



Integrated Circuits Design by FPGA

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Lecture 1

Lecture 1 : Introduction to “Integrated Circuits Design by FPGA”

Objectives of this Lecture

- **To understand what is an “Integrated Circuit”.**
- **To introduce the FPGA technique .**
- **To study the fundamentals of VHDL.**

Contents of this Lecture

- **What is “Integrated Circuits” ?**
- **What and Whys FPGA ?**
- **What is VHDL?**
- **VHDL Code Structure**

What is “Integrated Circuits” ?

An **integrated circuit** is also referred to as an **IC**, a **chip**, or a **microchip**. The term **IC** is a set of electronic circuits on one small flat piece (or "chip") of semiconductor material that is normally silicon. The integration of large numbers of tiny MOS (metal–oxide–semiconductor) transistors into a small chip results in circuits that are smaller, faster, and less expensive than those constructed of discrete electronic components. Look at Fig. 1 which shows different discrete electronic components. While Fig. 2 shows how an integrated circuits (IC) looks like.

What is “Integrated Circuits” ?

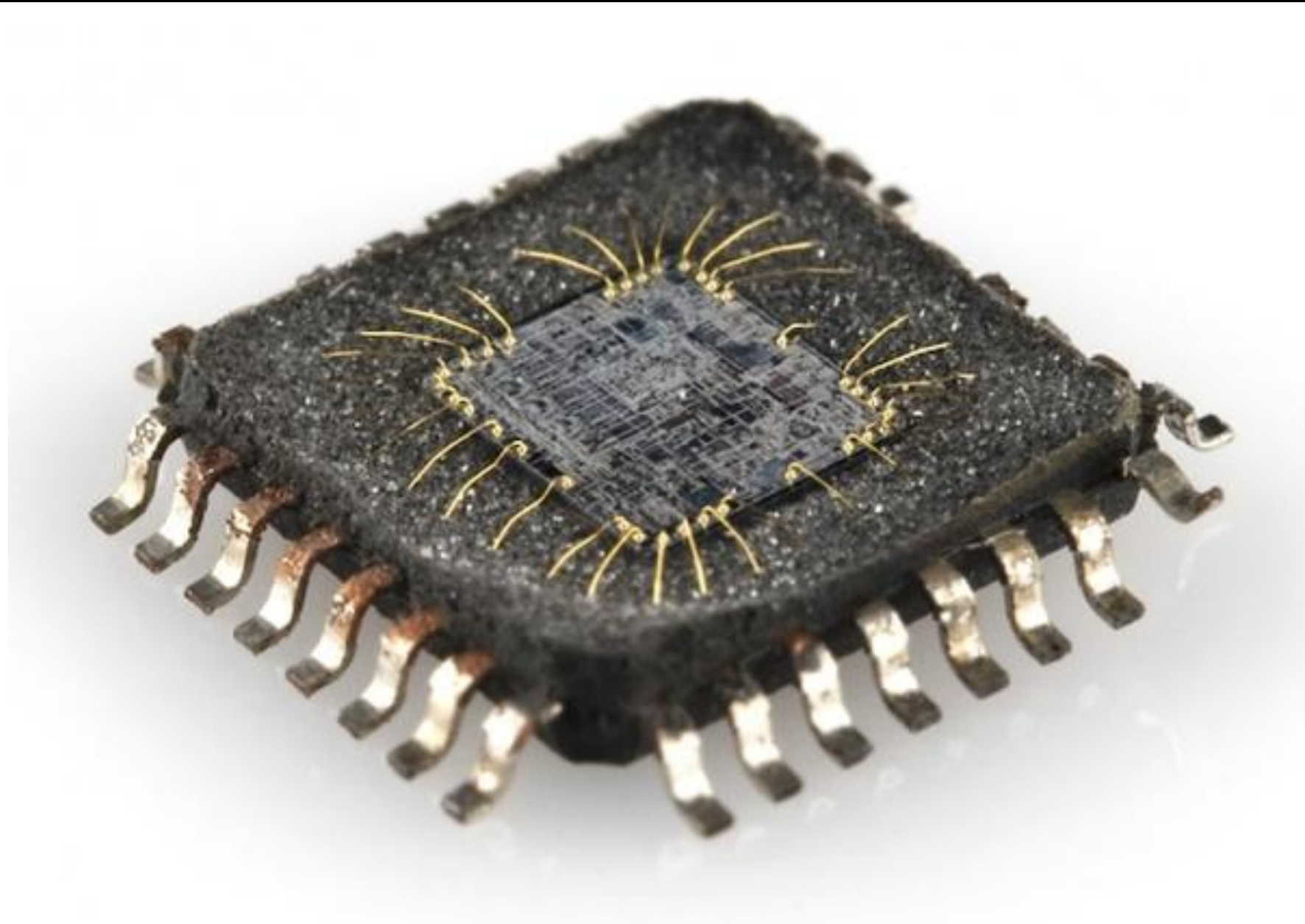
Fig.2. A: Integrated Circuits (ICs) on a PCB (Printed Circuit Board).



