Høgskolen i Buskerud

Løsning til skriftlig eksamen i emnet SESM3401 Styring av mekatroniske systemer

Eksamensdato: Mandag 8. desember 2008. Varighet: 3 timer. Vekt: 70%.

Hjelpemidler: Ingen trykte eller håndskrevne hjelpemidler. Kalkulator ikke tillatt.

Kontakt under eksamen: 1. am. Finn Haugen (telefon 97019215)

Hvis du mener at det i en oppgave mangler forutsetninger for løsning, skal du selv definere disse forutsetningene slik at du allikevel kan løse oppgaven.

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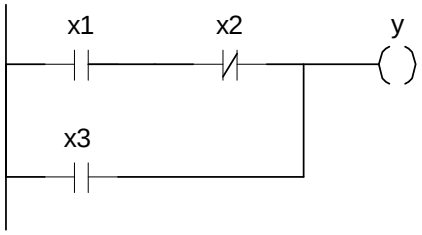
1. (15% vekt i dette oppgavesettet) Den logiske funksjonen

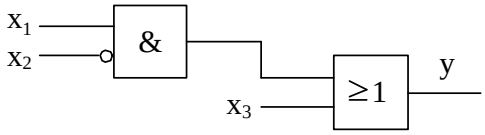
$$y = (x_1 \text{ AND } \overline{x_2}) \text{ OR } x_3 \tag{1}$$

kan realiseres med ladderdiagram som vist i figur 1 og med



Figur 1:

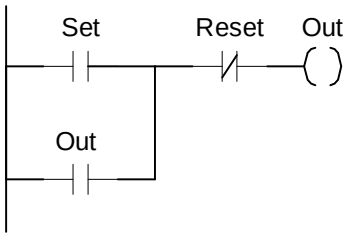
funksjonsblokkdiagram som vist i figur 2.



Figur 2:

2. (15%) Se figur 3.

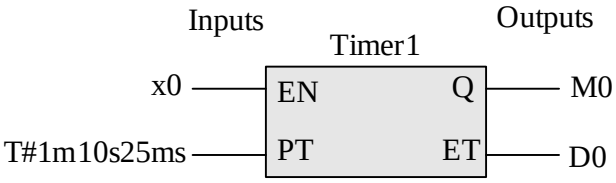
3. (15%) Fra kompendiet: A timer function is similar to a clock which is started (triggered) by a starting signal changing value from OFF to ON. When a preset time has elapsed, the timer output is set to ON.



Figur 3:

As an example, a timer can be used to implement a time-delayed start of a motor. Another example is to control the ON-time of a heater.

PLCs have a number of different timers in their functions library. Figure 4 shows an example of a timer. (The example can be found in a user's manual of the GX IEC Developer programming tool of Mitsubishi PLCs.) The timer parameters are as follows.

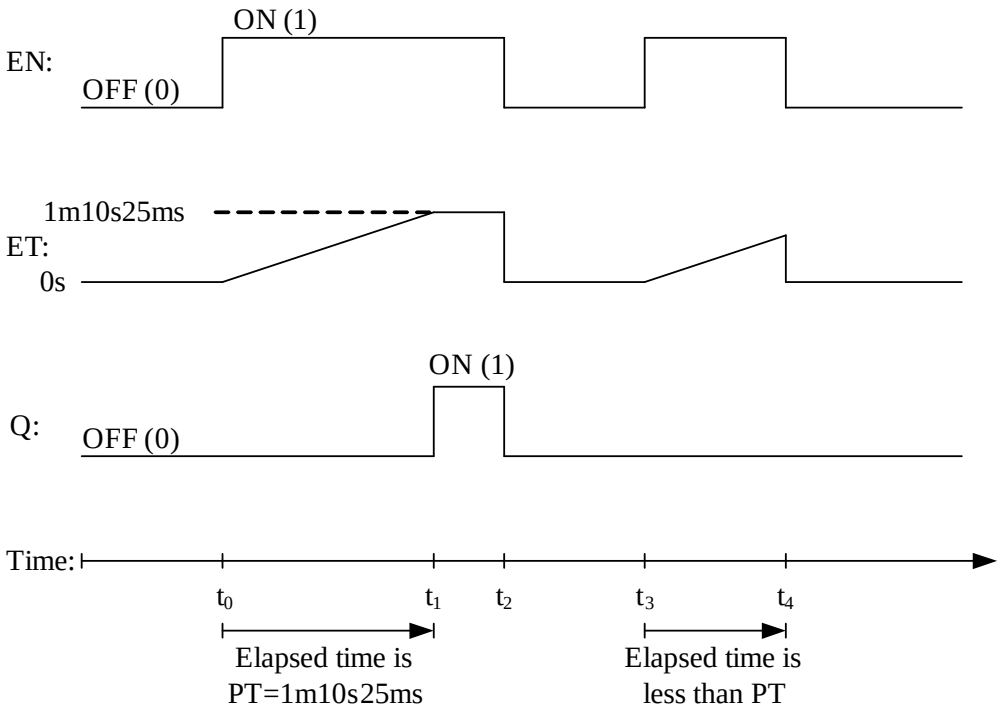


Figur 4:

