

CSA vs. Conditional Signal Assignment

- ▶ Concurrent Signal Assignment Statements are suitable for describing gate-level circuits.
- ▶ Models for higher level abstraction are difficult to express with Concurrent Signal Assignment Statements.
- ▶ Higher level abstraction models are required for multiplexors, decoders ...
- ▶ VHDL provides Conditional Signal Assignment statements for these situations.

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4 to 1 - 8bit Multiplexor

```
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;

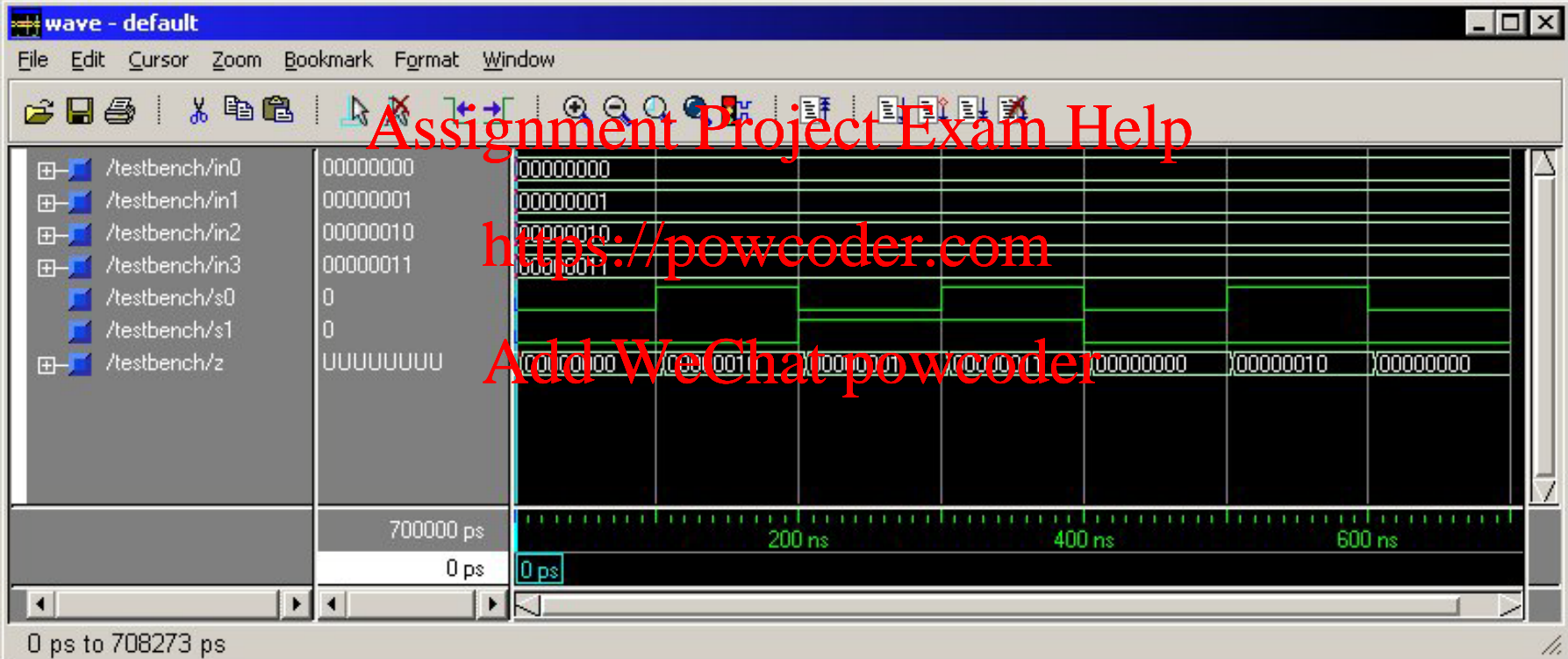
entity mux4 is
    Port (in0, in1, in2, in3: in std_logic_vector (7 downto 0);
          s0, s1: in std_logic;
          z: out std_logic_vector (7 downto 0));
end mux4;

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architecture behavioural of mux4 is
begin
    z <= in0 after 5ns when s0 = '0' and s1 = '0' else
        in1 after 5ns when s0 = '0' and s1 = '1' else
        in2 after 5ns when s0 = '1' and s1 = '0' else
        in3 after 5ns when s0 = '1' and s1 = '1' else
        "00000000" after 5ns;
end behavioural;
```