What is “Integrated Circuits” ?

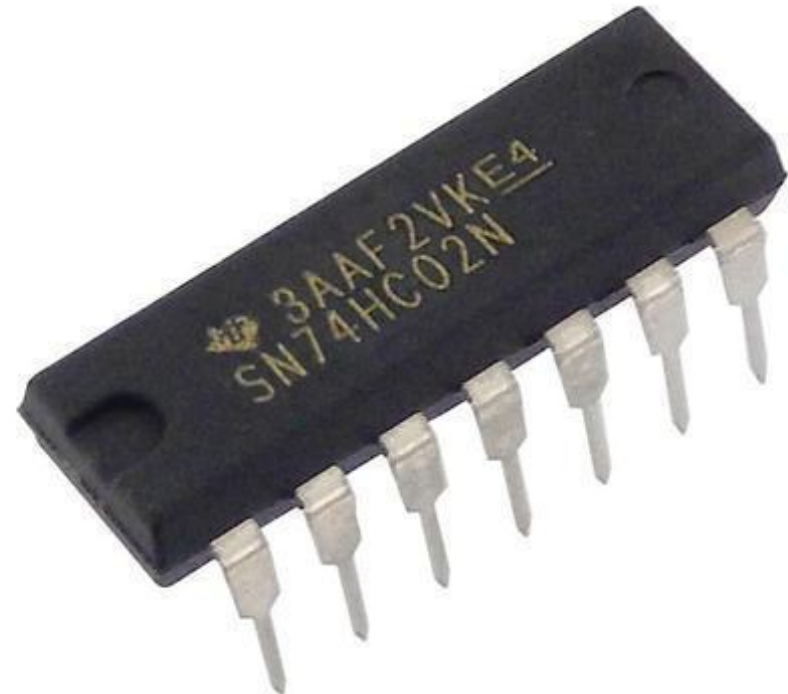
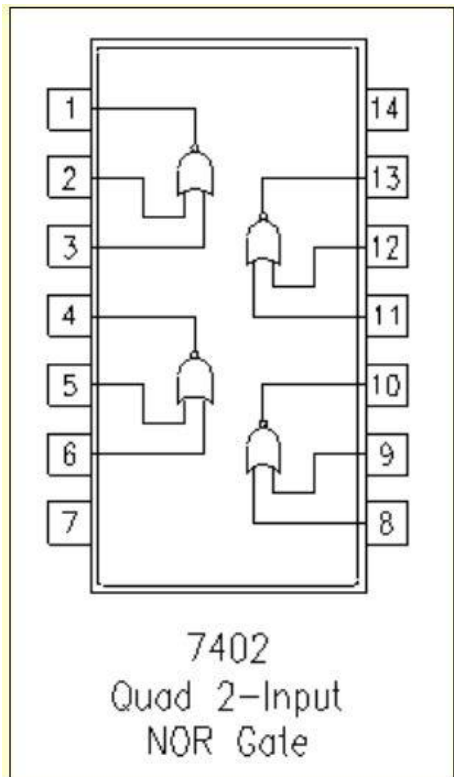
Fig.2. B: Integrated Circuit (IC) from inside view.
Basically consists of grid of MOS transistors.

