



LUNDS  
UNIVERSITET

Elektro- och informationsteknik

# Tentamen i Digitalteknik, EITF65

3 januari 2018, kl. 14-19

- ▶ Skriv anonymkod och identifierare, eller personnummer, på alla papper.
- ▶ Börja en ny uppgift på ett nytt papper. Använd bara en sida av pappret.
- ▶ Lösningarna skall tydligt visa tillvägagångssättet.
- ▶ Minimering av funktioner, var och en för sig, ses som en naturlig del av lösningen. Minimalt antal tillstånd i tillståndsgrafer förväntas. Metoder för bra tillståndskodning behöver ej användas om det inte efterfrågas i uppgiften.
- ▶ Om det efterfrågas skall kopplingar för realiseringar ritas.
- ▶ Hjälpmedel: kursboken, föreläsningbilder och föreläsninganteckningar (allt under fliken "föreläsningar"), samt enkel miniräknare.

Lycka till!

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## Uppgift 1

Betrakta följande funktion i fem variabler, som ska realiseras i disjunktiv form

$$f^{-1}(1) = \{0, 2, 10, 13, 15, 16, 18, 19, 20, 21, 24, 26, 28\},$$

$$f^{-1}(-) = \{5, 7, 8, 9, 11, 22, 23\}.$$

- (a) Ange samtliga primimplikatorer samt vilka av dem som är väsentliga.
- (b) Realisera funktionen i minimal form. Ange dess booleska uttryck.

(4+6=10p)

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## Uppgift 2

Du ansvarar för konstruktion av ett digitalt system som skall detektera ett visst insignalbeteende. Insignalen vid varje tidpunkt  $t$  består av två binära värden  $x_0(t)$ ,  $x_1(t)$ . När ekvationen  $x_0(t) + x_0(t-1) + x_0(t-2) = 2x_1(t)$  (ekvation över heltalen) är sann så ska utsignalen  $y(t) = 1$  vara ett, annars skall den vara noll. Systemet startas vid  $t = 0$  och för  $t < 0$  så gäller  $x_0(t) = x_1(t) = 0$ .

Exempelvis så ger insignalen

11, 01, 11, 10, 11, 01, 11, 01, 00, 00, 01, ...

utsignal

0, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, ...

Insignalen är då given som  $x_0(t)$ ,  $x_1(t)$  för  $t = 0, 1, 2, \dots$

Eftersom början av sekvensen 11, 01, 11 ger  $x_0(0) = 1$ ,  $x_0(1) = 0$ ,  $x_0(2) = 1$  och  $x_1(2) = 1$  så gäller  $x_0(2) + x_0(1) + x_0(0) = 1 + 0 + 1 = 2 = 2x_1(2)$  och då blir  $y = 1$  vid tidsenhet 2, etc.

- (a) Ta fram en tillståndsgraf för problemet. Minimera grafen.
- (b) Realisera ett sekvensnät med minimalt antal D-vippor som implementerar den givna detektorn. Ange funktioner i minimal form. Rita sekvensnätet!

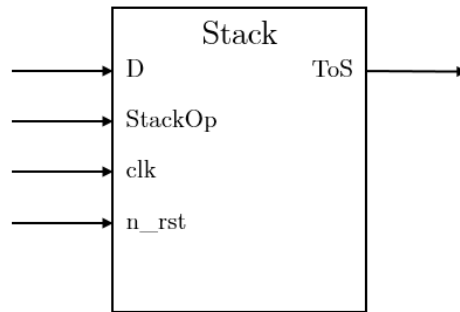
(5+5=10p)

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## Uppgift 3

I denna uppgift ska en stack realiseras, som en modul av ett större system. Stacken som ska implementeras ska i varje cell kunna lagra ett värde som är 6 bitar långt. **Dessutom ska stacken klara av att lagra upp till 8 värden.**

I Figur 3.1 ses stacken med dess in- och utsignaler. Observera antalet bitar för de olika signalerna. Stackens tillstånd ska ändras vid klocksignalens `clk` stigande flank. Utsignal `ToS` (Top-of-Stack) ges av stackens översta cell. Signalen `n_rst` är en synkron aktiv låg resetsignal som nollställer stackens celler. Signal `StackOp` ska styra stacken enligt tabellen nedan



**Figur 3.1:** Symbol av stacken som ska implementeras. Anslutningarna `D` och `ToS` är 6 bitar breda och `StackOp` 2 bitar bred.

| StackOp | Funktion                                                                                       |
|---------|------------------------------------------------------------------------------------------------|
| PUSH    | Värdet av <code>D</code> sparas överst på stacken. tidigare sparade värdet trycks ned ett steg |
| POP     | Stackens innehåll flyttas upp ett steg. och den understa cellen får värdet 0.                  |
| HOLD    | Stackens innehåll oförändrat                                                                   |

