
AHDL Training Class

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What is AHDL

■ Altera Hardware Description Language

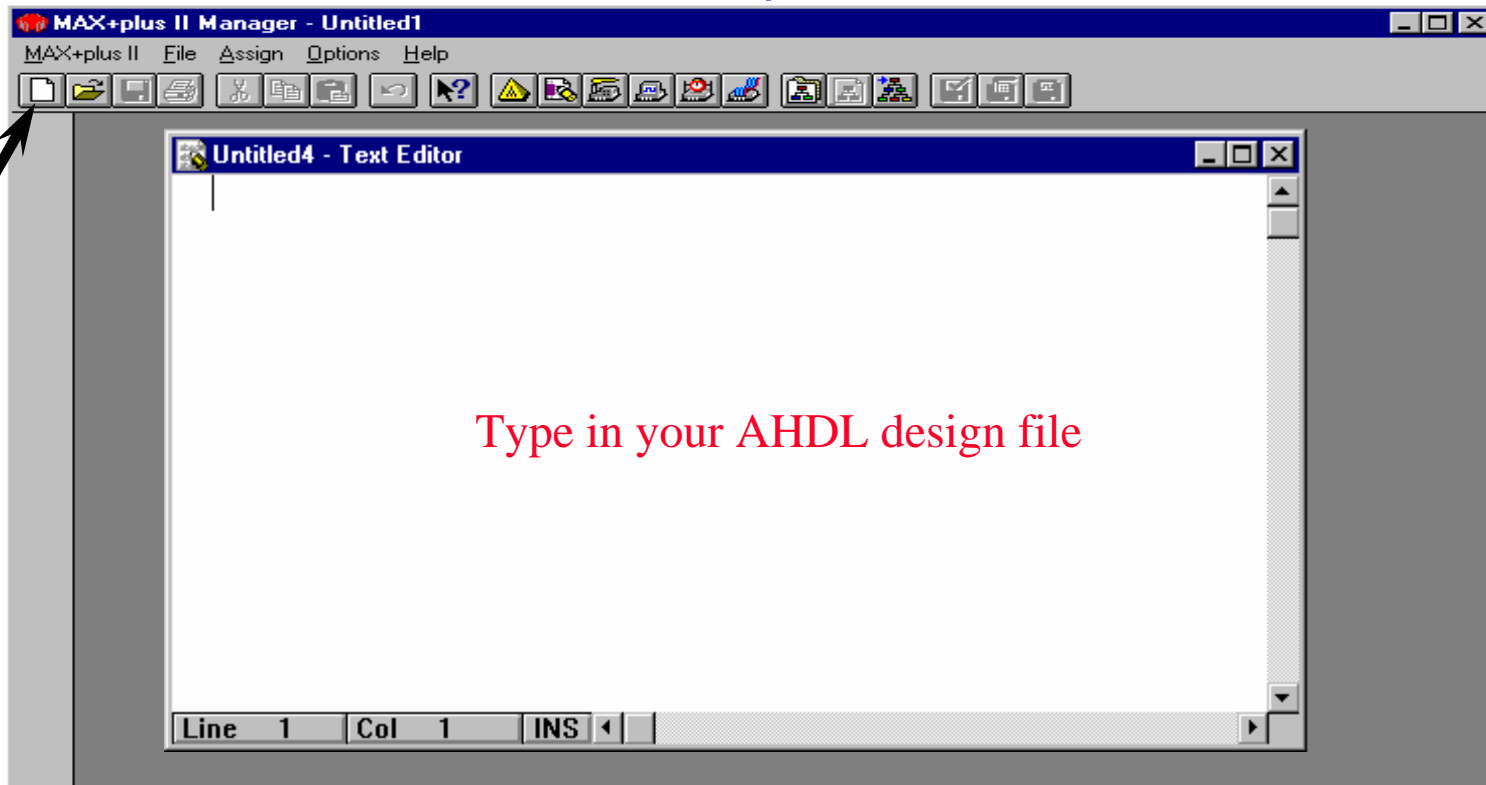
- develop by Altera
- integrate into the Altera software Max+Plus II
- description the hardware in language instead of graphic
 - easy to modify
 - easy to maintane
- very good for
 - complex combinational logic
 - BCD to 7 Segment converter
 - address decoding
 - state machine
 - more than you want.....

continue...

- As easy as Graphic Entry
- As powerful as HDL (Hardware Description Language)
 - VHDL, Verilog HDL etc.

How to use the ADHL

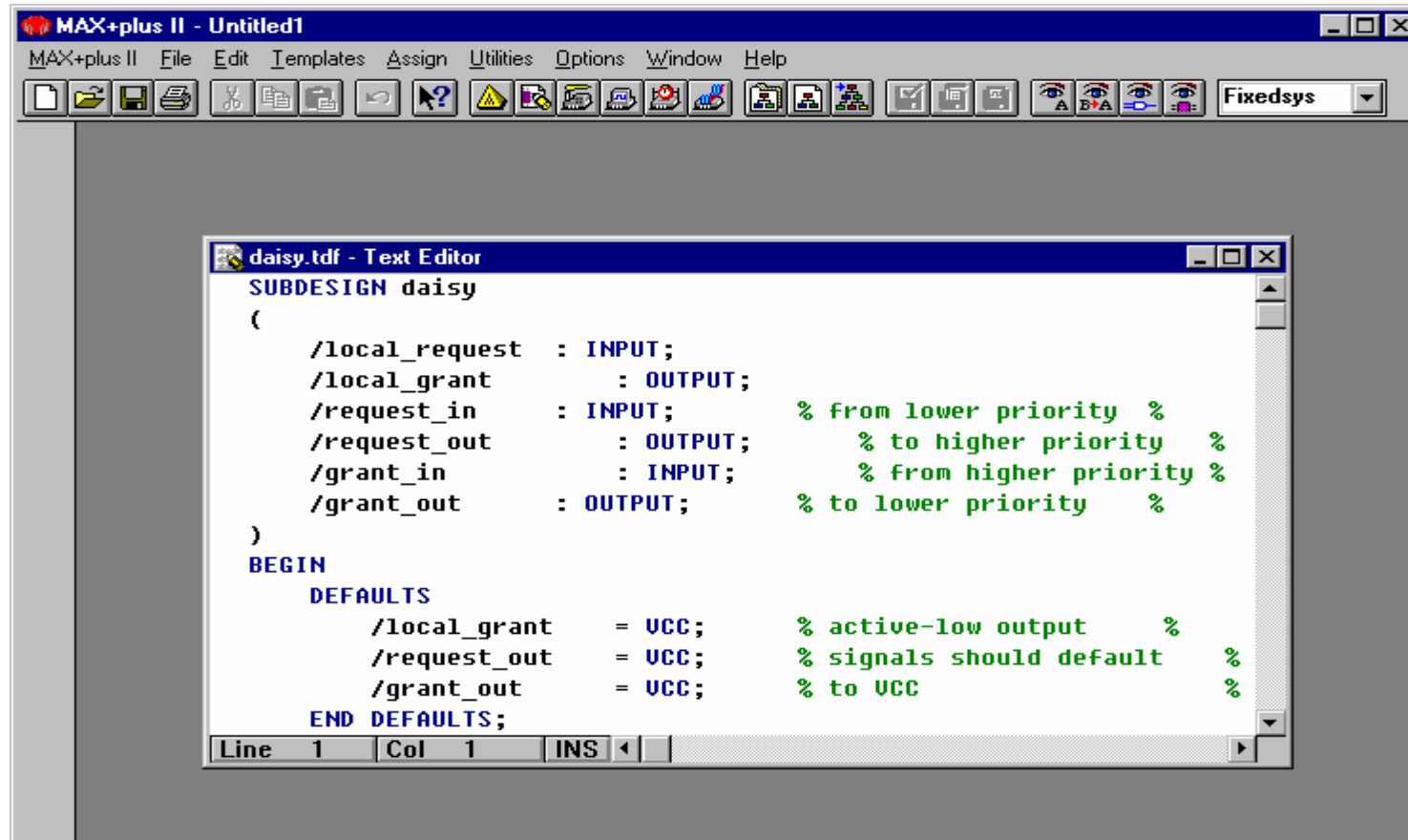
- use any text editor to create the file
 - Altera Software Max+Plus II provide text editor



Click
the
button

continue.....

■ Create your AHDL file



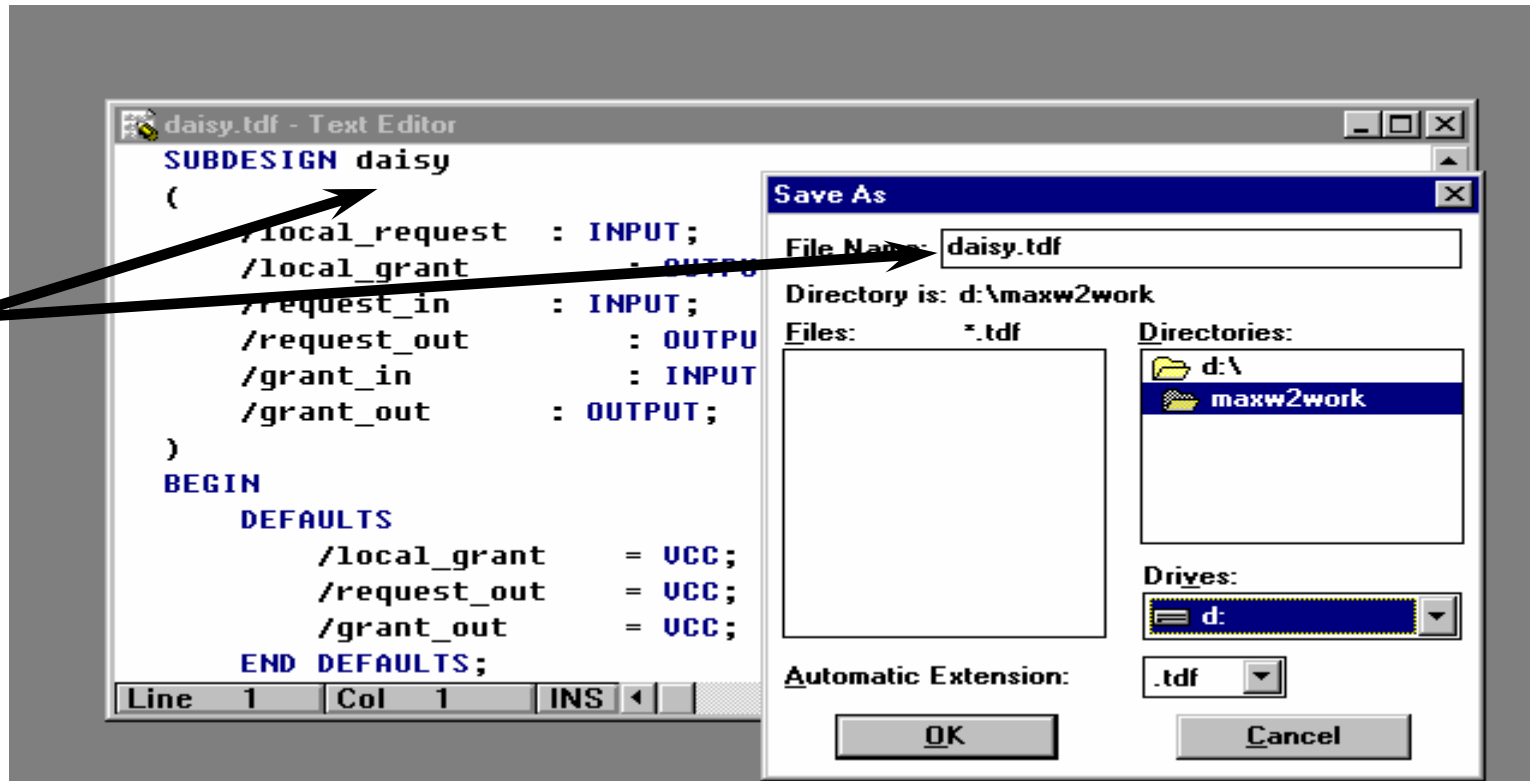
```
MAX+plus II - Untitled1
MAX+plus II File Edit Templates Assign Utilities Options Window Help
Fixedsys

daisy.tdf - Text Editor
SUBDESIGN daisy
(
  /local_request : INPUT;
  /local_grant   : OUTPUT;
  /request_in   : INPUT;      % from lower priority %
  /request_out  : OUTPUT;     % to higher priority %
  /grant_in     : INPUT;      % from higher priority %
  /grant_out    : OUTPUT;     % to lower priority  %
)
BEGIN
  DEFAULTS
    /local_grant = UCC;      % active-low output %
    /request_out = UCC;     % signals should default %
    /grant_out   = UCC;     % to UCC %
  END DEFAULTS;
Line 1 Col 1 INS
```