MOS transistors are performing amplification or switching.



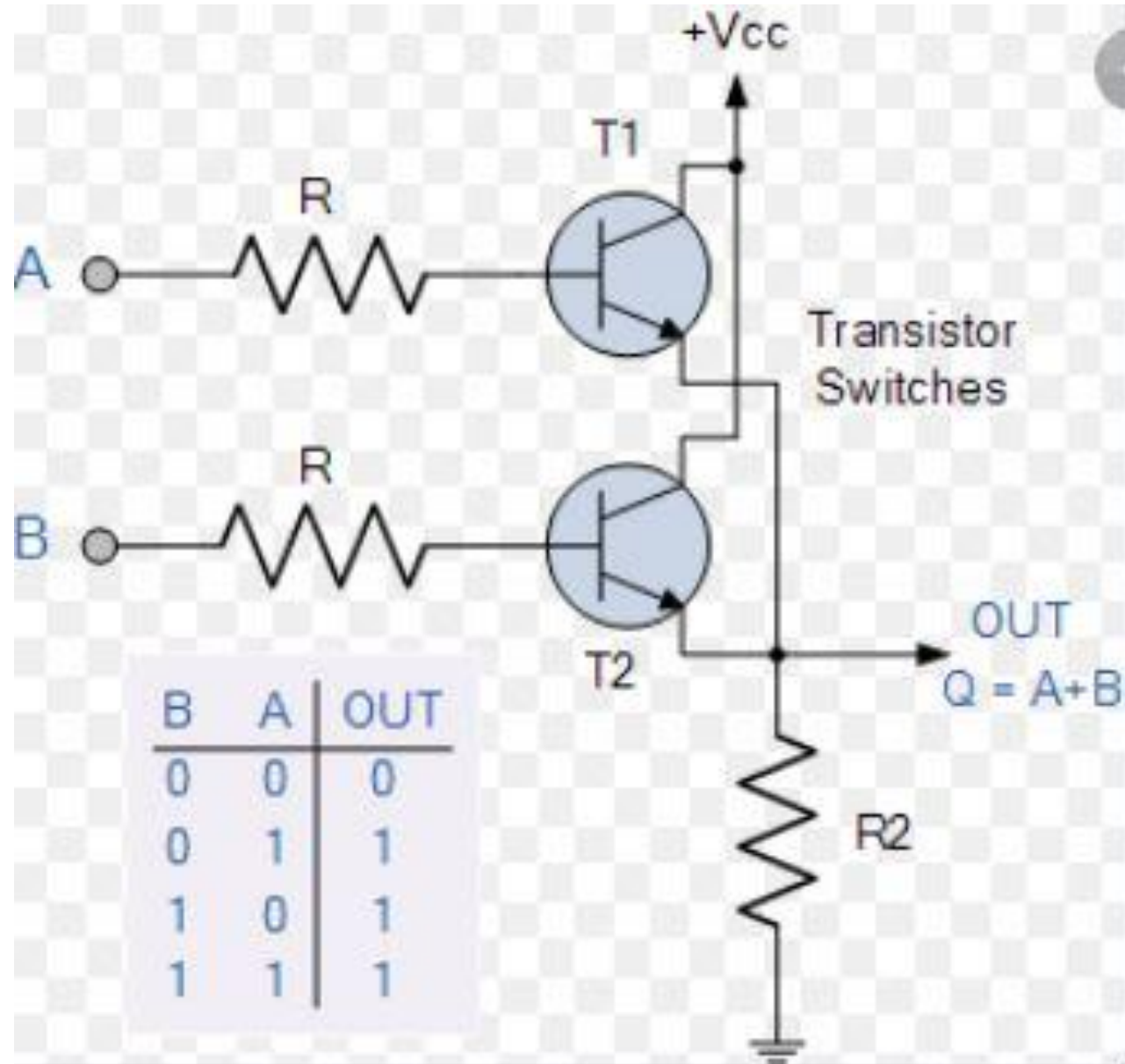
What is “Integrated Circuits” ?

