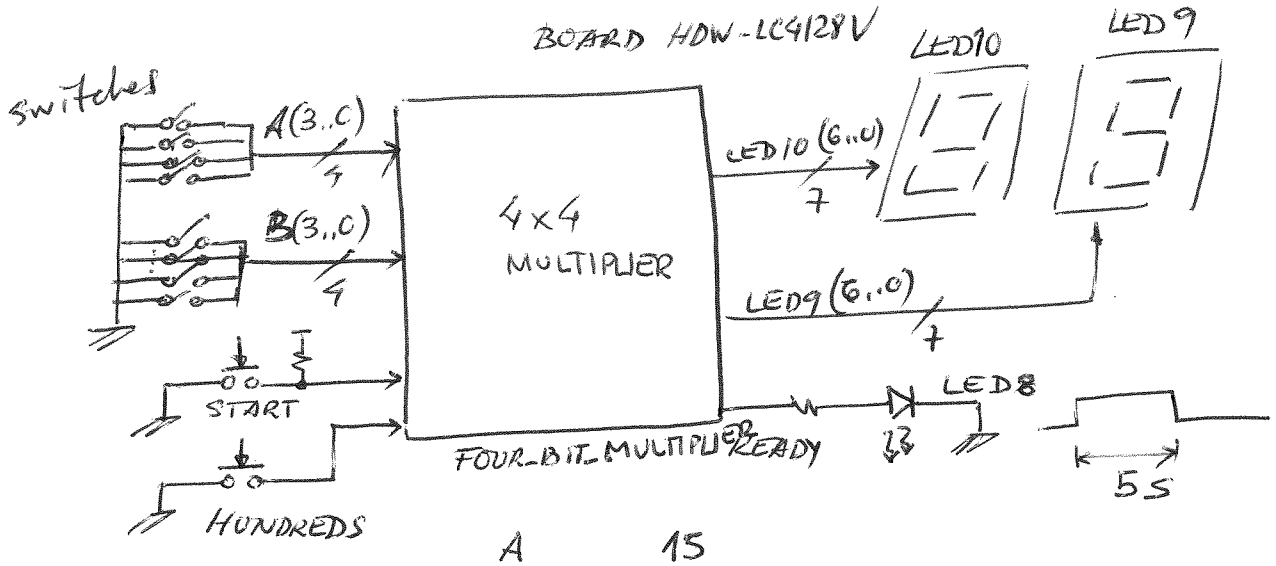
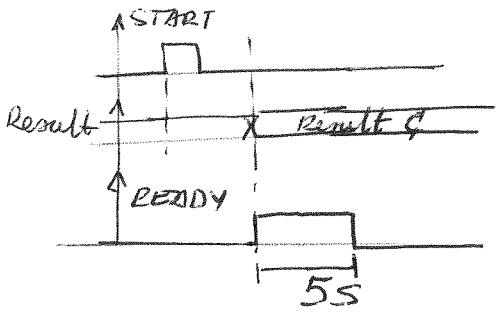
Planning the problem





A 15
xB x15
C 225 → 1110 0001

0010	0010	0101
Hundreds	Tens	Units

LED10 shows the operand A (multiplier) → F
LED9 shows the operand B (multiplicand) → F