continue.....

- save your ADHL file as **name.TDF**

Must be
the same



continue...

Click on this icon

The screenshot displays the MAX+plus II software interface. At the top, a menu bar includes 'MAX+plus II', 'File', 'Edit', 'Templates', 'Assign', 'Utilities', 'Options', 'Window', and 'Help'. Below the menu is a toolbar with various icons. The main window is titled 'daisy.tdf - Text Editor' and contains the following Verilog code:

```
SUBDESIGN daisy
(
  /local_request : INPUT;
  /local_grant   : OUTPUT;
  /request_in   : INPUT;      % from lower priority %
  /request_out  : OUTPUT;     % to higher priority %
  /grant_in     : INPUT;      % from higher priority %
)
```

Below the text editor is a 'Compiler' window. It features a progress bar from 0 to 100, with a red line indicating progress. Below the progress bar are 'Start' and 'Stop' buttons. The compiler window is divided into several sections: 'Compiler Netlist Extractor' (cnf icon), 'Database Builder', 'Logic Synthesizer', 'Partitioner' (hourglass icon), 'Fitter' (rpt icon), 'Timing SNF Extractor' (snf icon), and 'Assembler' (pof icon).

At the bottom, a 'Messages - Compiler' window shows the following information:

- Info: Selecting a device from 'MAX7000' family for AUTO device 'daisy'
- Info: Chip 'daisy' successfully fit into AUTO device

A small dialog box titled 'MAX+plus II - Compiler' is overlaid on the messages window, displaying:

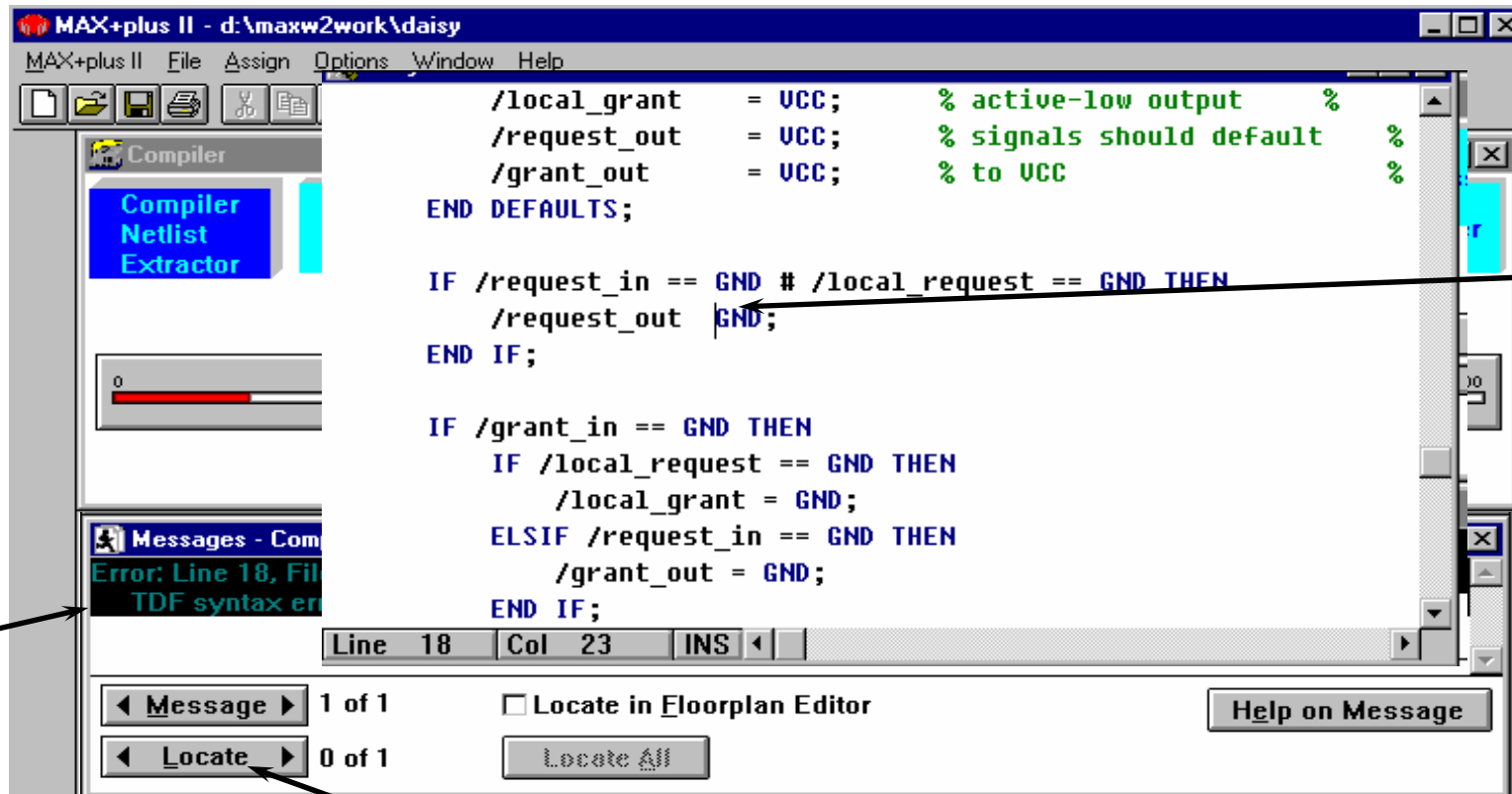
- Project compilation was successful
- 0 errors
- 0 warnings

The dialog box has an 'OK' button. The messages window also includes a 'Help on Message' button and navigation controls for messages and locating them in the source code.



Error Location during Compilation

- Easy to locate the error



Error location

Click the error message

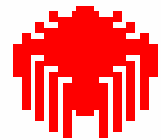
Click the Locate button

AHDL Template

I forgot



If-then-else
case-end case
loop-end loop
??...???



MAX+plus II

A screenshot of the MAX+plus II software interface. The window title is "MAX+plus II - d:\maxw2work\daisy - [Untitled6 - Text Editor]". The menu bar includes "MAX+plus II", "File", "Edit", "Templates", "Assign", "Utilities", "Options", "Window", and "Help". The toolbar contains various icons for file operations and editing. The main text area displays the following AHDL code template:

```
IF _expression THEN
    _statement;
    _statement;
ELSIF _expression THEN
    _statement;
    _statement;
ELSE
    _statement;
    _statement;
END IF;
```

Two black arrows originate from the bottom of the code block. One arrow points to the first line "IF _expression THEN" and the other points to the last line "END IF;".

Modify the code

General AHDL Format

```
SUBDESIGN decode1
(
  input_pin_name : INPUT;
  input_bus_name[15..0] : INPUT;
  output_pin_name : OUTPUT;
  output_bus_name : OUTPUT;
)
BEGIN
  ouputut_pin_name = input_pin_name;
  output_bus_name = input_bus_name;
END;
```

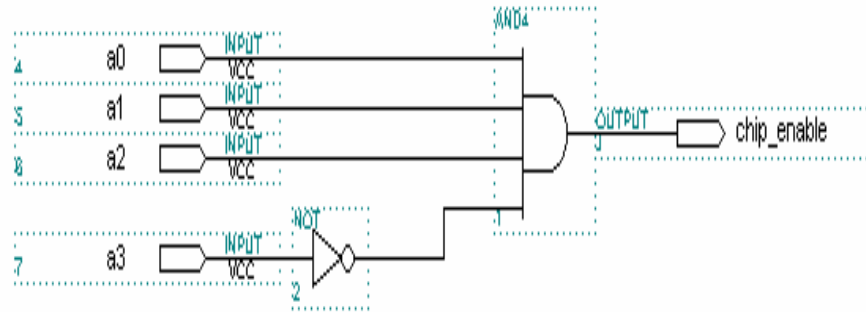
Key Word

Defien I/O port

Logic

AHDL format

Your First AHDL design -- Address Decoder



SUBDESIGN decode1

(a[3..0] : input;

chip_enable : output;

)

begin

chip_enable = (a[3..0] == H"7");