- Input **EN** (enable) [boolean] starts or triggers the timer.
- Input **PT** (preset time) [time] is the (elapsed) time or time delay before the timer output Q is set to ON. The time format is a special data format used to represent time. In Figure the PT value is 1 minute 10 second 25 milliseconds.
- Output **Q** (output[1]) [boolean] is the timer output. It gets value ON when the elapsed time is larger than the preset time.
- Output **ET** (elapsed time) [time] is the continuously running time.

Figure 5 shows a timing diagram which shows the behaviour of the timer along a time axis. The timer operates as follows:

[1] Q means output. The ideal symbol O for output is not used since it is too easily misinterpreted as zero.



Figur 5:

- The timer starts when the input x0 at the EN input goes from OFF to ON. As the timer starts, the ET output increases continuously from the initial value of 0 seconds. In this example, the ET time value is stored in the data register D0 which is a general register or memory cell where a value can be stored for use in subsequent programming expressions.
- When the ET time has become larger than the PT (preset time) value the boolean output Q is set to ON. In this example, the value of Q is stored in memory cell M0 which is a general memory cell where a boolean value can be stored for use in subsequent programming expressions.
- If EN goes from ON to OFF, ET is reset to zero.

4. (15%) Transferfunksjonen for motor med sensor (prosessen) er

$$H(s) = \frac{K}{Ts + 1} \tag{2}$$

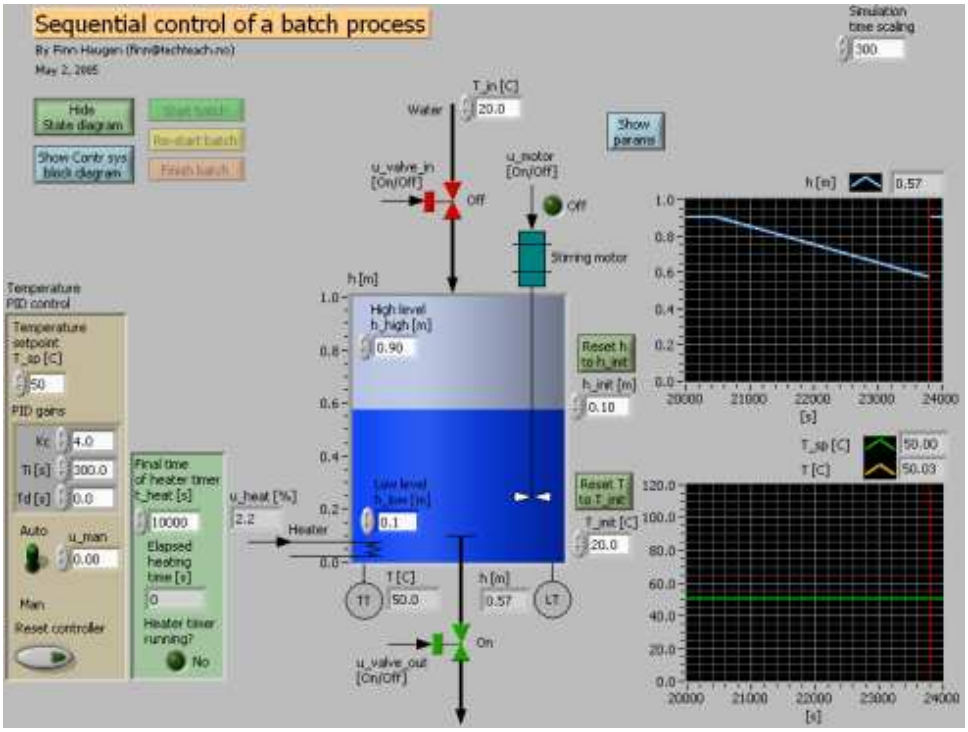
der K og T har kjente verdier. Det er spesifisert at reguleringssystemets responstid T_C skal være omtrent lik T. Får da

ihht. Skogestads tabell:

$$\underline{\underline{K_p}} = \frac{T}{KT_C} = \frac{T}{KT} = \frac{1}{\underline{\underline{K}}} \tag{3}$$

$$\underline{\underline{T_i}} = \min[T, 1.44T_C] = \min[T, 1.44T] = \underline{\underline{T}} \tag{4}$$