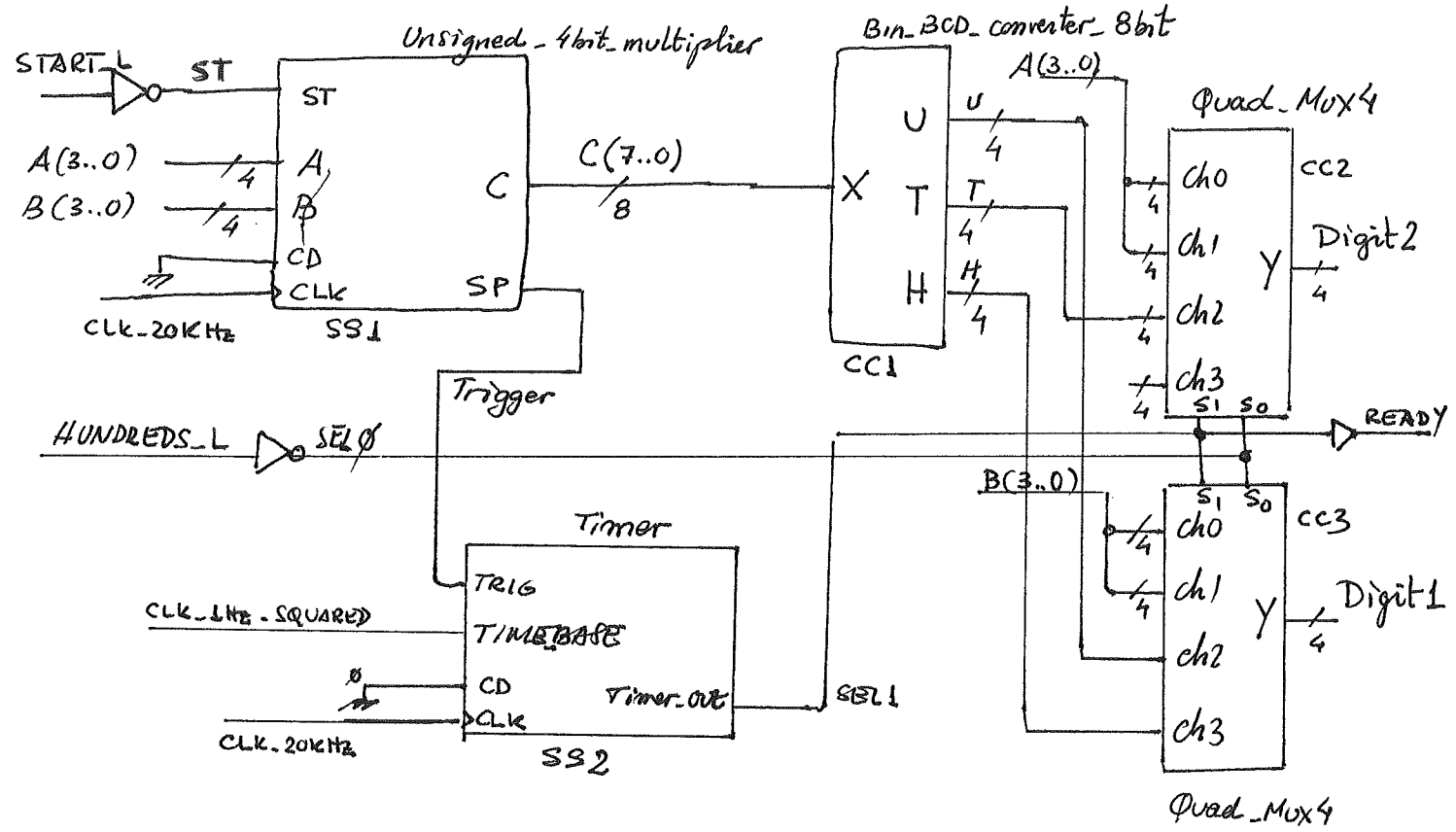
start pulse triggers the operation

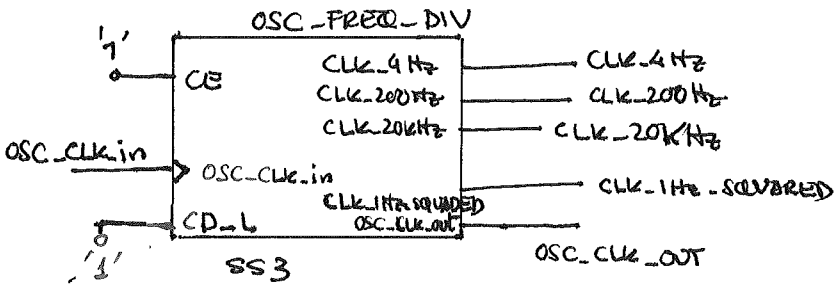
LED10 → shows the Tens → 2
LED9 → shows the Units → 5

Push button Hundreds shows the hundreds → H2
at LED9, while the symbol "H" is displayed at LED10

→ The result is displayed while READY is High (5s), then the operand are shown again

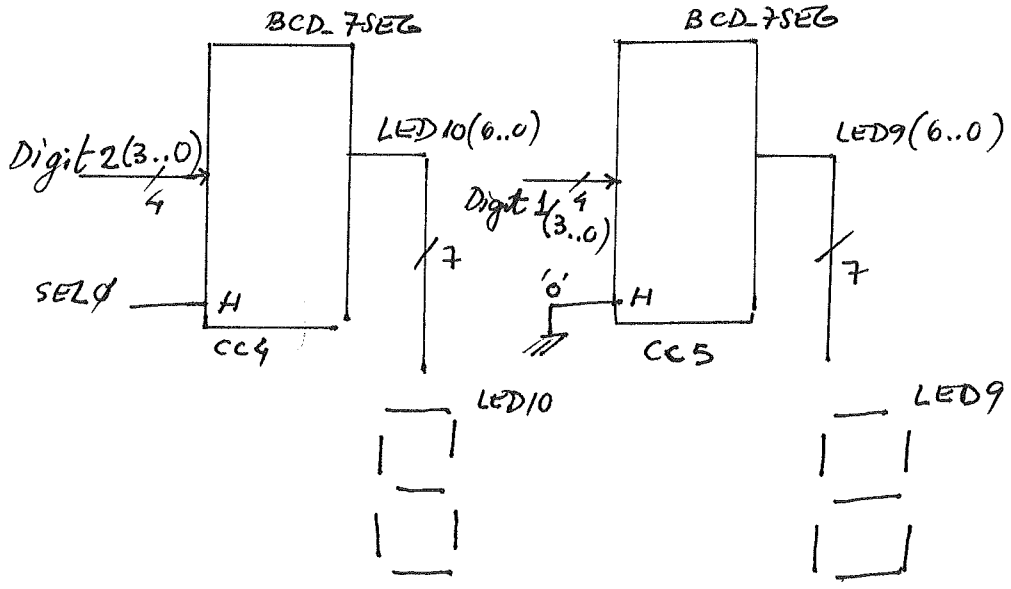
The internal architecture





(Ready) S1	(Hundreds) S0	LED10 LED9
0	0	shows A, B
0	1	shows A, B
1	0	shows T, U
1	1	shows H, H