One of the most famous IC example is the 7400 series. This series contains hundreds of ICs that provide everything from basic logic gates, flip-flops, and counters, to special purpose bus transceivers and arithmetic logic units (ALU).



What is “Integrated Circuits” ?

Fig. 3: OR gate architecture.



What is “Integrated Circuits” ?



What is “Integrated Circuits” ?



What and Whys FPGA ?

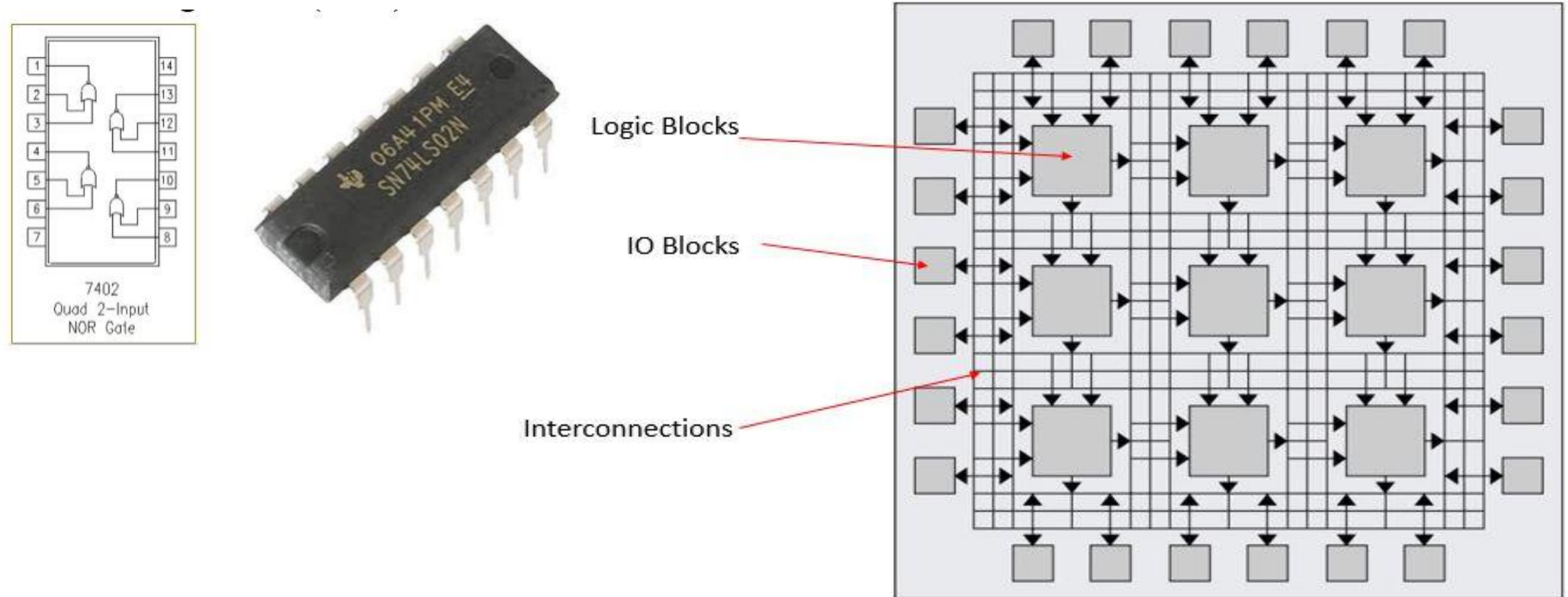


Fig.4: Simplified Internal Architecture of FPGA.

