when $x_2 = 1$). Working pump should be switched off when the water lever is below the sensor $x_1$ (i.e. when $x_1 = 0$). Assume that water level grows when pumps are off, and that it decreases when any pump is working.

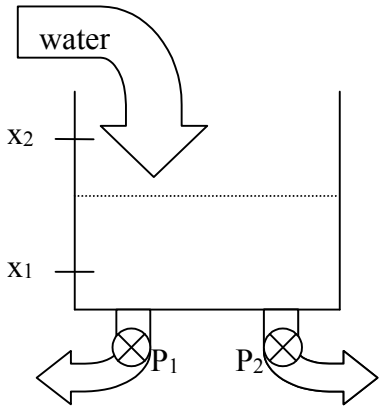


Fig 1. Pumps controlling the water level

2. Implement as microprogrammable circuit in a chosen by the supervisor structure (without or with 2 multiplexers of condition), a circuit controlling the operation of the inertial two-directional engine (fig 2). The engine can start to rotate only if it is stopped (RIGHT = 0, LEFT = 0, STOP = 1). The engine should start to rotate in right direction (RIGHT = 1) when button R is pressed for a short moment and it should keep rotating until button S is pressed. Pressing the R or L button when engine rotates right should be ignored. The engine should start to rotate in left direction (LEFT = 1) when button L is pressed for a short moment and it should keep rotating until button S is pressed. Pressing the L or R button when engine rotates left should be ignored. Similarly pressing S button when engine is stopped should not change its state. Pressing it when engine rotates in any direction should stop it by assigning outputs: RIGHT = 0, LEFT = 0, STOP = 1. Since all input buttons are monostable radio ones, it is assumed that only one of buttons S, L, R can be equal to one at a time.

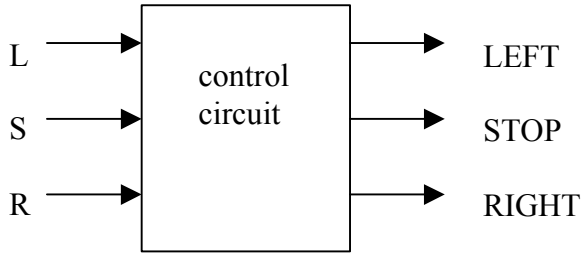


Fig. 2 Control circuit for inertial two-directional engine

## 3. Instructions to follow

1. Solve all tasks before the exercise.
2. Implement the circuits specified by your supervisor (using given elements).
3. Present working circuits to your supervisor for acceptance.