symbol



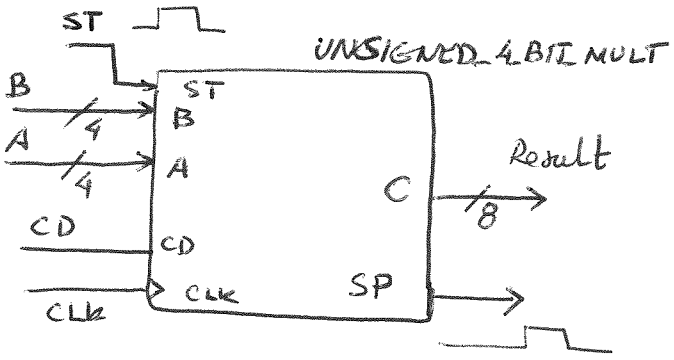
15
×14
210

T U
1 0

H
H 2

LED10 LED9

The 4x4 multiplier



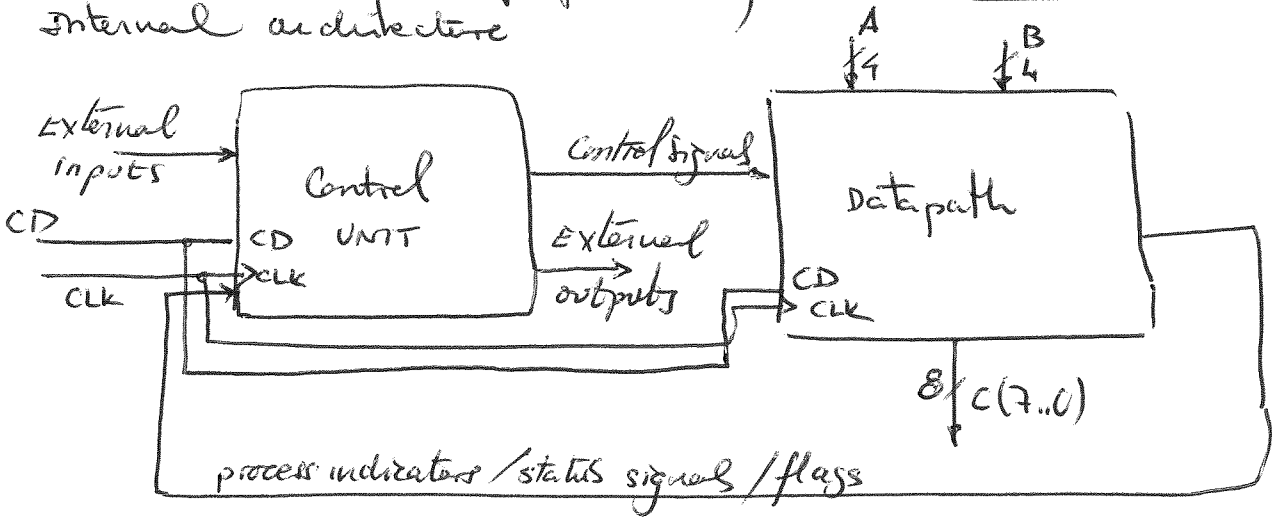
multiplier
multiplicand

A	1 1 0 0	12
x B	x 1 0 1 1	x 11
C	1 1 0 0	
	1 1 0 0	
	0 0 0 0	
	1 1 0 0	
	1 0 0 0 0 1 0 0	132