What and Whys FPGA ?

- **FPGA:** It is **F**ield **P**rogrammable **G**ate **A**rray technique. This technique provides a configurable system, in addition to the parallel processing capability. In contrast, to sequential processing provided by controllers and CPUs.
- **Why FPGA?** Offers flexibility and parallel processing capability.

What and Whys FPGA ?

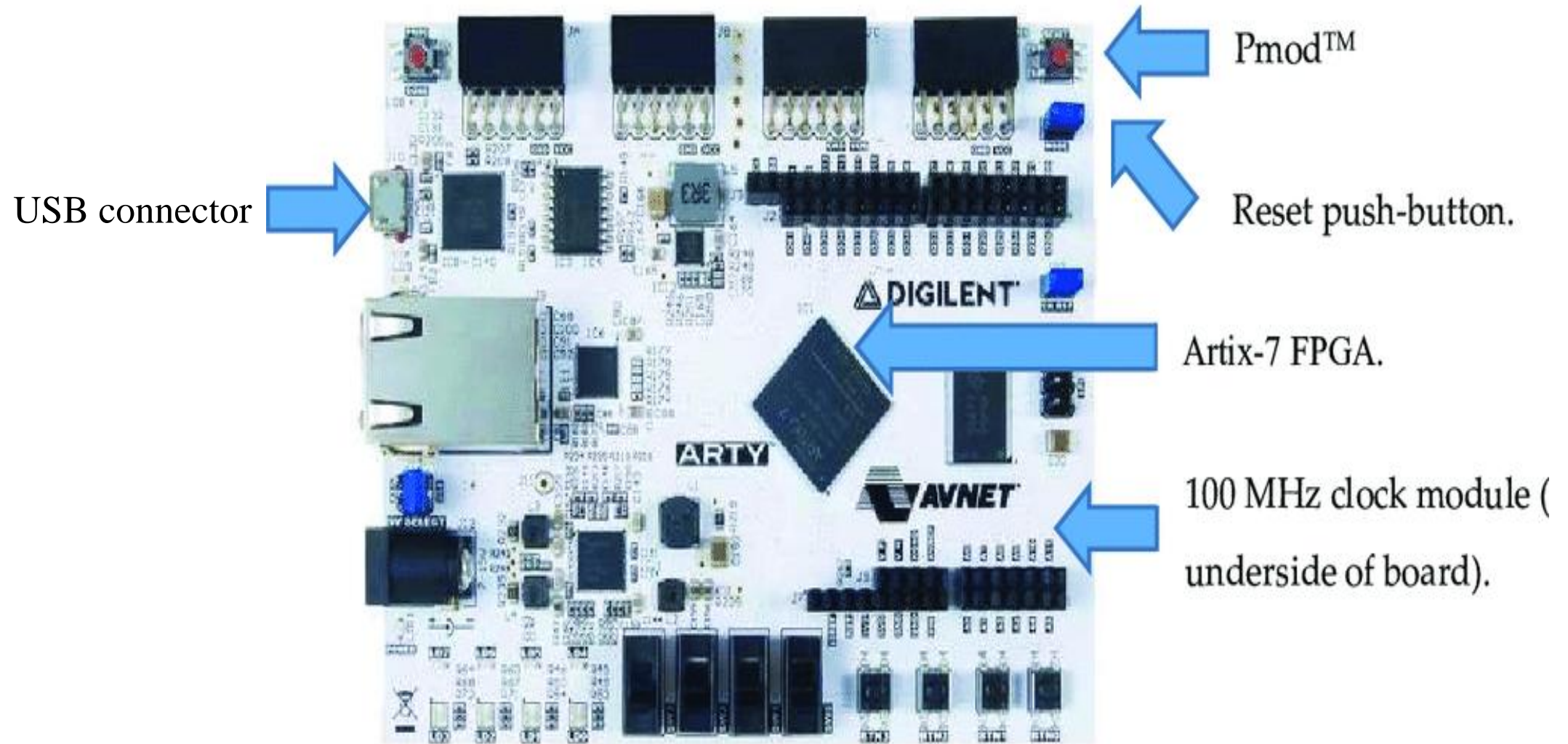
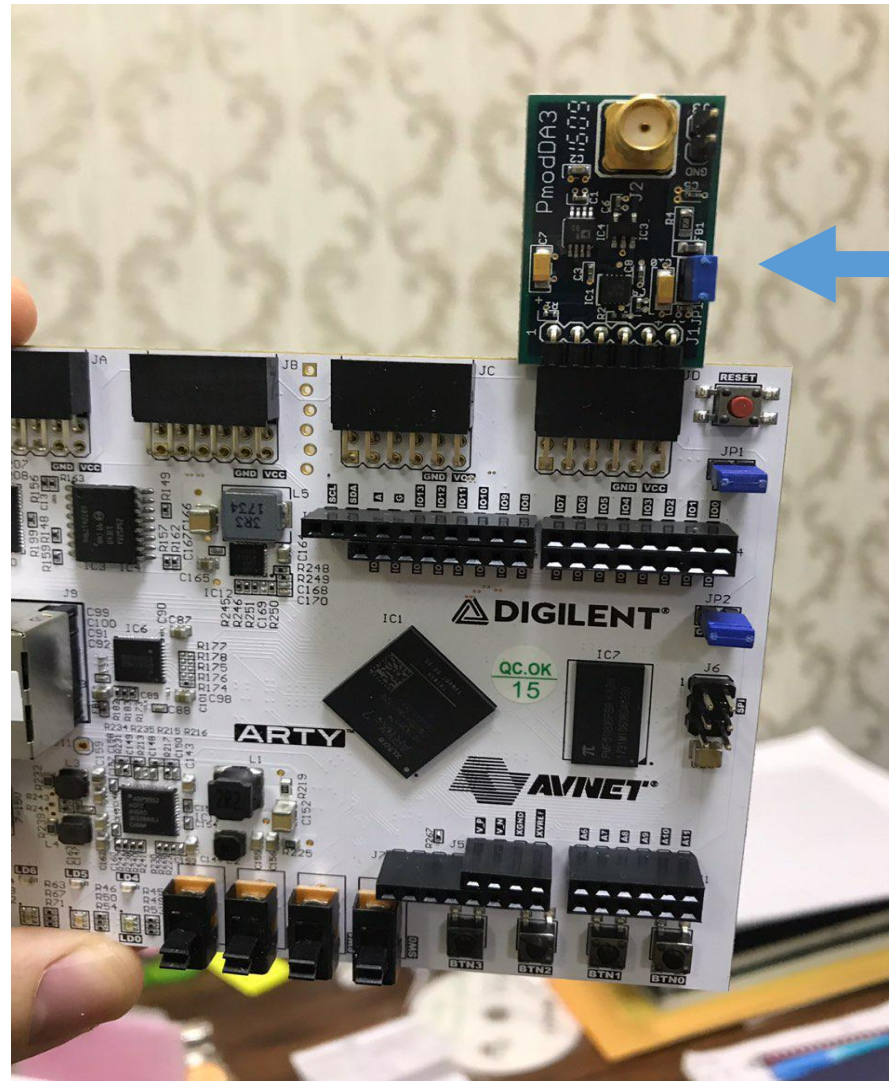