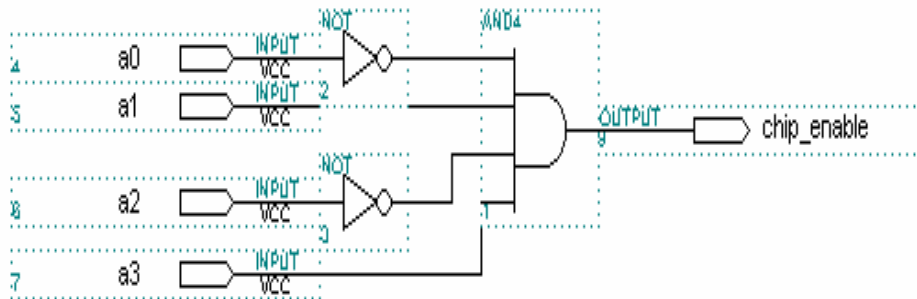
end;

Chip_enable = a0 & a1 & a2 & !a3

Why I use AHDL instead of Graphic

- Easy to Modify
- Document during the coding
- I want to decode H"A" not H"7"

Chip_enable = !a0 & a1 & !a2 & a3



Need more effort to modify

SUBDESIGN decode1

```
( a[3..0] : input;  
  chip_enable : output;  
)  
begin  
  chip_enable = (a[3..0] == H"A");  
end;
```

Self Explain the Function

Only thing to change

More

```
SUBDESIGN decode1
( a[3..0] : input;
  chip_enable : output;
)
begin
chip_enable = (a[3..0] == B"1x0x");
end;
```

Some bit can be **ignore** for comparsion



Something you need to know

- Addition : +
- Subtraction : -
- Numeric Equality : ==
- Not equal to : !=
- Greater than : >
- Greater than or equal to : >=
- Less than : <
- Less than or equal to : <=
- Logical OR : #
- Logical AND : &

Use Constant Function

- Use Constant if the same number, text string, or arithmetic expression is repeated several times in a file
- Advantage

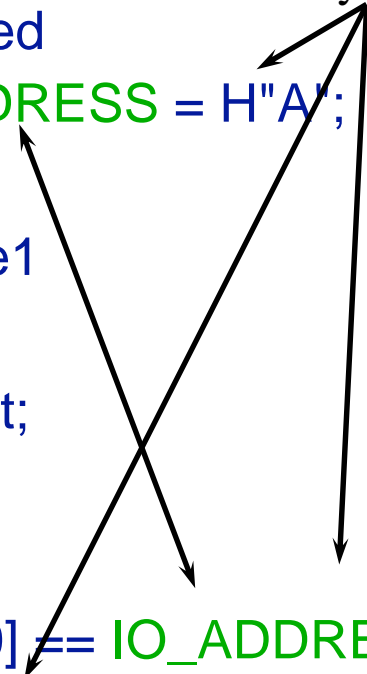
- Only one statement needs to be changed

```
CONSTANT IO_ADDRESS = H"A";
```

```
SUBDESIGN decode1  
( a[3..0] : input;  
  chip_enable : output;  
)  
begin  
  chip_enable = (a[3..0] == IO_ADDRESS);  
  if (a[3..0] == IO_ADDRESS) then  
    .....  
  end;
```

Modify One Place will modify all

Define **CONSTANT**
before **SUBDESIGN**
keyword



More about Constant

■ Constant example

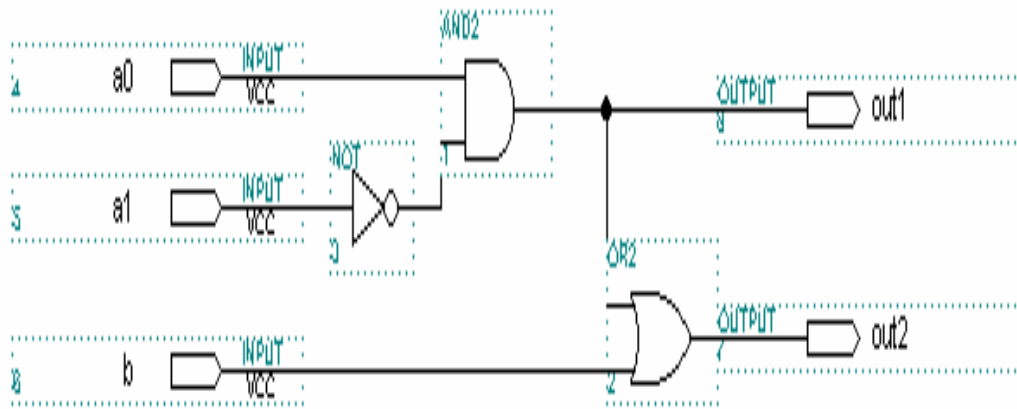
Constant IO_ADDRESS = H"370"; ← Define a constant value

Constant FOO = 1+2*3 - LOG2(256); ← Define an arithmetic equation

Constant FOO_PLUS_one = FOO + 1;

Depends on pre-define constant

Implement Combinational Logic



$\text{out1} = a0 \ \& \ !a1$
 $\text{out2} = \text{out1} \ \# \ b$

AHDL ?

SUBDESIGN decode1

(a0, a1, b : input;
out1, out2 : output;

)

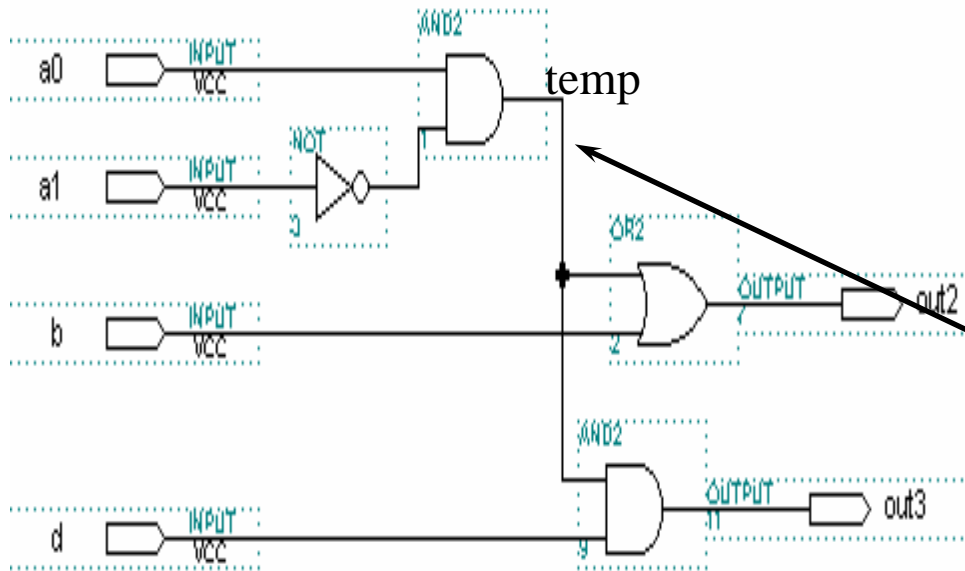
begin

out1 = a0 & !a1;

out2 = out1 # b;

end;

Define NODEs



$out2 = a0 \& !a1 \# b$
 $out3 = a0 \& !a1 \& d$

AHDL ?

SUBDESIGN decode1
(a0, a1, b, d: input;
 out2, out3 : output;

)

variable

temp : node;

begin

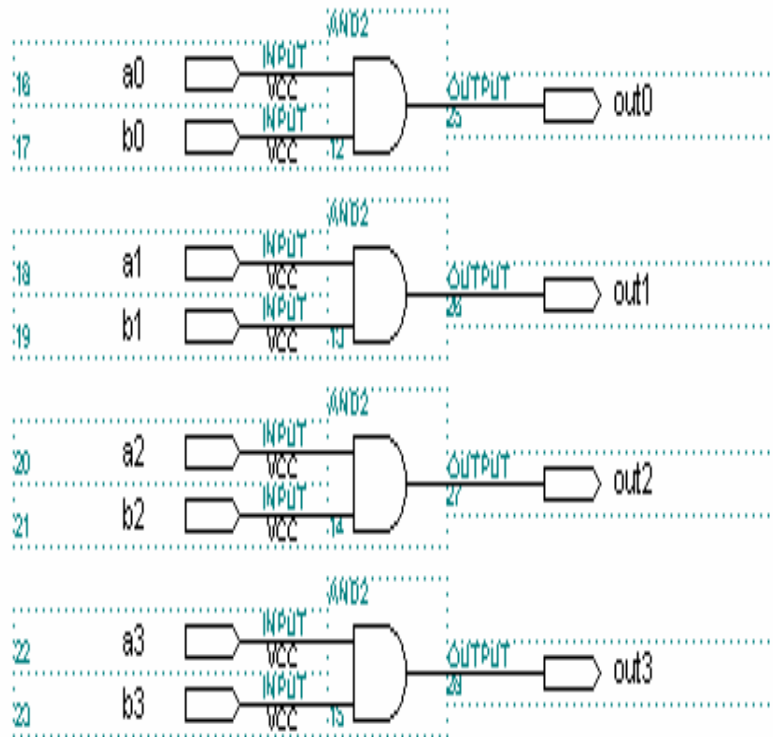
temp = a0 & !a1;

out2 = **temp** # b;

out3 = **temp** & d;

end;

Bus Operation



```
SUBDESIGN decode1  
( a[3..0], b[3..0] : input;  
  out[3..0] : output;  
)  
begin  
  out0 = a0 & b0;  
  out1 = a1 & b1;  
  out2 = a2 & b2;  
  out3 = a3 & b3;  
end;
```

Same function
but easier

```
SUBDESIGN decode1  
( a[3..0], b[3..0] : input;  
  out[3..0]: output;  
)  
begin  
  out1[] = a[] & b[];  
end;
```

More on Bus Operation

Bus Operation

$a[9..0]$, $b[9..0]$

- $a[] = b[]$;
- $a[7..4] = b[9..6]$; $a7=b9$, $a6=b8$, $a5=b7$, $a4=b6$
- $a[9..8] = VCC$; $a[9..8]$ connect to VCC
- $a[9..8] = 1$; $a[9..8] = B''01''$
- $a[9..8] = 2$; $a[9..8] = B''10''$
- $a[9..8] = 3$; $a[9..8] = B''11''$
- $a[3..0] = GND$ $a[3..0]$ connect to GND
- $a[3..0] = 0$; $a[3..0] = B''0000''$
- $temp = b0 \& b1$;
 $a[2..1] = temp$ $a2 = temp$, $a1 = temp$

Advance Bus Operation

■ Bus

- b[3..0]
 - b3, b2, b1, b0 (having 4 members)
 - **MSB** is b3, **LSB** is b0

■ ARRAY BUS

- a[3..0][2..0]
 - a3_2, a3_1, a3_0, a2_2, a2_1, a2_0, a1_2, a1_1, a1_0, a0_2, a0_1, a0_0 (having 12 members)
 - **MSB** is a3_2, **LSB** is a0_0

a[3..2][1..0] = b[];

a3_1 = b3 a3_0 = b2
a2_1 = b1 a2_0 = b0

← This one change **first**

Truth Table

i[3..0]