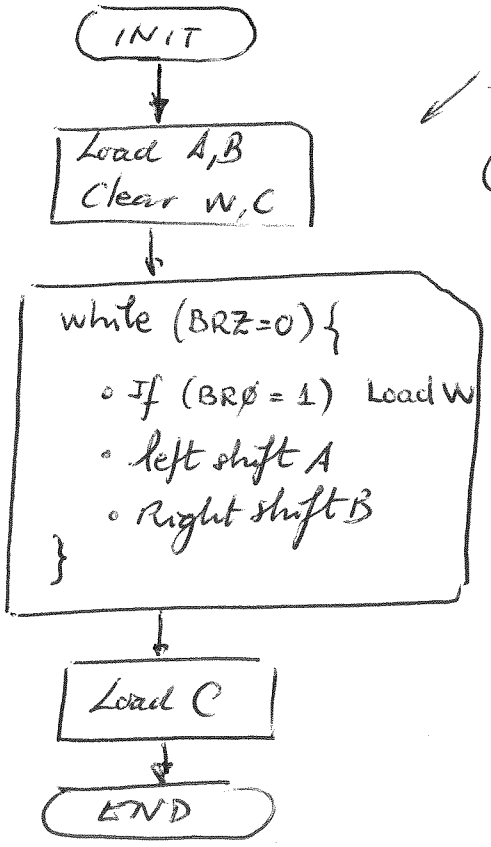
shift + add algorithm

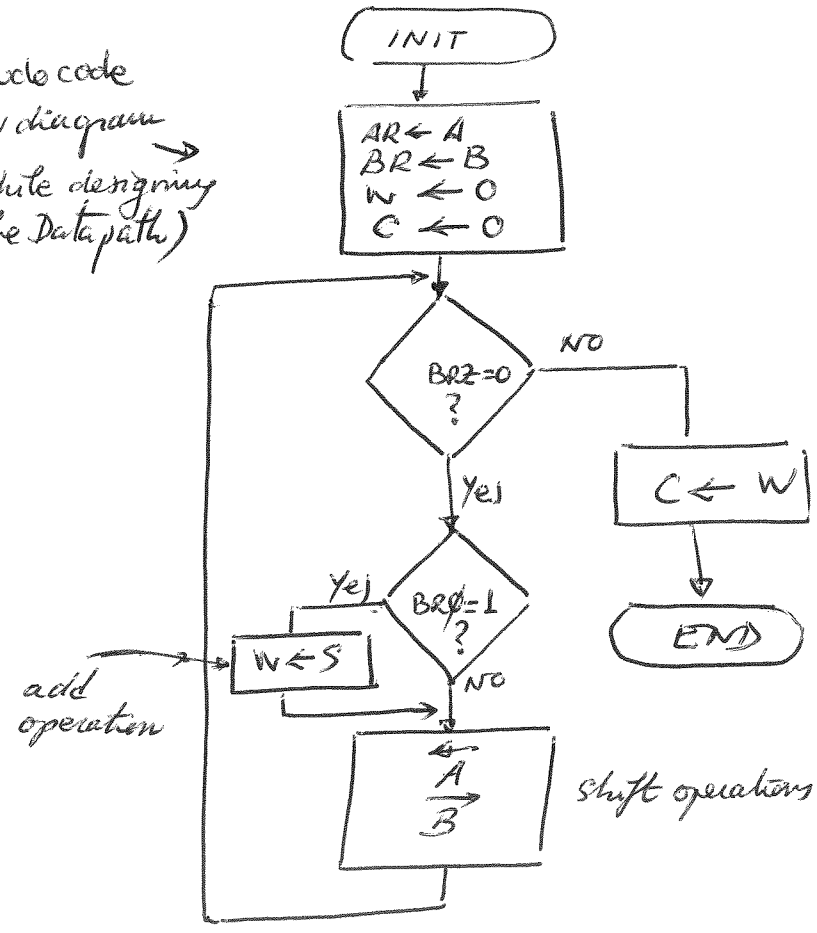
start → ST (start operation)
stop → SP (end of operation)