5. (25%) Sekvesiell styring av en batch-prosess (fra kompendiet benyttet i emnet): Figure 6 shows a simple batch process. The tank



Figur 6: A batch process to be controlled by sequential control

is filled with water. The water is then heated and stirred[2], and finally the heated water is discharged from the tank. The *control signals* are

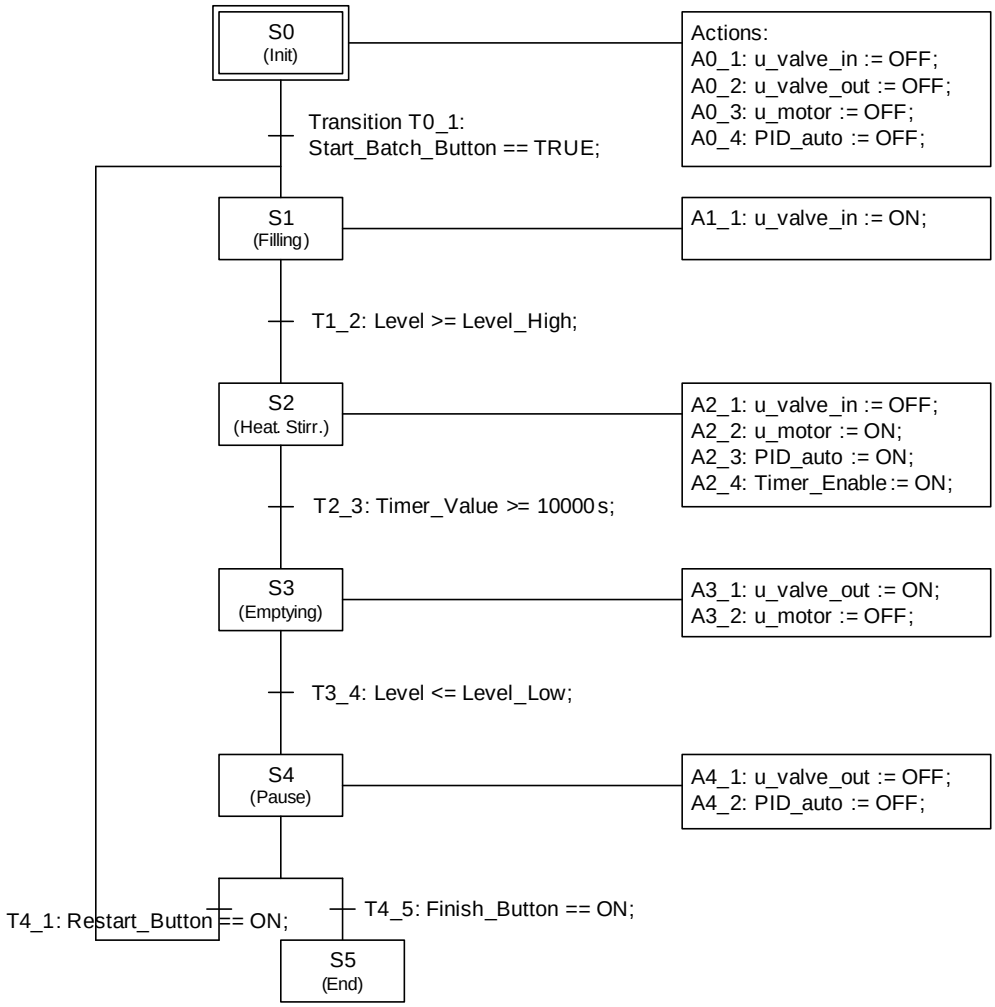
- u_valve_in (boolean, i.e. having value TRUE or FALSE, or ON or OFF)
- u_valve_out (boolean)
- u_motor (boolean)
- u_heat (continuous having any value between 0% and 100%)

[2]The motor is assumed to ensure homogenuous thermal conditions in the water in the tank.

The *measurements* are

- Temperature T of the water in the tank
- Level h of the water in the tank

In the exam you are asked to draw a state diagram of the control system. The state diagram will be identical to the SFC (Sequential Function Chart) shown in Figure 7. E.g. the *states* are S0, S1, etc. The *actions* are A0_1, A0_2, etc. The *transitions* are T0_1, T1_2, etc.



Figur 7:

6. (5%) Posisjonen er den tidsintegrerte av hastigheten. I s-planet

uttrykkes tidsintegrasjon med divisjon med s. Transferfunksjonen fra pådraget u til posisjonen x blir da

$$\frac{K}{(Ts+1)\,s} \tag{5}$$

7. (10%) HIL-simulering: Fysisk reguleringsutstyr (kalt ECU – Electronic Control Unit) regulerer en simulert prosess. HIL-simulering kan være nyttig for testing og opplæring.