Nedan ges ett exempel på hur stacken ska bete sig vid de olika operationerna.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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| <p>PUSH</p> <p>Före:</p> <table style="display: inline-table; border-collapse: collapse;"> <tr><td style="border: 1px solid black; padding: 2px;"><code>D</code> = 20</td><td style="padding: 0 10px;"><code>ToS</code></td><td style="border: 1px solid black; padding: 2px;">2</td></tr> <tr><td></td><td></td><td style="border: 1px solid black; padding: 2px;">0</td></tr> <tr><td></td><td></td><td style="border: 1px solid black; padding: 2px;">0</td></tr> <tr><td></td><td></td><td style="border: 1px solid black; padding: 2px;">0</td></tr> <tr><td></td><td></td><td style="border: 1px solid black; padding: 2px;">0</td></tr> <tr><td></td><td></td><td style="border: 1px solid black; padding: 2px;">0</td></tr> <tr><td></td><td></td><td style="border: 1px solid black; padding: 2px;">0</td></tr> <tr><td></td><td></td><td style="border: 1px solid black; padding: 2px;">0</td></tr> <tr><td></td><td></td><td style="border: 1px solid black; padding: 2px;">0</td></tr> </table> <p>Efter:</p> <table style="display: inline-table; 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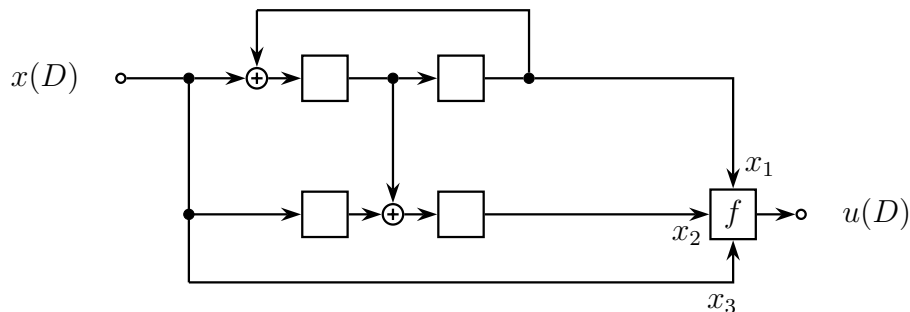
För att implementera stacken ska skiftregister `SR4` användas som en del av konstruktionen. Anslut lämpligt antal kretsar för att realisera stacken enligt beskrivningen ovan. Rita nätet samt sätt ut signalerna från Figur 3.1. Specifikation för `SR4` finns sist på tentan.

(10p)

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## Uppgift 4

Funktionen  $f = f(x_1, x_2, x_3)$  används i en krets med fyra D-element, insignal  $x$  och utsignal  $u$ , som ser ut på följande vis:



- För vilka av de booleska uttrycken  $f_1 = x_1x_2' \vee x_1'x_2$ ;  $f_2 = x_2 \wedge (x_1 \vee x_3)$ ;  $f_3 = x_2 \vee x_3$ ;  $f_4 = x_1 \wedge (x_2 \vee x_1x_2x_3')$  är  $f = f_i$  en linjär funktion?
- Låt  $f$  vara en linjär funktion från a). Bestäm om kretsen är minimal. Bevisa att den är minimal, eller, om så inte är fallet, ta fram en ekvivalent men minimal krets.
- Bestäm systemfunktionen  $G(D)$  för den minimala kretsen.

(2+4+4=10p)

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## Uppgift 5

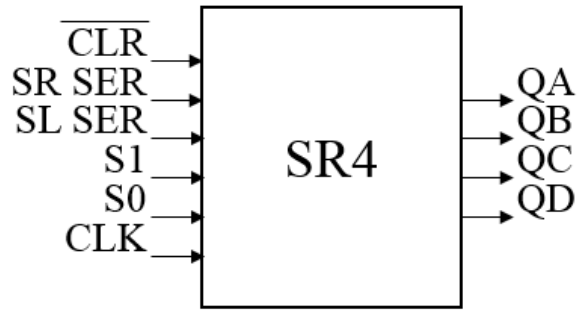
Att kunna räkna på vanligt vis med mängder som innehåller ett ändligt antal element är viktigt i många digitala system. Låt oss betrakta ringen  $\mathbb{Z}_{1021}$ , med addition och multiplikation modulo 1021. Vi noterar också att 1021 är ett primtal. För att representera ett element  $u$  i  $\mathbb{Z}_{1021}$  använder vi en vektor med 10 bitar  $\mathbf{u} = (u_9, u_8, \dots, u_0)$ .

- Konstruera en kombinatorisk krets som kan utföra addition av två element  $x$  och  $y$  från  $\mathbb{Z}_{1021}$  och generera resultatet  $u$  som också är ett element från  $\mathbb{Z}_{1021}$ . Signalen skall vara två 10-bitars vektorer och utsignalen ska vara en 10-bitars vektor. Konstruktionen kan med fördel innehålla minst ett iterativt kombinatoriskt nät, dvs en kaskadkoppling av ett antal mindre block som är sammankopplade. Rita en tydlig bild över nätet och eventuella komponenter!
- Hitta alla lösningar till ekvationen  $5x^2 - 11x - 1 = 1020$  definierad över  $\mathbb{Z}_{1021}$ . (Enbart prövning ger inga poäng)

(7+3=10p)

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God Fortsättning på 2018!



**SR4** 4-bitars skiftregister

| INPUTS |      |    |     |        |        | OUTPUTS |     |     |     |
|--------|------|----|-----|--------|--------|---------|-----|-----|-----|
| CLR    | MODE |    | CLK | SERIAL |        | QA      | QB  | QC  | QD  |
|        | S1   | S0 |     | SL SER | SR SER |         |     |     |     |
| L      | X    | X  | ↑   | X      | X      | L       | L   | L   | L   |
| H      | L    | H  | ↑   | X      | H      | H       | QAn | QBn | QCn |
| H      | L    | H  | ↑   | X      | L      | L       | QAn | QBn | QCn |
| H      | H    | L  | ↑   | H      | X      | QBn     | QCn | QDn | H   |
| H      | H    | L  | ↑   | L      | X      | QBn     | QCn | QDn | L   |
| H      | L    | L  | X   | X      | X      | QA0     | QB0 | QC0 | QD0 |