→ Internal architecture

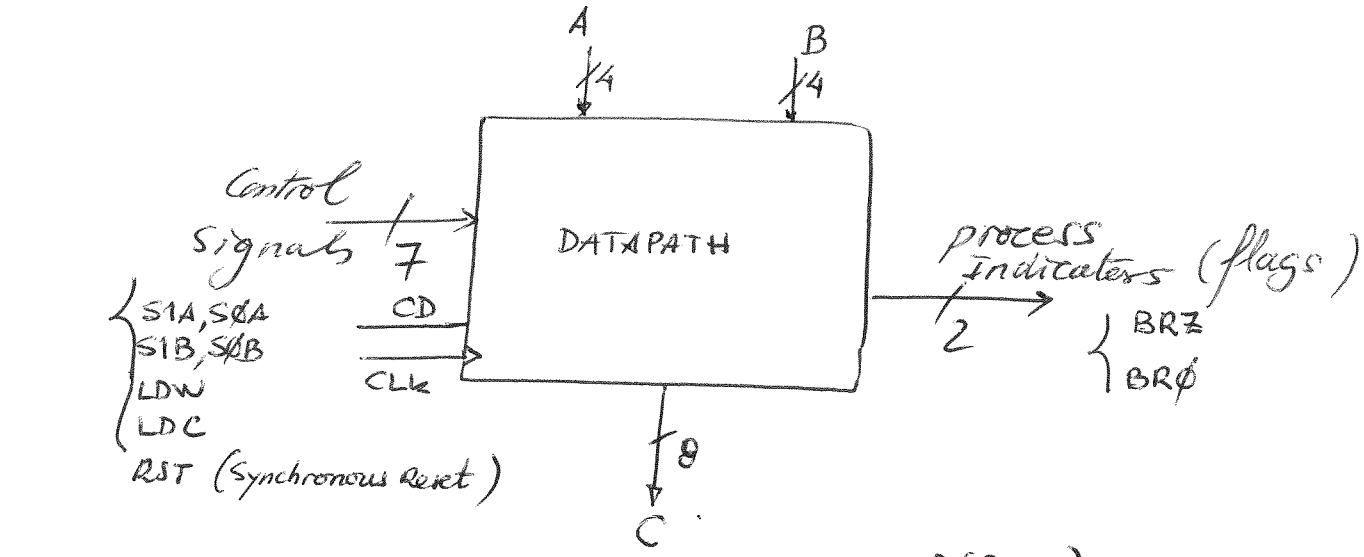


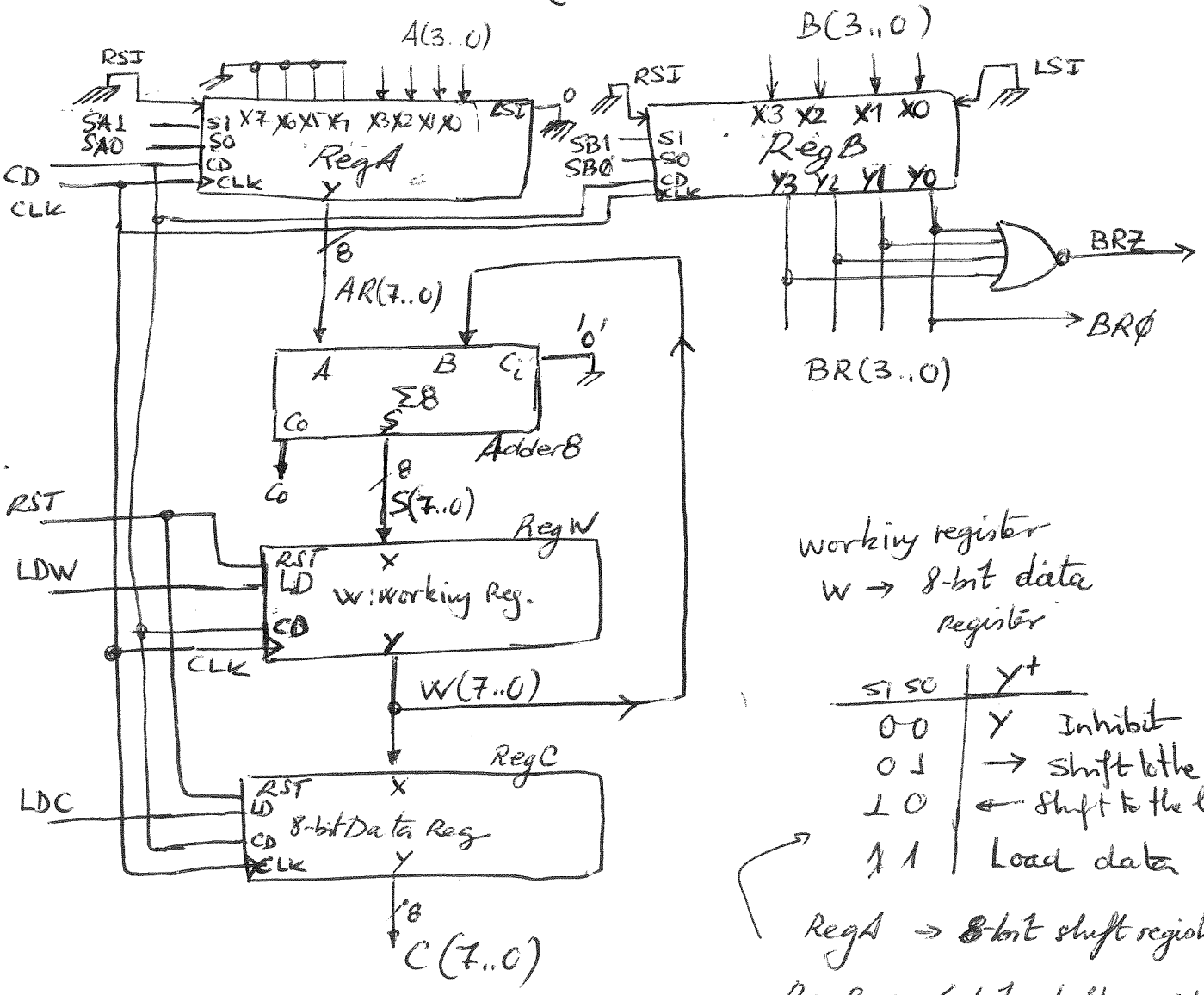
Pseudo code
Flow diagram
(while designing the Datapath)