Fig.5: ARTY A7 35T FPGA board

What and Whys FPGA ?



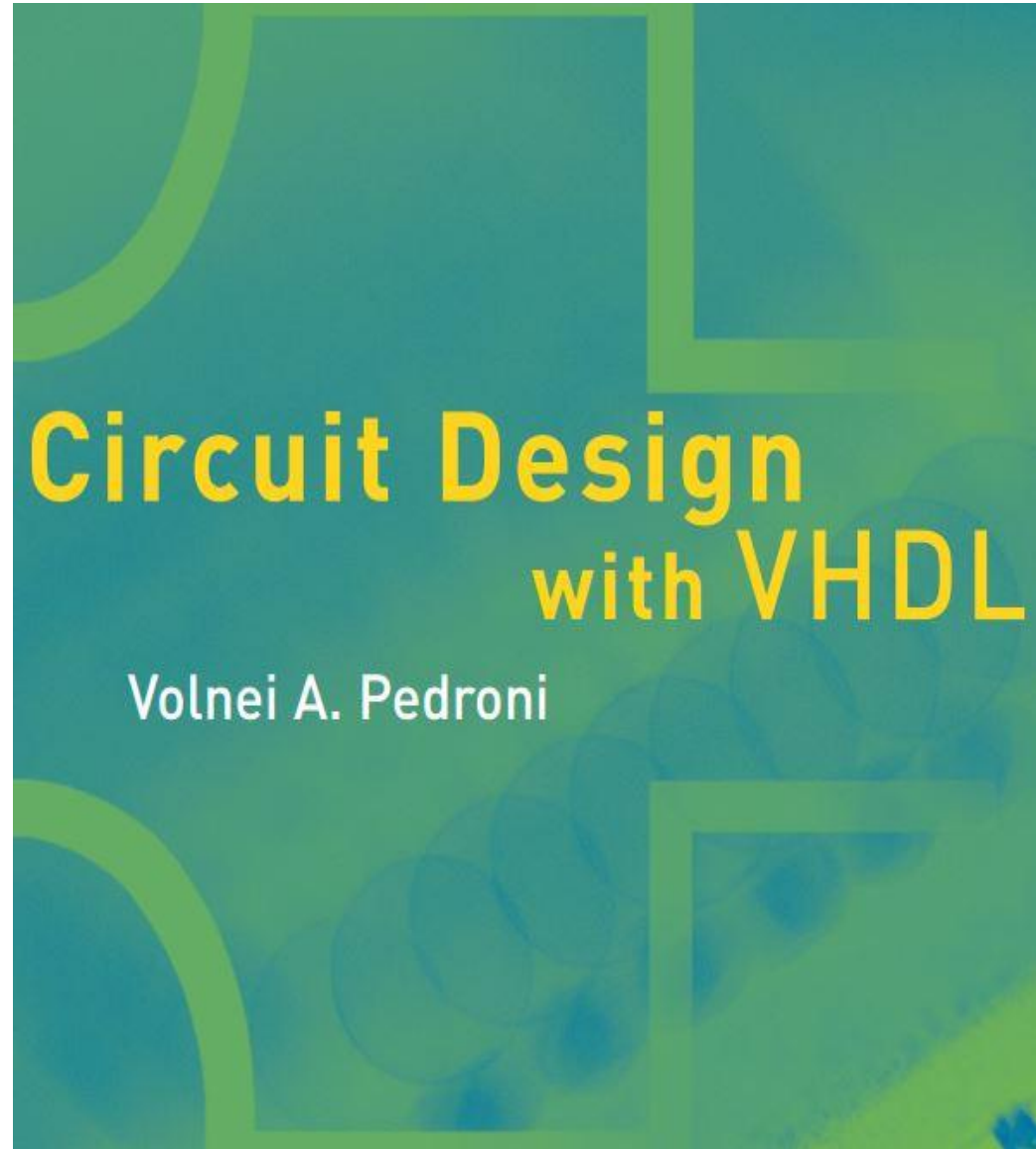
**DAC model
attached to
Pmod
connector**

Fig.6: ARTY A7 35T FPGA board with DAC model attached

What and Whys FPGA ?

FPGA can be configured by several languages. The most common are VHDL and Verilog.

Reference Book



What is VHDL?

V

VHSIC- Very High Speed
Integrated Circuit

H

Hardware

D

Descriptive

L

Language

- VHDL is used to describe the actual physical circuit.

What is VHDL?

VHDL is not a programming language

What is VHDL?