0

1

2

F

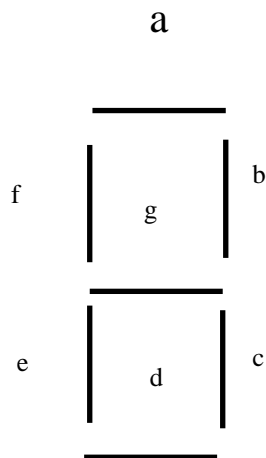
Segment 7

0

1

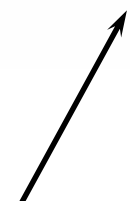
2

F



```

SUBDESIGN 7segment
(
    i[3..0]                : INPUT;
    a, b, c, d, e, f, g : OUTPUT;
)
BEGIN
    TABLE
        i[3..0] => a, b, c, d, e, f, g;
        H"0"    => 1, 1, 1, 1, 1, 1, 0;
        H"1"    => 0, 1, 1, 0, 0, 0, 0;
        H"2"    => 1, 1, 0, 1, 1, 0, 1;
        H"3"    => 1, 1, 1, 1, 0, 0, 1;
        H"4"    => 0, 1, 1, 0, 0, 1, 1;
        H"5"    => 1, 0, 1, 1, 0, 1, 1;
        H"6"    => 1, 0, 1, 1, 1, 1, 1;
        H"7"    => 1, 1, 1, 0, 0, 0, 0;
        H"8"    => 1, 1, 1, 1, 1, 1, 1;
        H"9"    => 1, 1, 1, 1, 0, 1, 1;
        H"A"    => 1, 1, 1, 0, 1, 1, 1;
        H"B"    => 0, 0, 1, 1, 1, 1, 1;
        H"C"    => 1, 0, 0, 1, 1, 1, 0;
        H"D"    => 0, 1, 1, 1, 1, 0, 1;
        H"E"    => 1, 0, 0, 1, 1, 1, 1;
        H"F"    => 1, 0, 0, 0, 1, 1, 1;
    END TABLE;
END;
    
```

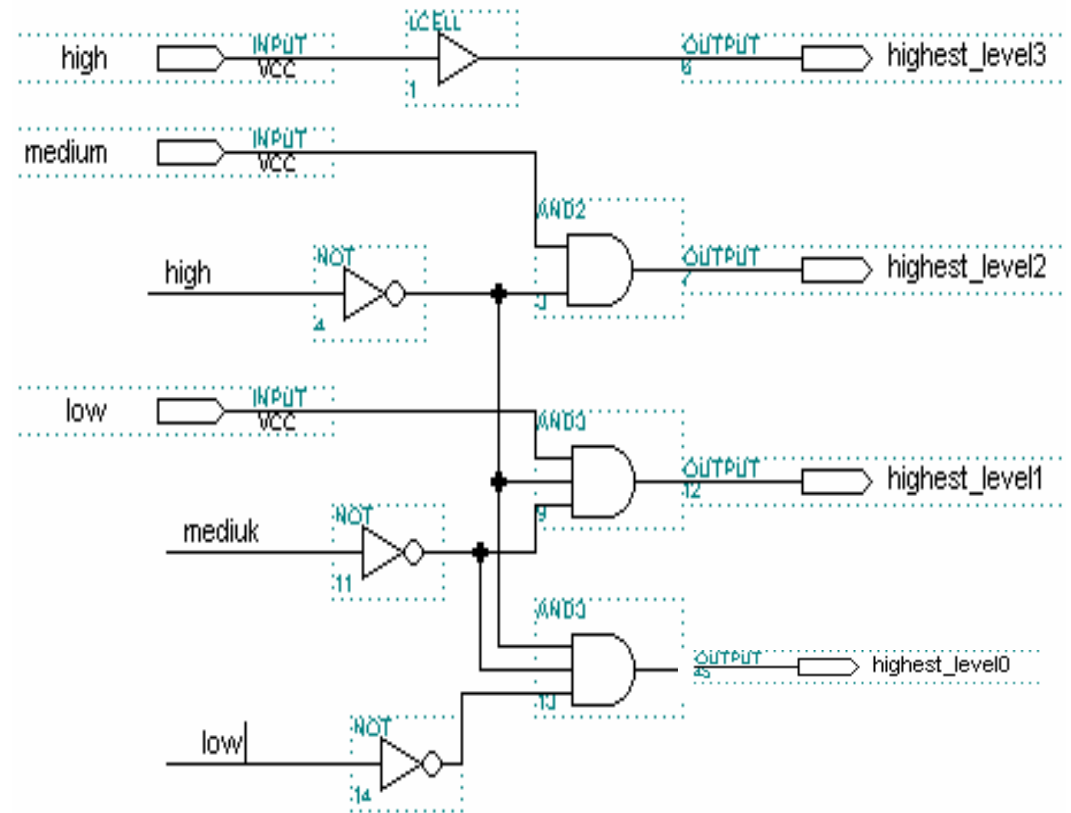


How easy to make any modification

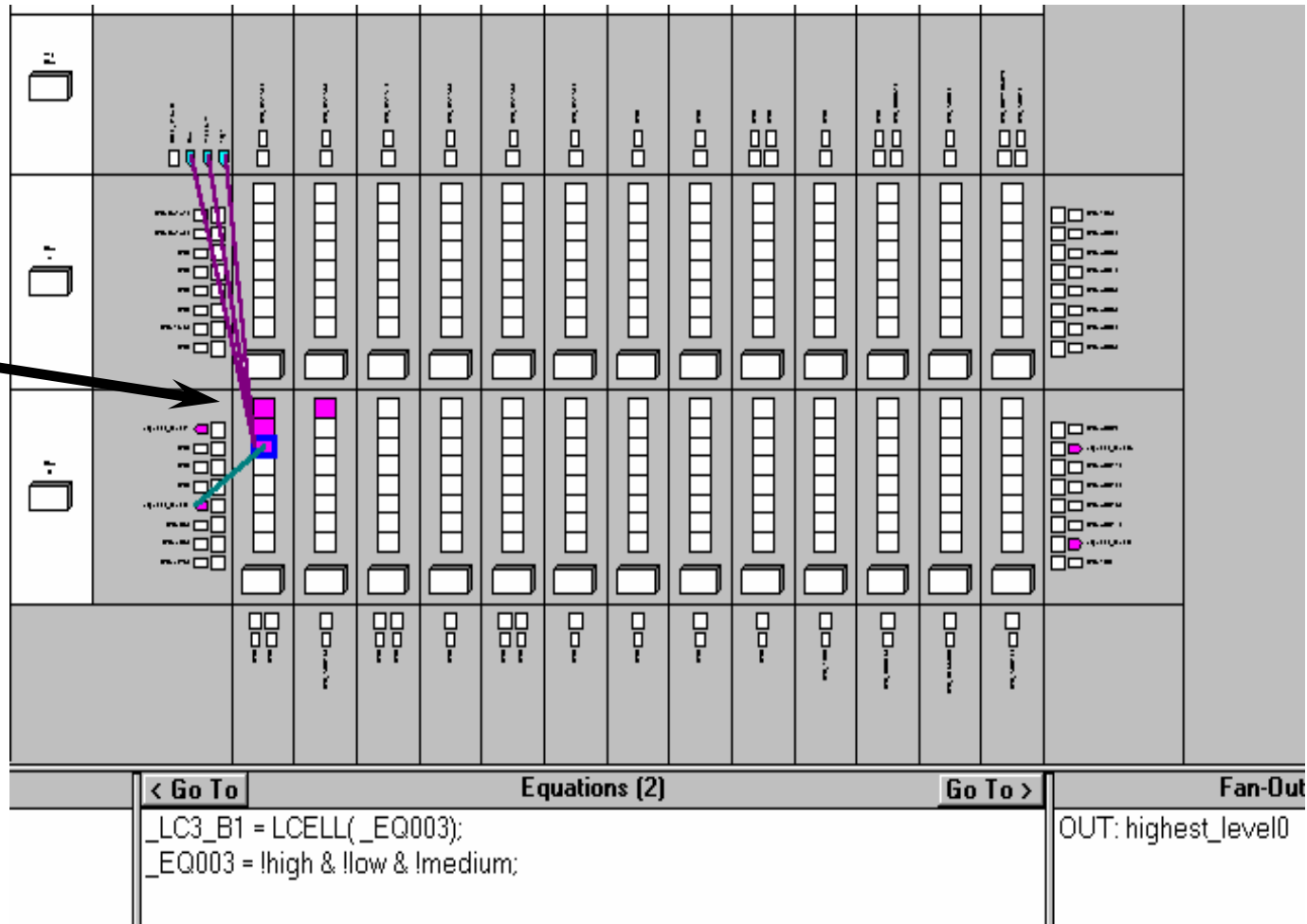


IF-THEN-ELSE

```
SUBDESIGN priority
( low, medium, high : input;
  highest_level[3..0] : output;
)
begin
  if ( high == B"1" ) then
    highest_level[] = B"1000";
  elsif ( medium == B"1" ) then
    highest_level[] = B"0100";
  elsif ( low == B"1" ) then
    highest_level[] = B"0010";
  else
    highest_level[] = B"0001";
  end if;
end;
```



Need 4
LCELL



CASE Statement

SUBDESIGN decoder

```
(low, medium, high : input;  
  highest_level[3..0] : output;  
)
```

variable

```
code[2..0] : node;
```

```
begin
```

```
code2=high;
```

```
code1=medium;
```

```
code0=low;
```

```
case code[] is
```

```
when 4 => highest_level[] = B"1000";
```

```
when 2 => highest_level[] = B"0100";
```