The datapath or operational unit





Working register
W → 8-bit data register

S1 S0	Y+	
0 0	Y	Inhibit
0 1	→	shift to the right
1 0	←	shift to the left
1 1		Load data

RegA → 8-bit shift register

RegB → 4-bit shift register

RegW, RegC → 8-bit data register

Example 1 $A = 1100$, $B = 1011$

$$\begin{array}{r} 12 \\ \times\ 11 \\ \hline 132 \end{array} \rightarrow 10000100 \Rightarrow C$$

W ← working register

① Load A, B,
Clear W, C

$A = 00001100$
$B = 1011$ (1)

↖ bit testing

② BRZ = Ø ⇒ (bit testing)

BRØ = 1 ⇒ $W = S = AR + W = 00001100$

$AR = 00011000$ shift to the left (←)

$BR = 0101$ (1) shift to the right (→)

③ BRZ = Ø ⇒ BRØ = 1 ⇒

$$\begin{array}{r} 00001100 \\ +\ 00011000 \\ \hline 00100100 \end{array}$$

$AR = 00110000$ (←)

$BR = 0010$ (0) (→)

④ BRZ = Ø ⇒ BRØ = 0

$AR = 01100000$ (←)

$BR = 0001$ (1) (→)

⑤ BRZ = Ø → BRØ = 1 → $W = S =$

$$\begin{array}{r} 00100100 \\ +\ 01100000 \\ \hline 10000100 \end{array}$$

$AR = 11000000$ (←)

$BR = 0000$ (0) (→)

⑥ BRZ = 1 → $C = W = 10000100$

Example 2

A = 0101
B = 1101

5 × 13 = 65

01000001 ← C

① Load A, B
Clear W, C

AR = 00000101 ; W = 00000000
BR = 1101

② BRZ = 0 ⇒ BRO = 1 ⇒ W = S = AR+W = 00000101

AR = 00001010
BR = 0110

shift to the left
shift to the right

③ BRZ = 0 ⇒ BRO = 0

AR = 00010100
BR = 0011

④ BRZ = 0 ⇒ BRO = 1 ⇒ W = S = AR+W = 00010100
00000101
00011001

AR = 00101000
BR = 0001

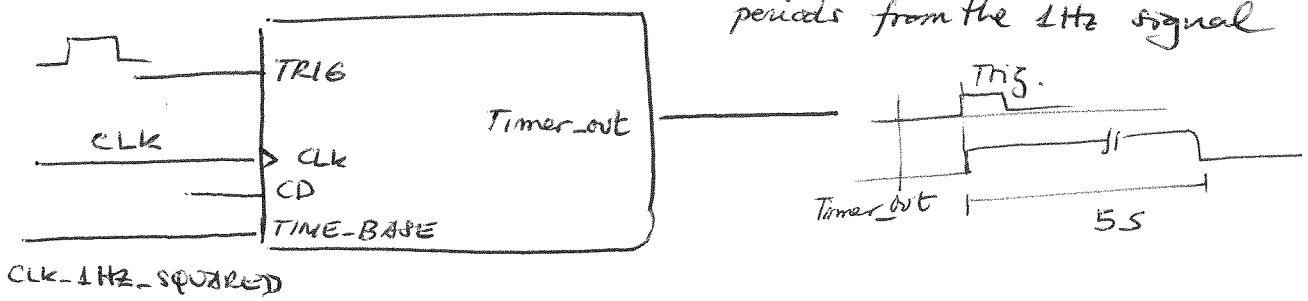
⑤ BRZ = 0 ⇒ BRO = 1 ⇒ W = S = AR+W = 00101000
00011001
01000001