Conditional Signal Assignment

- ▶ In the 4to1 - 8bit multiplexor example:
- ▶ If S1 or S2 changes the concurrent assignment statement is executed.
- ▶ All four conditions may be checked.
- ▶ The order is relevant.
- ▶ The evaluation takes place in the order that they appear.
- ▶ The first true condition determines the output.
- ▶ The order should reflect the physical implementation.

Waveform (4 to 1 - 8bit Multiplexor)



4 to 2 - Priority Encoder

library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
use IEEE.STD_LOGIC_ARITH.ALL;
use IEEE.STD_LOGIC_MISC.ALL;

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entity four_to_two_priority is
Port (S0, S1, S2, S3 : in std_logic;
Z : out std_logic_vector(1 downto 0));
end four_to_two_priority;

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architecture Behavioral of four_to_two_priority is
begin

Z <= "00" after 5 ns when S0='1' else
"01" after 5 ns when S1='1' else
"10" after 5 ns when S2='1' else
"11" after 5 ns when S3='1' else
"00" after 5 ns;

end Behavioral;

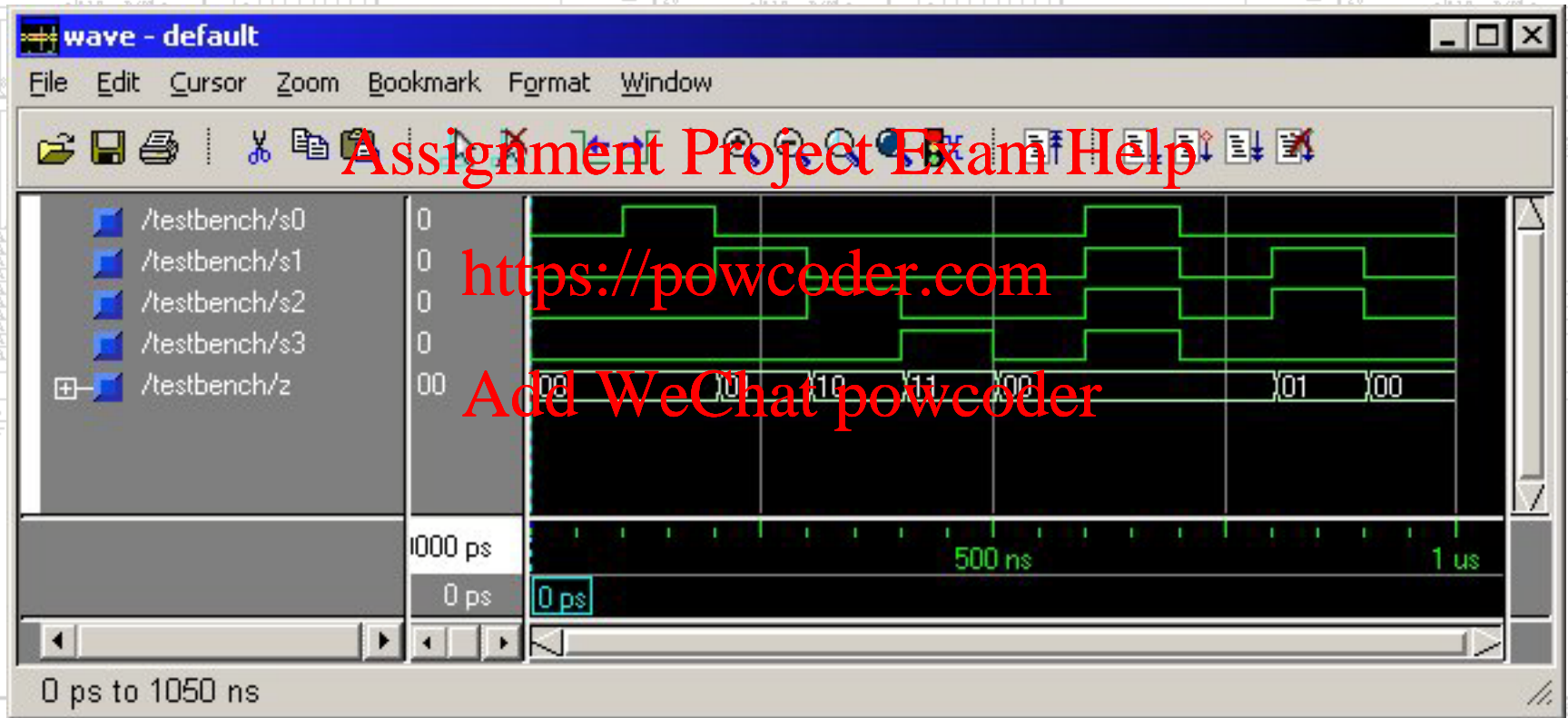
Conditional Signal Assignment

- ▶ The order in the conditional signal assignment statement in the 4 to 2- Priority Encoder example is important.

- ▶ Note in the <https://powcoder.com>

- ▶ The last statement set the output to zero.
- ▶ This is necessary because the select signals can have values other than '1' and '0'.
- ▶ This is the case because the select signals are declared as `std_logic` and `std_logic_vector`.

Waveform (4 to 2 -Priority Encoder)



Unaffected

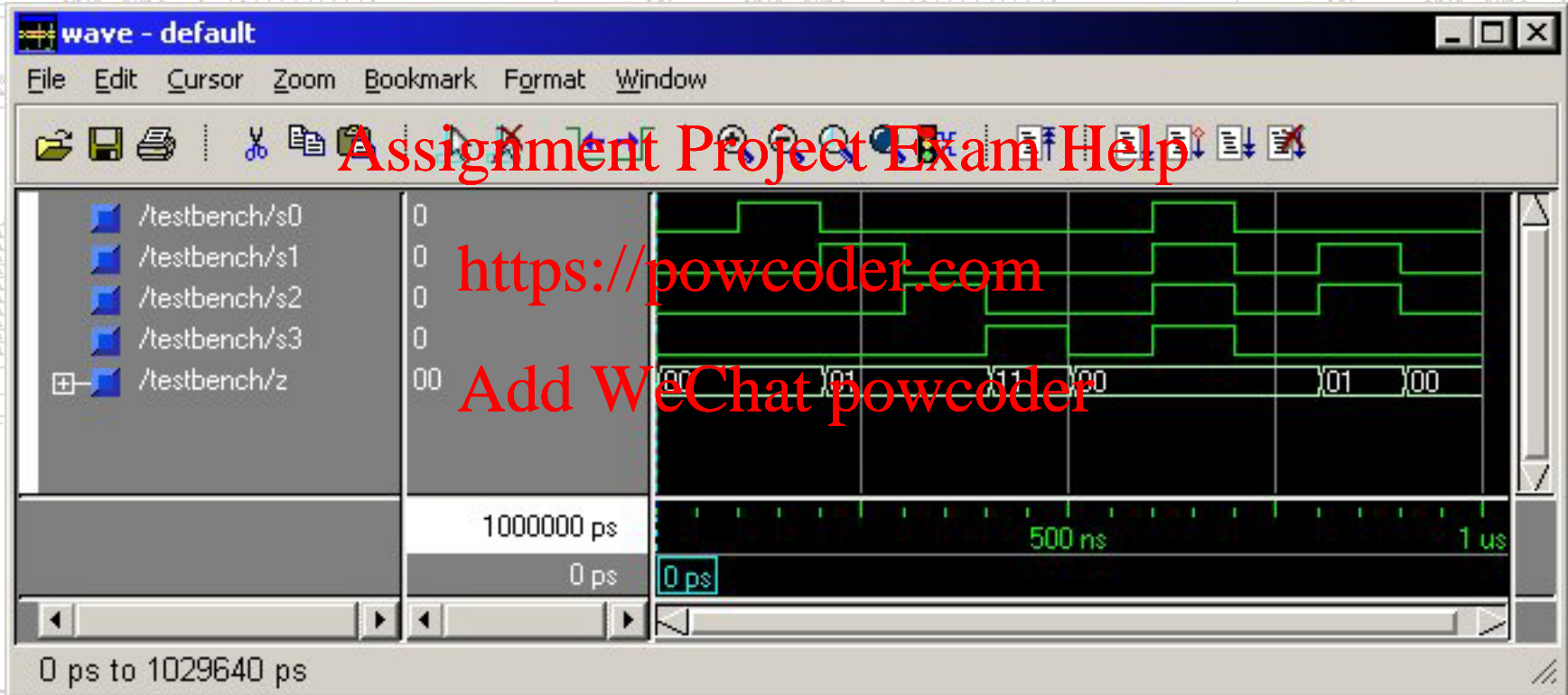
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
use IEEE.STD_LOGIC_ARITH.ALL;
use IEEE.STD_LOGIC_FUNCTIONS.ALL;