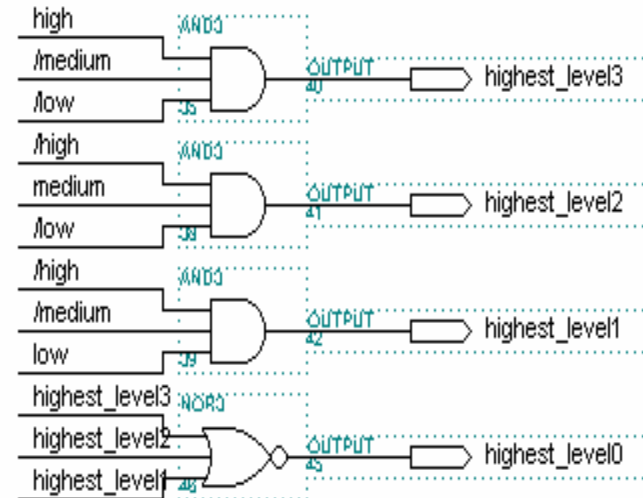
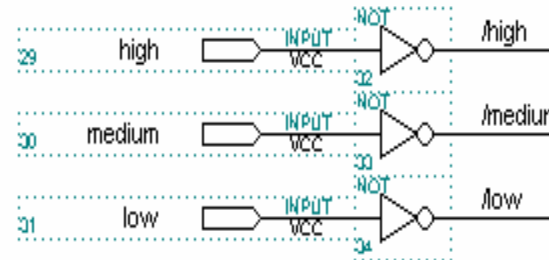
```
when 1 => highest_level[] = B"0010";
```

```
when others => highest_level[] = B"0001";
```

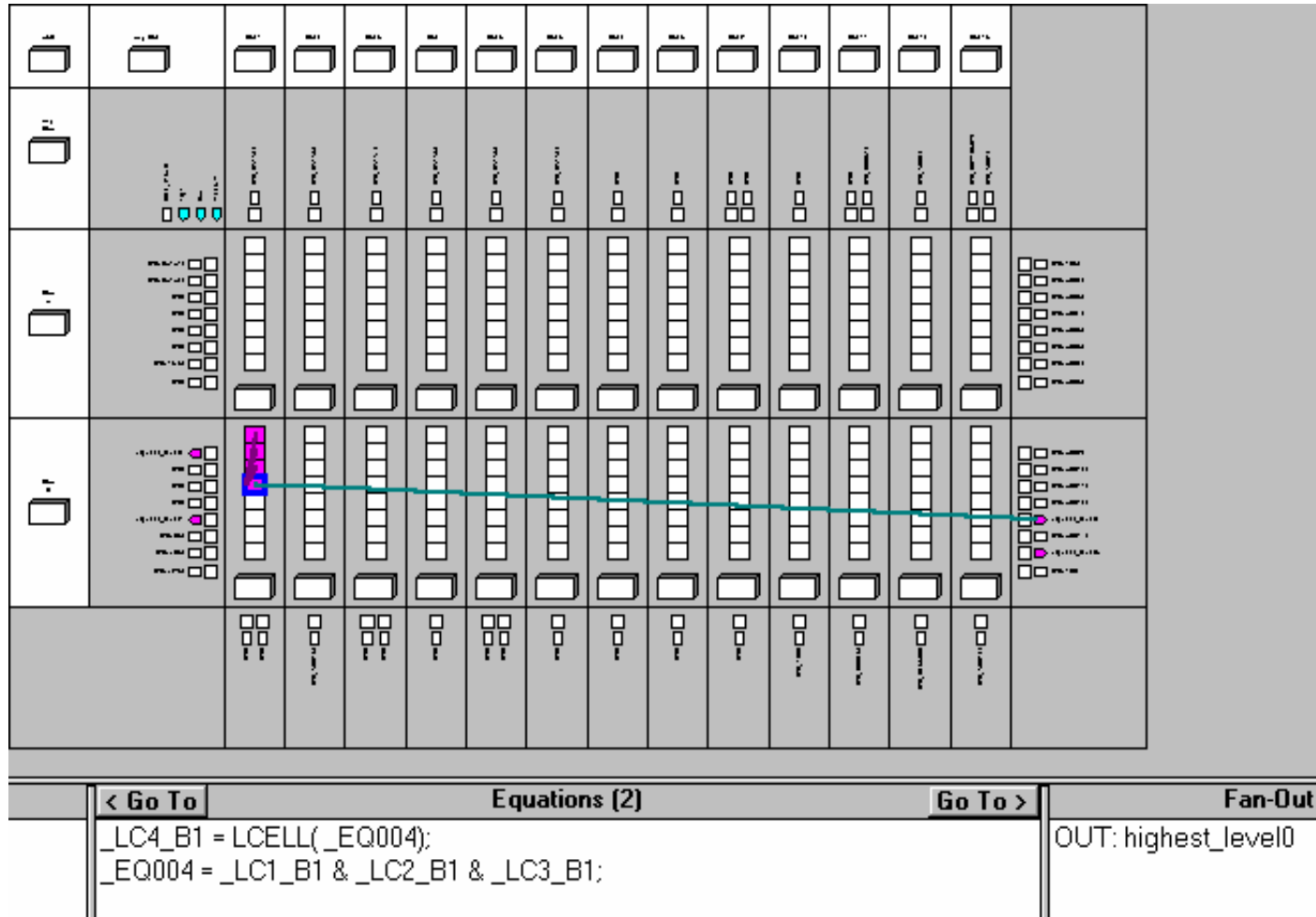
```
end case;
```

```
end;
```

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What is the usage of this statement

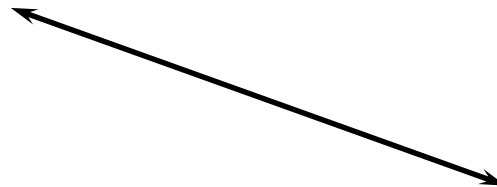


For Loop

```
CONSTANT num_of_bit = 8;
SUBDESIGN numbit
( a[num_of_bit..0] : input;
  b[num_of_bit..0] : output;
)
begin
b[8] = a[0];
b[7] = a[1];
b[6] = a[2];
b[5] = a[3];
b[4] = a[4];
b[3] = a[5];
b[2] = a[6];
b[1] = a[7];
b[0] = a[8];
end;
```



easier with same function

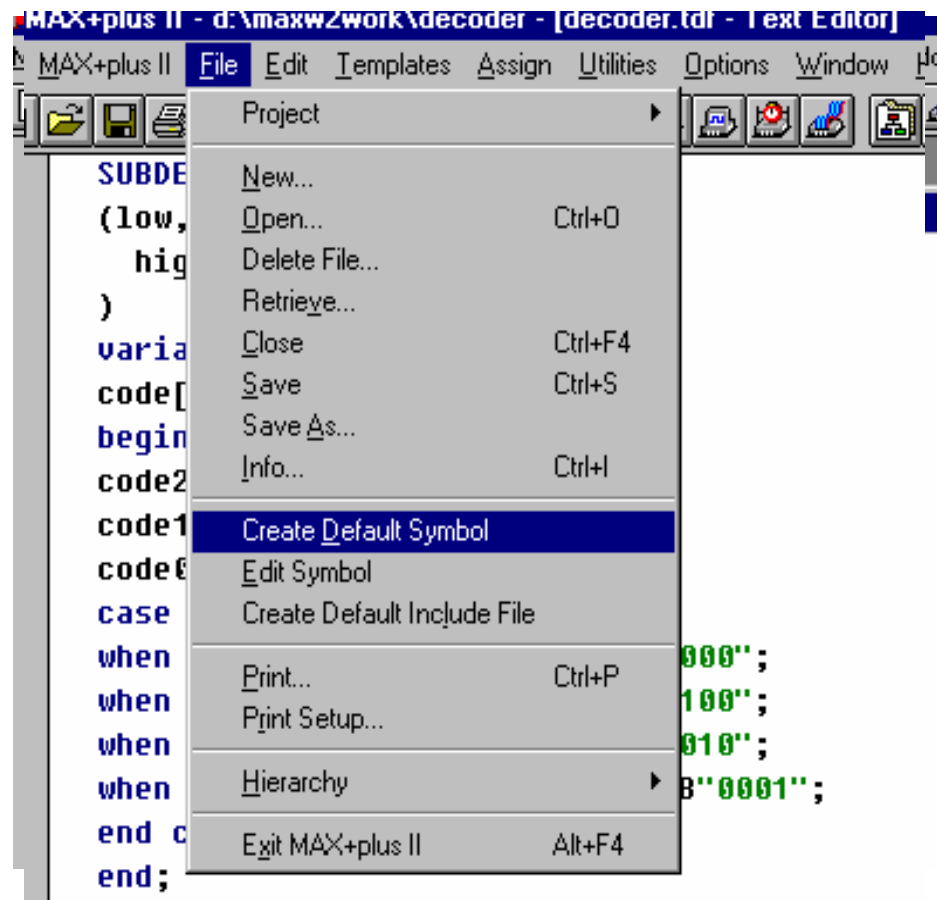
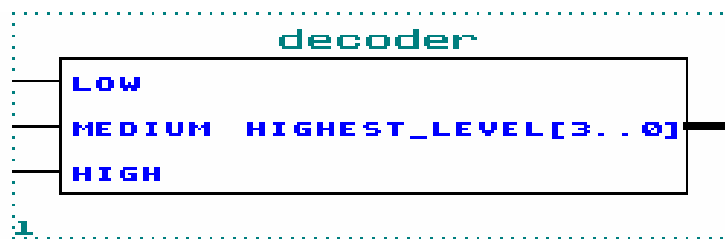


```
CONSTANT num_of_bit = 8;
SUBDESIGN numbit
( a[num_of_bit..0] : input;
  b[num_of_bit..0] : output;
)
begin
for i in 0 to num_of_bit generate
b[num_of_bit - i] = a[i];
end generate;
end;

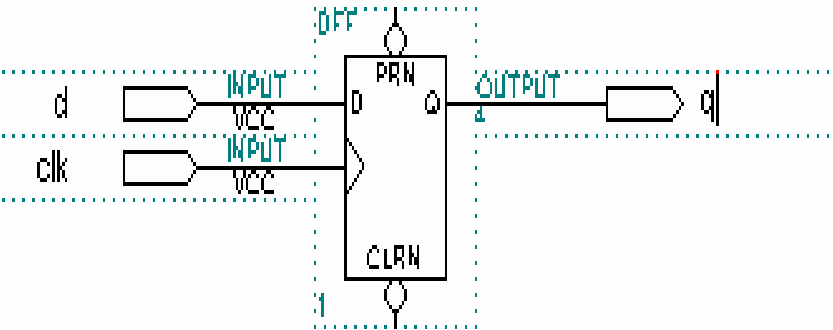
CONSTANT num_of_bit = 8;
SUBDESIGN numbit
(a[num_of_bit..0] : input;
 b[num_of_bit..0] : otuput;
)
begin
b[num_of_bit..0] = a[0..num_of_bit];
end;
```

AHDL with Graphic

- Use the File menu to create Symbol for the AHDL design
- The symbol can be used for graphic entry