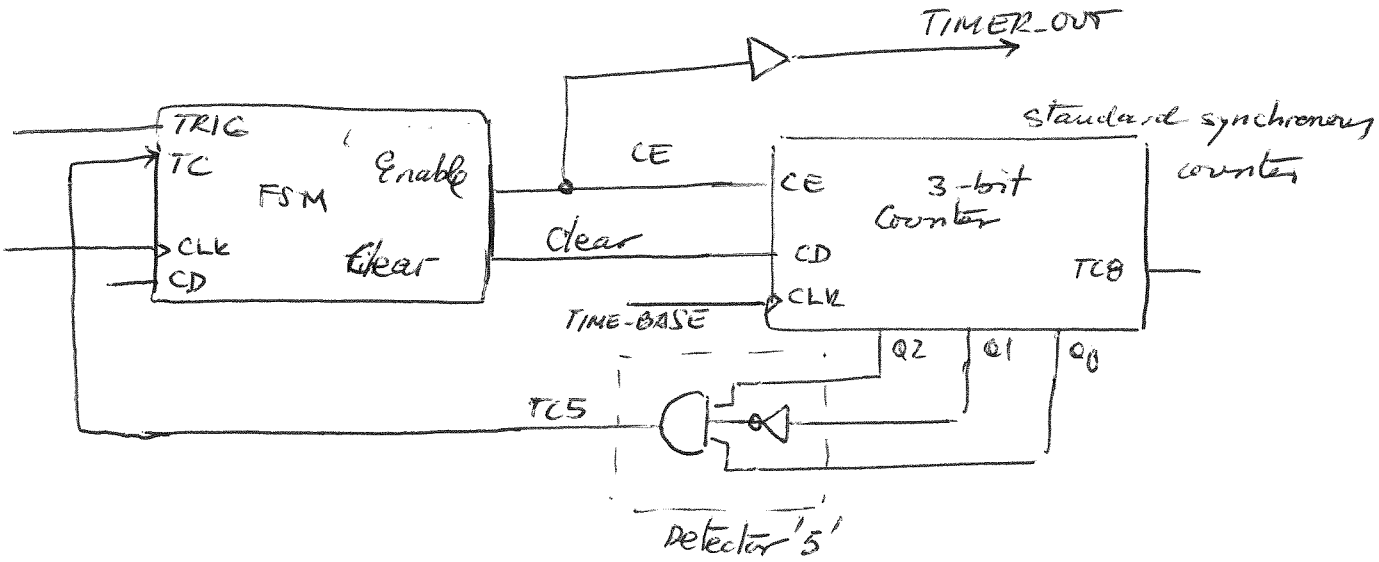
AR = 01010000
BR = 0000

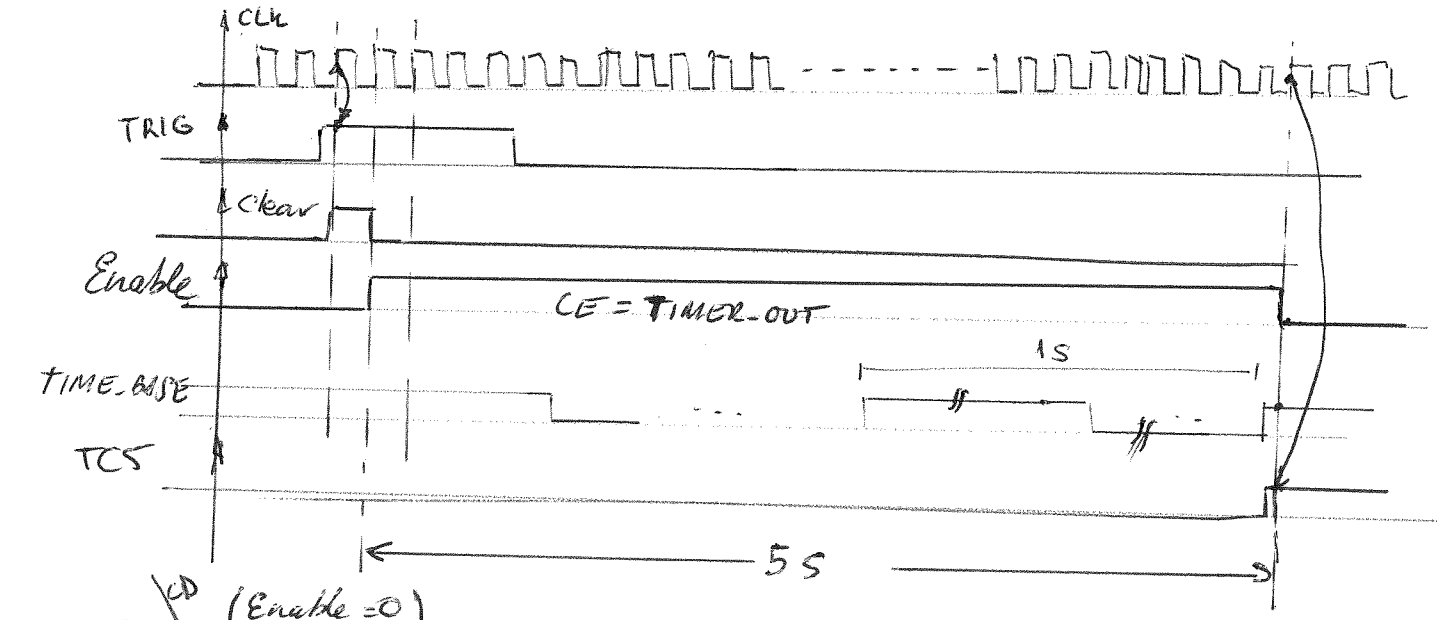
⑥ BRZ = 1 ⇒ C = W = 01000001

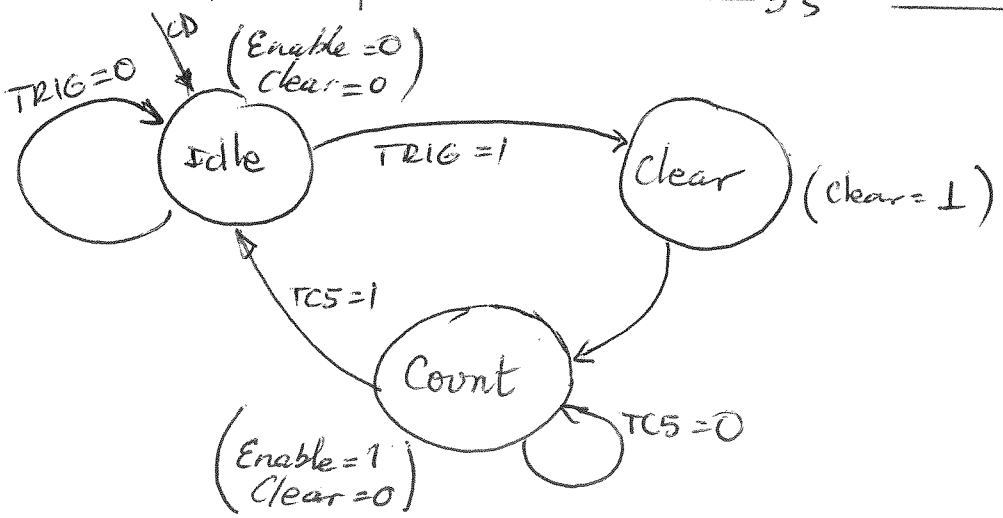
The 5 s timer

The idea is to count up to 5 periods from the 1Hz signal