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entity four_to_two_priority is
Port (S0, S1, S2, S3 : in std_logic;
Z : out std_logic_vector(1 downto 0));
end four_to_two_priority;

architecture Behavioral of four_to_two_priority is
begin
Z <= "00" after 5 ns when S0='1' else
"01" after 5 ns when S1='1' else
unaffected when S2='1' else
"11" after 5 ns when S3='1' else
"00" after 5 ns;
end Behavioral;

Waveform (Unaffected)



Selected Signal Assignment Statement

- ▶ Signal value is determined by the select expression
- ▶ In this example we read from a register file with eight registers (reg0...reg7)

▶ Read only register file with 8 read ports

%000	\$12345678	reg0
%001	\$ABCDEF00	reg1
%010	\$12345678	reg2
%011	\$ABCDEF00	reg3
%100	\$12345678	reg4
%101	\$ABCDEF00	reg5
%110	\$12345678	reg6
%111	\$ABCDEF00	reg7

SSA Statement Example

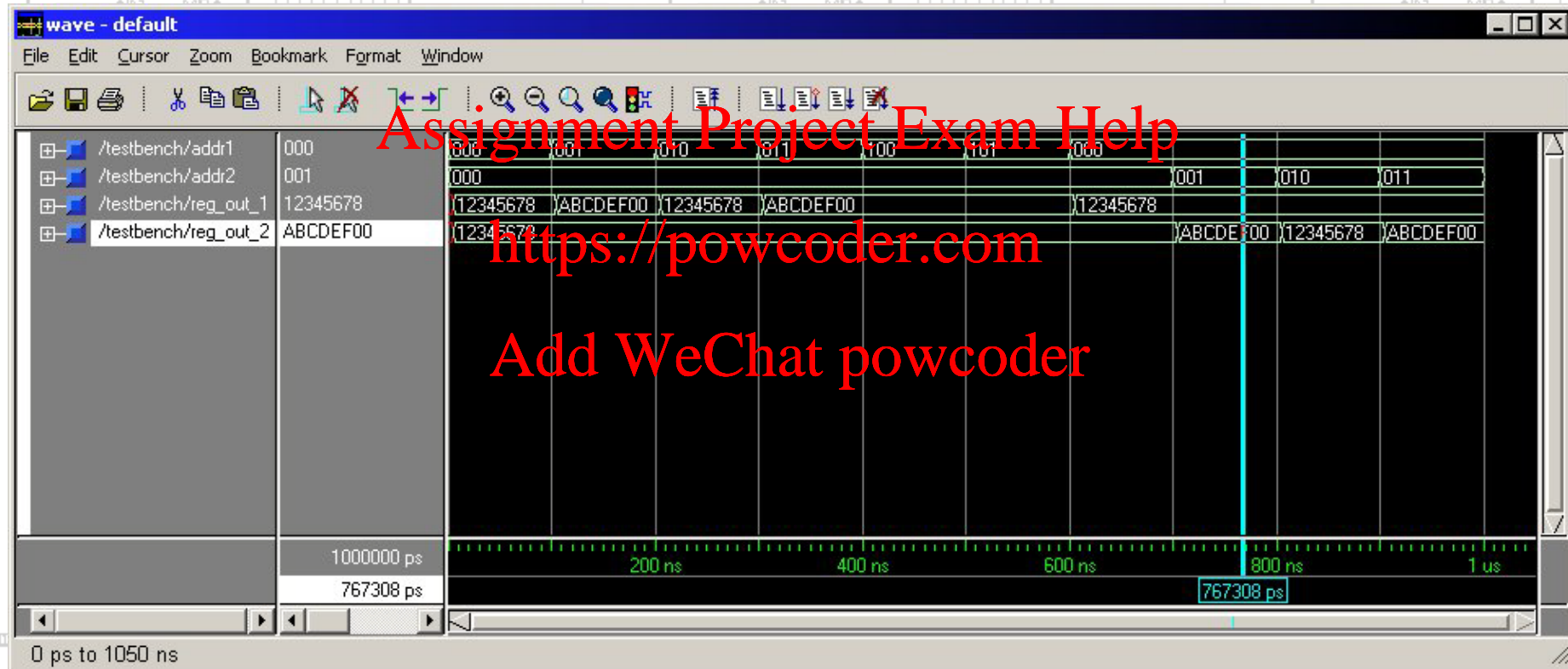
```
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
entity reg_file is
    Port ( addr1, addr2 : in std_logic_vector(2 downto 0);
          reg_out_1, reg_out_2 : out std_logic_vector(31 downto 0));
end reg_file;
architecture Behavioral of reg_file is
    signal reg0, reg2, reg4, reg6 : std_logic_vector(31 downto 0) := x"12345678";
    signal reg1, reg3, reg5, reg7 : std_logic_vector(31 downto 0) := x"abcdef00";
begin
    with addr1 select
        reg_out_1 <= reg0 after 5 ns when "000",
                    reg1 after 5 ns when "001",