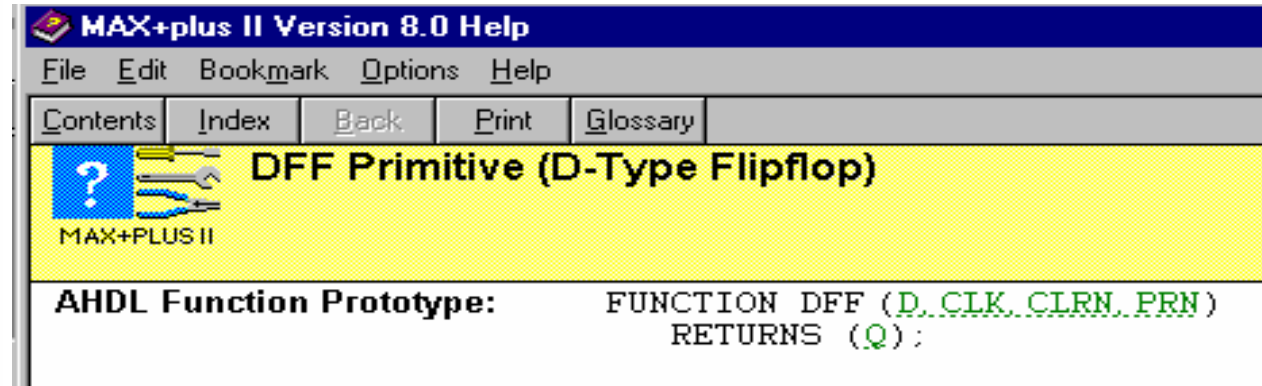
Register Logic



Method 1

```

SUBDESIGN flip_flop
(d, clk : input;
 q : output;)
begin
q = dff(d,clk, ,);
end;
    
```



Method 2

```

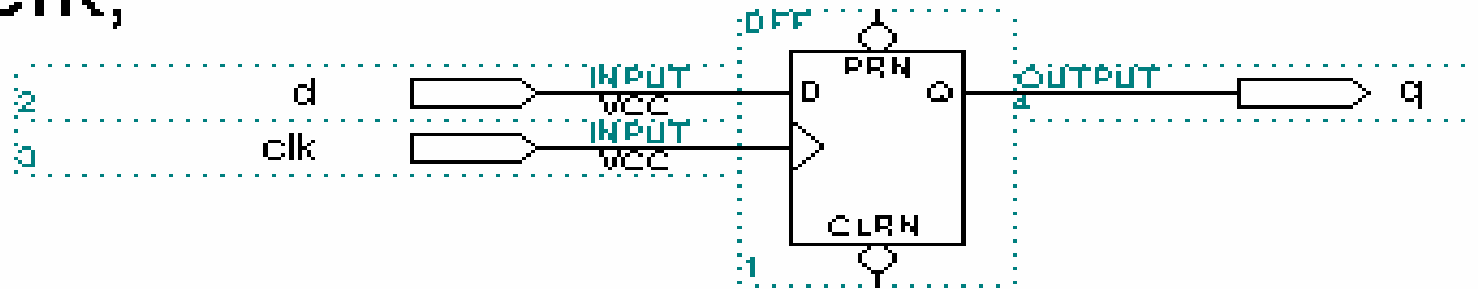
SUBDESIGN flip_flop
(d, clk : input;
 q : output;)
variable
temp : dff;
begin
temp.d = d;
temp.clk = clk;
q = temp.q;
end;
    
```

I want a **D-Flipflop**



More Detail

```
temp : dff  
temp.d = d;  
temp.clk = clk;  
q = temp.q
```



More on Register

- How to do the Bus with Register
- How to do the other type of Register
 - DFFE (D-FF with enable)
 - TFF/TFFE
 - JKFF/JKFFE
 - SRFF/SRFFE

Register Buses

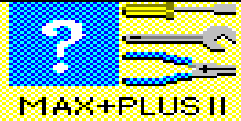
```
SUBDESIGN bus_reg
( clk, d[7..0] : input;
  q[7..0] : output;
)
variable
  ff[7..0] : dff;
begin
  ff[].clk = clk;
  ff[].d = d[];
  q[] = ff[].q;
end;
```

```
q[0] = ff[0].q;
q[1] = ff[1].q;
q[2] = ff[2].q;
q[3] = ff[3].q;
q[4] = ff[4].q;
q[5] = ff[5].q;
q[6] = ff[6].q;
q[7] = ff[7].q;
```

```
ff[0].d = d[0];
ff[1].d = d[1];
ff[2].d = d[2];
ff[3].d = d[3];
ff[4].d = d[4];
ff[5].d = d[5];
ff[6].d = d[6];
ff[7].d = d[7];
```

```
ff[0].clk = clk;
ff[1].clk = clk;
ff[2].clk = clk;
ff[3].clk = clk;
ff[4].clk = clk;
ff[5].clk = clk;
ff[6].clk = clk;
ff[7].clk = clk;
```


D-Flip-Flop with Enable/Preset/Clear

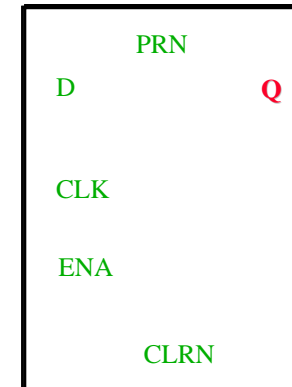


DFFE Primitive (D-Type Flipflop with Clock Enable)

AHDL Function Prototype:

FUNCTION DFFE (D, CLK, CLRN, PRN, ENA)
RETURNS (Q);

```
SUBDESIGN flip_flop_enable  
( clock, data, enable, preset, clear : input;  
  qout : output;  
)  
variable  
  temp : dffe;  
begin  
  temp.d = data;  
  temp.clk = clock;  
  temp.clrn = clear;  
  temp.prn = preset;  
  temp.ena = enable;  
  qout = temp.q;  
end;
```



Other Type of Flip-Flop

 MAX+PLUS II	JKFFE Primitive (JK-Type Flipflop with Clock Enable)
AHDL Function Prototype: <code>FUNCTION JKFFE (J,K,CLK,CLR,N,PRN,ENA) RETURNS (Q);</code>	
Contents Index Back Print Glossary	
 MAX+PLUS II	TFFE Primitive (T-Type Flipflop with Clock Enable)
AHDL Function Prototype: <code>FUNCTION TFFE (T,CLK,CLR,N,PRN,ENA) RETURNS (Q);</code>	
Contents Index Back Print Glossary	
 MAX+PLUS II	SRFFE Primitive (SR-Type Flipflop with Clock Enable)
AHDL Function Prototype: <code>FUNCTION SRFFE (S,R,CLK,CLR,N,PRN,ENA) RETURNS (Q);</code>	

How to use Help Menu

Q : I don't know how to use Altera DFF/JKFFE....., what can I do ?

A : Altera Help Menu is a good place to find information

Q : How do I use the Help Menu ?

A : It is easy..... and Fun



How to use Help Menu

Help Topics: MAX+plus II Version 8.0 Help

? X

MAX+plus II Version 8.0 Help

File Edit Bookmark Options Help

Contents Index Back Print Glossary

MAX+PLUS II

DFF Primitive (D-Type Flipflop)

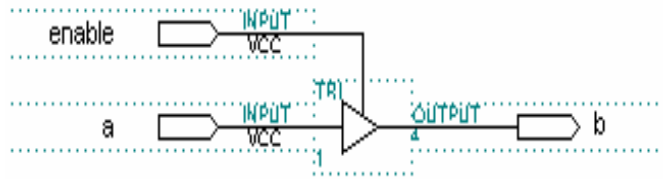
AHDL Function Prototype: FUNCTION DFF (D, CLK, CLRN, PRN)
RETURNS (Q):

VHDL Component Declaration: COMPONENT DFF
PORT (d : IN STD_LOGIC;
clk : IN STD_LOGIC;
clrn: IN STD_LOGIC;
prn : IN STD_LOGIC;
q : OUT STD_LOGIC_VECTOR);
END COMPONENT;

PRN	CLRN	Inputs CLK	D	Output Q
L	H	X	X	H
H	L	X	X	L
L	L	X	X	Illegal
H	H	↓	L	L
H	H	↓	H	H
H	H	L	X	Qo*
H	H	H	X	Qo

* Qo = level of Q before Clock pulse

Tri-state Buffer



The screenshot shows the MAX+PLUS II software interface. On the left, there is a question mark icon and a small diagram of the TRI primitive. The text 'MAX+PLUS II' is visible below the icon. On the right, the text 'TRI Primitive' is displayed. Below this, the AHDL Function Prototype is shown: 'FUNCTION TRI (in, oe) RETURNS (out);'.

Method 1

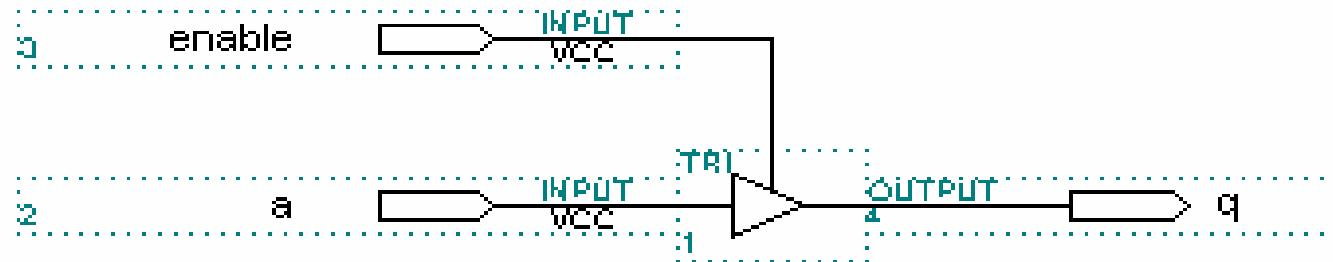
```
SUBDESIGN tri_state
(a, enable : input;
 b : output;)
begin
b = tri(a, enable);
end;
```

Method 2

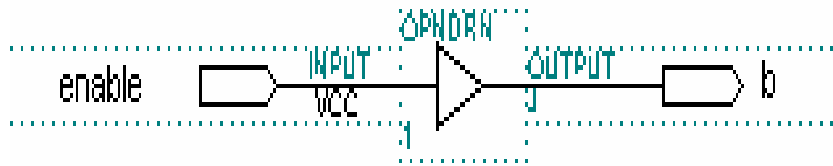
```
SUBDESIGN tri_state
(a, enable : input;
 b : output;)
variable
temp : tri;
begin
temp.in = a;
temp.oe = enable;
b = temp.out;
end;
```