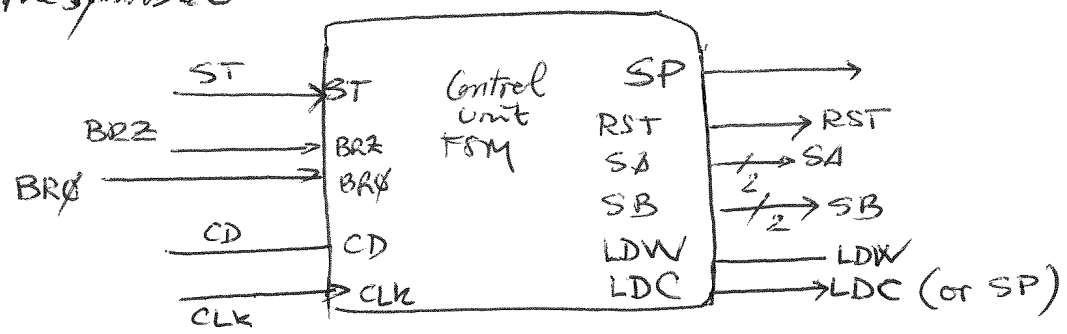




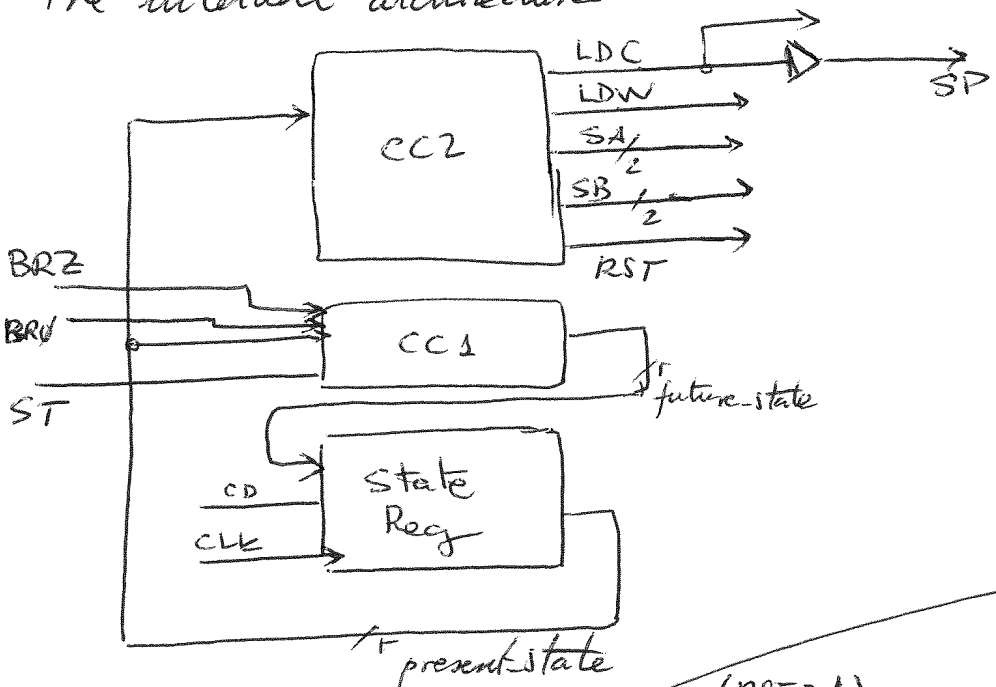
For example
The state machine may run this state diagram to control the counter device.

The multiplier FSM to control the datapath

- The symbol



- The internal architecture



- State Diagram