                    reg2 after 5 ns when "010",
                    reg3 after 5 ns when "011",
                    reg3 after 5 ns when others;
    with addr2 (1 downto 0) select
        reg_out_2 <= reg0 after 5 ns when "00",
                    reg1 after 5 ns when "01",
                    reg2 after 5 ns when "10",
                    reg3 after 5 ns when "11",
                    reg3 after 5 ns when others;
end Behavioral;
```

Waveform (Select)

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Selected Signal Assignment

- ▶ Similar to case statement in conventional languages.
- ▶ Choices are not evaluated in sequence.
- ▶ Only one must be true.
- ▶ The statement must cover all possible combinations.
- ▶ The **others** clause must be used in situation where not all possible combinations are covered by the select statement.

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reg3 after 5 ns when others;

- ▶ In the second select statement operates on a subset of the address range (addr2 (1 downto 0)).

- ▶ The **when** clause is still required because addr2 is declared as **std_logic_vector** and can therefore take 9 values.

- ▶ **unaffected** is also used in this type of statement.

```
with addr2 (1 downto 0) select
reg_out_2 <= reg0 after 5 ns when "00",
reg1 after 5 ns when "01",
reg2 after 5 ns when "10",
reg3 after 5 ns when "11",
reg3 after 5 ns when others;
end Behavioral;
```