More Detail

```
temp : tri
temp.in = a
temp.oe = enable
q = temp.out
```



OPNDRN - Open Drain Buffer



 **OPNDRN Primitive**
MAX+PLUS II

AHDL Function Prototype:

```
FUNCTION OPNDRN (in)  
  RETURNS (out);
```

Method 1

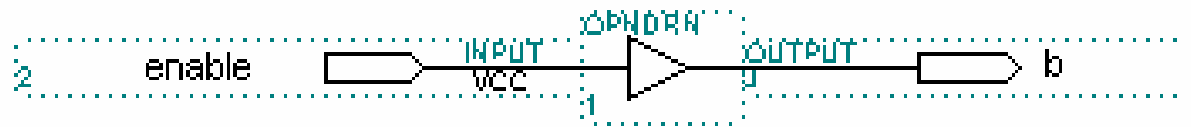
```
SUBDESIGN opn_drn  
(enable : input;  
 b : output;)  
begin  
  b = opndrn(enable);  
end;
```

Method 2

```
SUBDESIGN tri_state  
( enable : input;  
  b : output;)  
variable  
  temp : opndrn;  
begin  
  temp.in= enable;  
  b = temp.out;  
end;
```

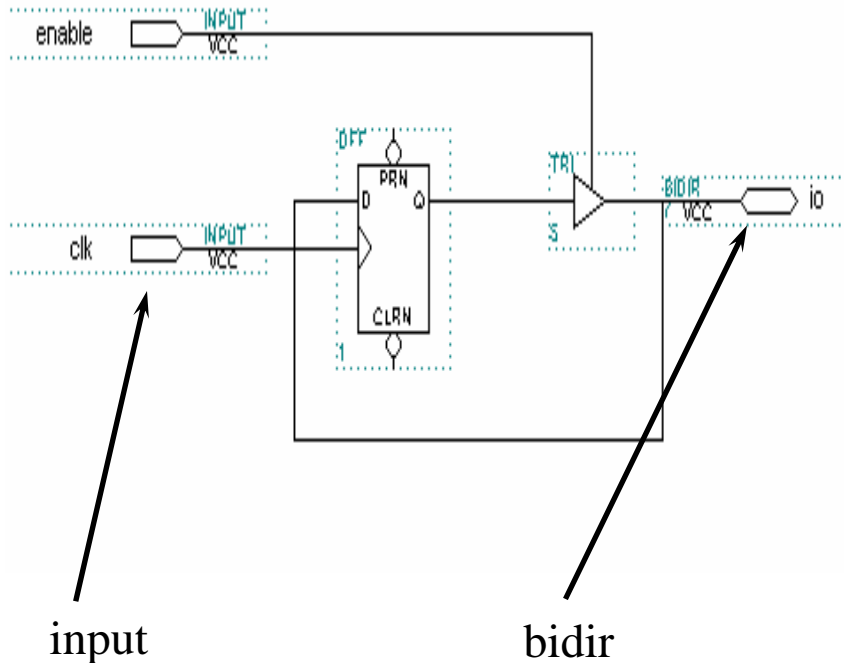
More Detail

temp : opndrn
temp.in = enable
b = temp.out



Using **AHDL** as **EASY** as Schematic
but
Using **AHDL** is more **POWERFUL**

Exercise



clk, enable : input;
io : **bidir**;

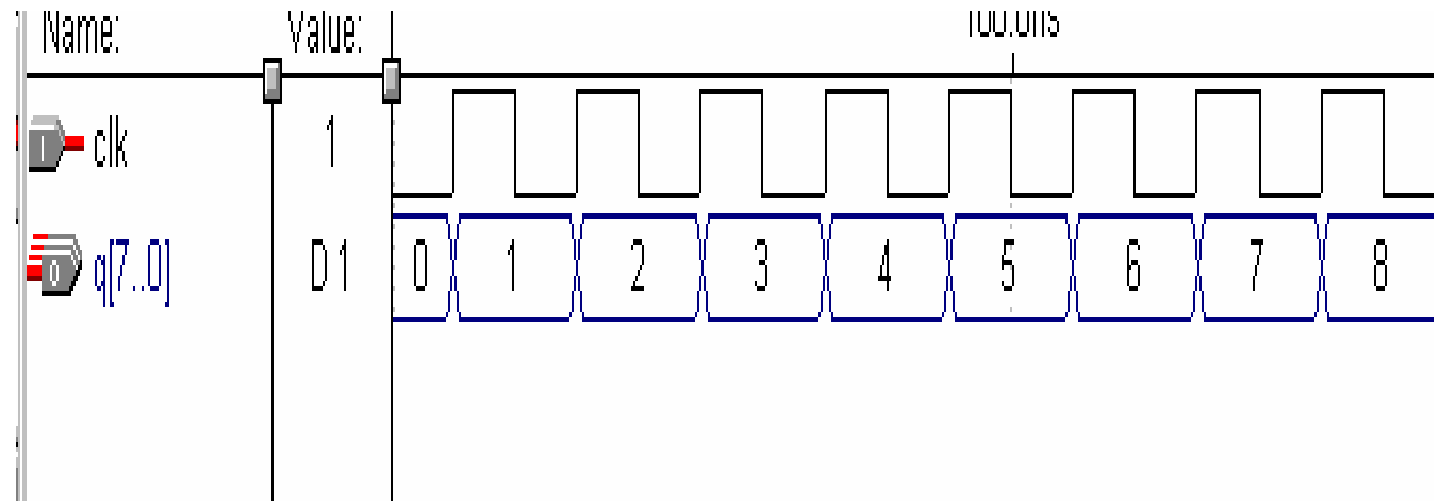
AHDL

```
SUBDESIGN tri_io  
( clk, enable : input;  
  io : bidir;)   
variable  
temp1 : dff;  
temp2 : tri;  
begin  
temp1.d = io;  
temp1.clk = clk;  
temp2.in = temp1.q;  
temp2.oe = enable;  
io = temp2.out;  
end;
```

Design 8 bits Counter is Easy

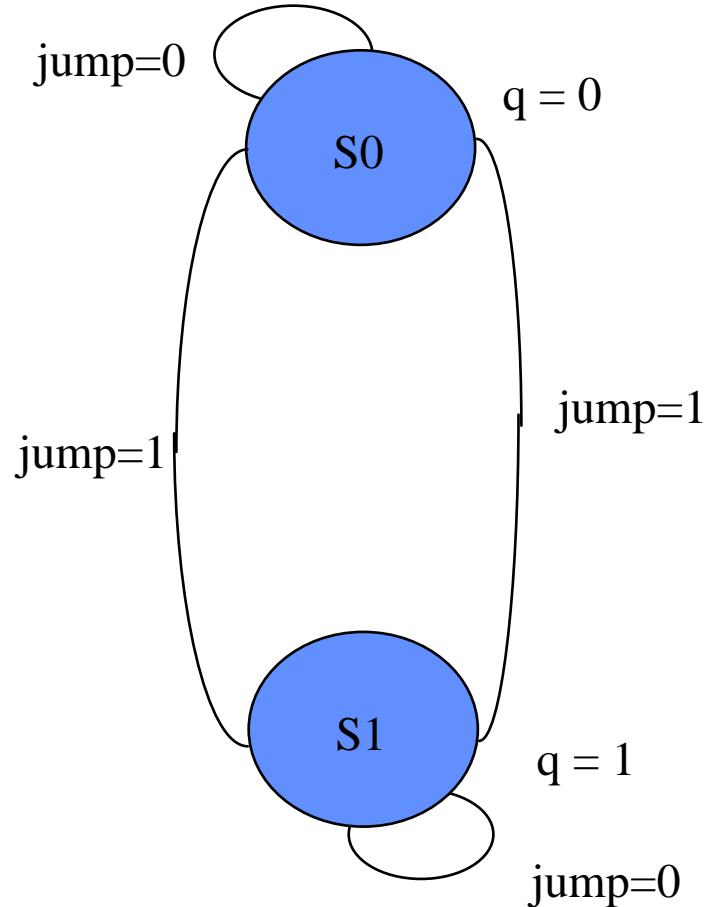
SUBDESIGN 8bits

```
(clk : input;  
  q[7..0] : output;  
)  
variable  
  temp[7..0] : dff;  
begin  
  temp[].clk = clk;  
  temp[].d = temp[].q + 1 ;  
  q[] = temp[].q;  
end;
```



State Machine

State Machine Diagram



SUBDESIGN simple

(clk, reset, jump : input;

q : output;

)

variable

ss : MACHINE WITH STATES (S0,S1);

begin

ss.clk = clk;

ss.reset = reset;

case ss is

when s0 =>

q = gnd;

if (jump) then

ss = s1;

end if;

when s1 =>

q = vcc;

if (jump) then

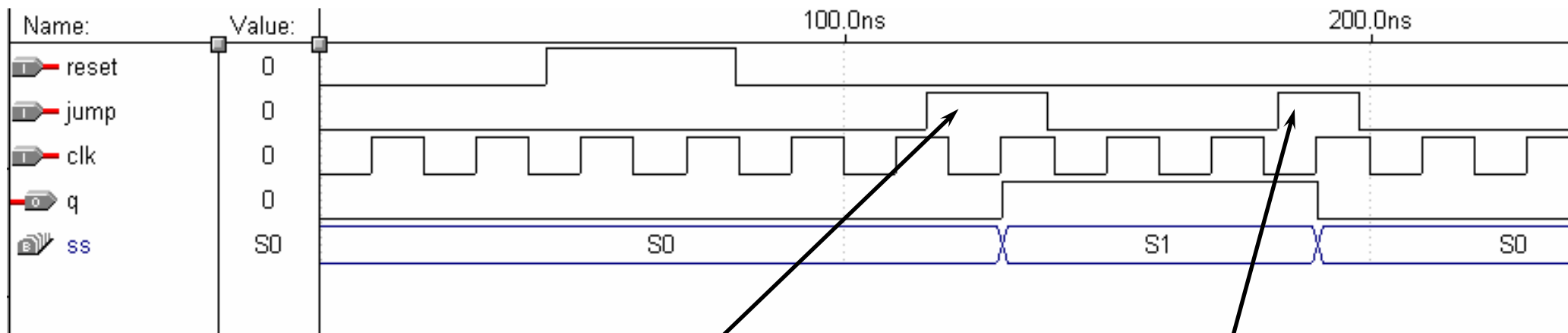
ss = s0;

end if;

end case;

end;

Note : All State Machine Variable must be associated with a CLOCK



```

if (jump) then
  ss = s1;
end if;

```

```

if (jump) then
  ss = s0;
end if;

```

More about State Machine

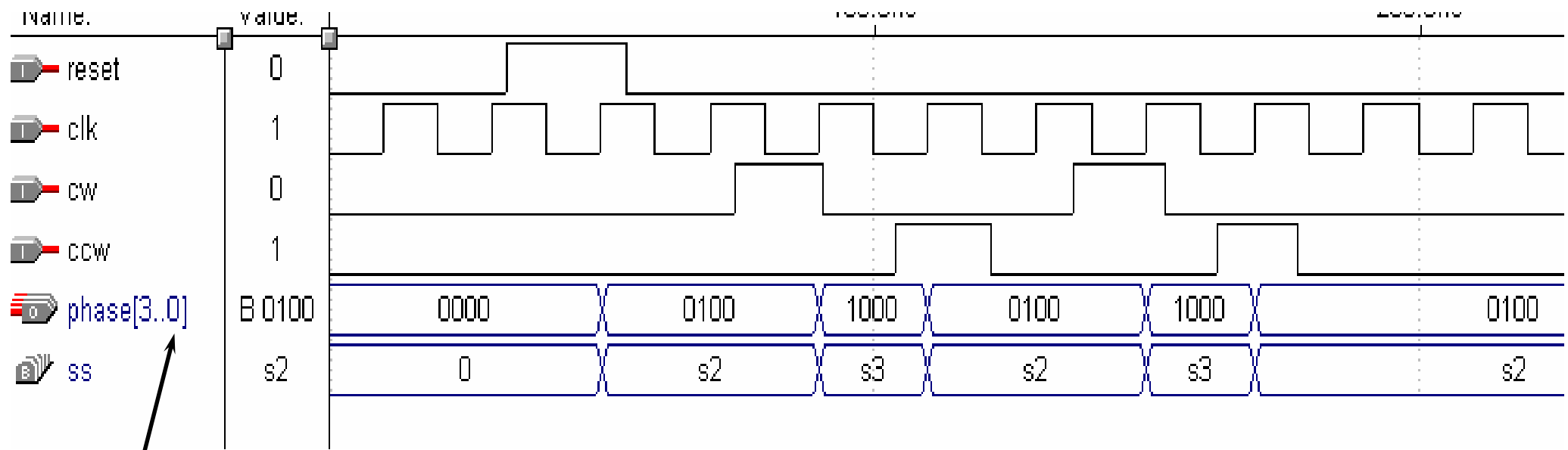
```
SUBDESIGN stepper
( reset, ccw, cw, clk : input;
  phase[3..0] : output;)
variable
  ss : MACHINE OF BITS (temp[3..0])
      WITH STATES ( s0 = B"0001",
                   s1 = B"0010",
                   s2 = B"0100",
                   s3 = B"1000");
begin
  ss.clk = clk;
  if (reset) then
    ss = s2;
  end if;
  phase[] = temp[];
```

TABLE

ss,	ccw,	cw =>	ss;
s0,	1,	x =>	s3;
s0,	x,	1 =>	s1;
s1,	1,	x =>	s0;
s1,	x,	1 =>	s2;
s2,	1,	x =>	s1;
s2,	x,	1 =>	s3;
s3,	1,	x =>	s2;
s3,	x,	1 =>	s0;

END TABLE;
end;

Note : No need to declare what is TEMP
It is automatic declare as DFF



User can control the State Bit

Exercise

```
SUBDESIGN stepper
( reset, ccw, cw, clk : input;
  phase[3..0] : output;)
variable
  ss : MACHINE OF BITS (temp[3..0])
      WITH STATES ( s0 = B"0001",
                   s1 = B"0010",
                   s2 = B"0100",
                   s3 = B"1000");

begin
  ss.clk = clk;
  if (reset) then
    ss = s2;
  end if;
  phase[] = temp[];
```

TABLE

ss,	ccw,	cw =>	ss;
s0,	1,	x =>	s3;
s0,	x,	1 =>	s1;
s1,	1,	x =>	s0;
s1,	x,	1 =>	s2;
s2,	1,	x =>	s1;
s2,	x,	1 =>	s3;
s3,	1,	x =>	s2;
s3,	x,	1 =>	s0;

END TABLE;
end;

Can you Modify this Truth Table to CASE statement

State Machine without Recover State

SUBDESIGN recover

```
( clk, go : input;  
  ok : output;)
```

variable

```
sequence : MACHINE OF BITS (q[2..0])
```

```
with STATES ( idle, one, two, three, four, illegal1, illegal2, illegal3);
```

begin

```
sequence.clk = clk;
```

```
case sequence is
```

```
when idle => if (go) then
```

```
    sequence = one;
```

```
    end if;
```

```
when one => sequence = two;
```

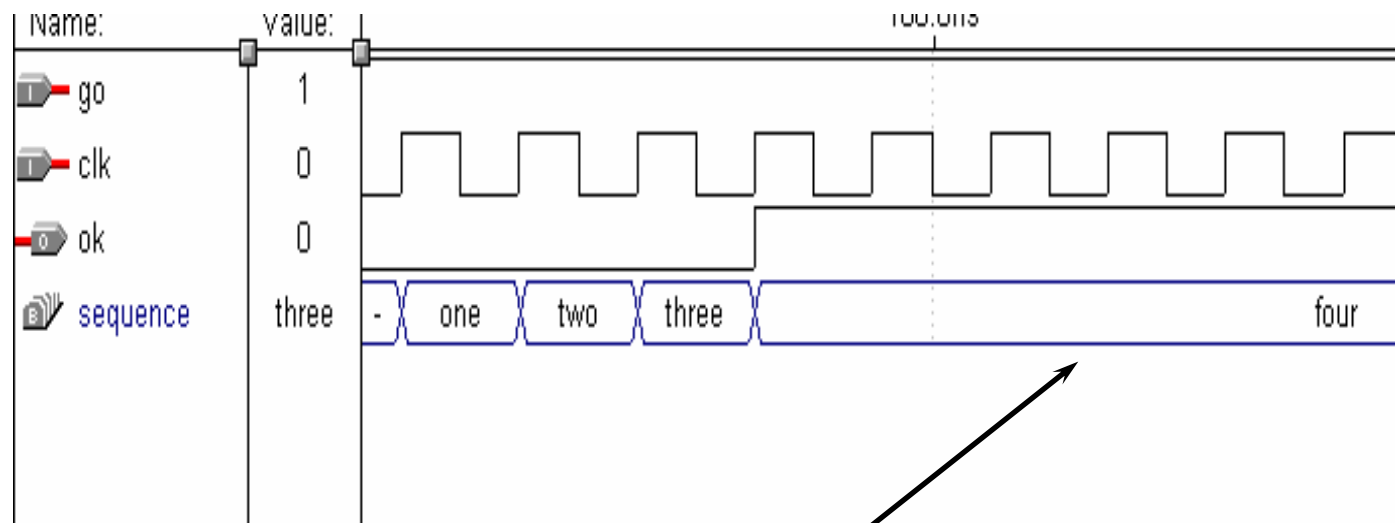
```
when two => sequence = three;
```

```
when three => sequence = four;
```

```
end case;
```

```
ok = (sequence == four);
```

```
end;
```



State Machine stuck at FOUR

Better have Recover within State Machine

SUBDESIGN recover

```
( clk, go : input;
  ok : output;)
```

variable

```
sequence : MACHINE OF BITS (q[2..0])
  with STATES ( idle, one, two, three, four, illegal1, illegal2, illegal3);
```

begin

```
sequence.clk = clk;
```

case sequence is

```
when idle => if (go) then
  sequence = one;
end if;
when one => sequence = two;
when two => sequence = three;
when three => sequence = four;
when OTHERS => sequence = idle;
```

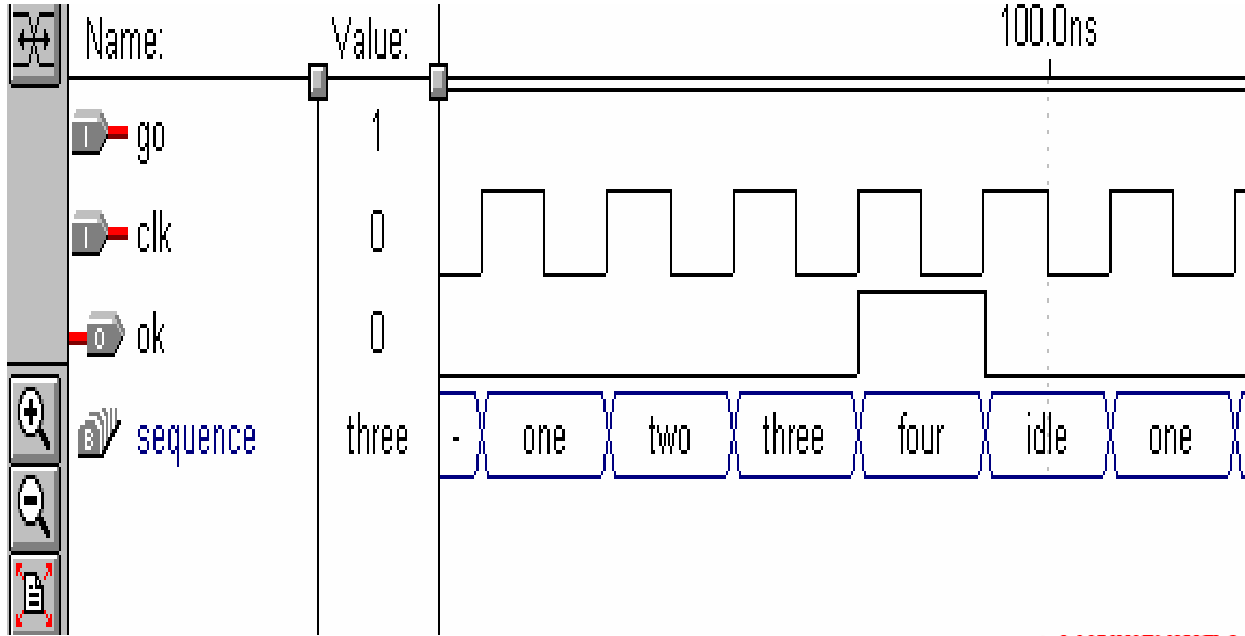
end case;

```
ok = (sequence == four);
```

end;

Three bits have Eight State

Only Five State is interesting, but better have this RECOVER options



Handwritten signature

Conclusion

- When the gate count and design getting for complex
 - AHDL
 - VHDL/Verilog
- When the design target for high speed and optimize
 - mixture of AHDL/Graphic/VHDL or Verilog
- Engineers is more talent than software

Right Tools
help you achieve the
Successful Product