Uses of VHDL

- VHDL is used as a way to **simulate** the behavior of a circuit.
- VHDL is typically used as a way of **describing** the circuit inside a FPGA (Field Programmable Gate Array).

Note: VHDL is not case sensitive.

VHDL Code Structure

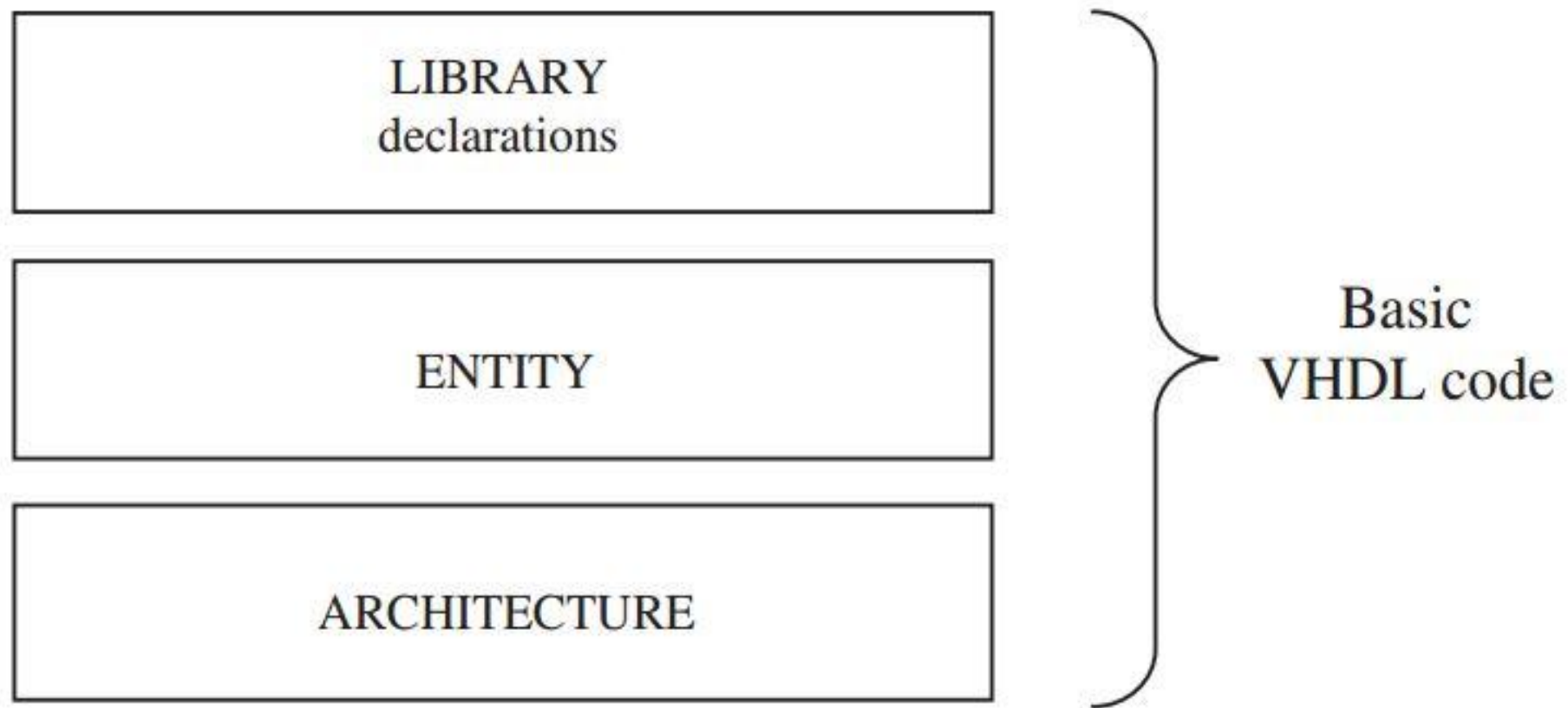


Fig.7: Fundamentals sections of VHDL code.

VHDL Code Structure

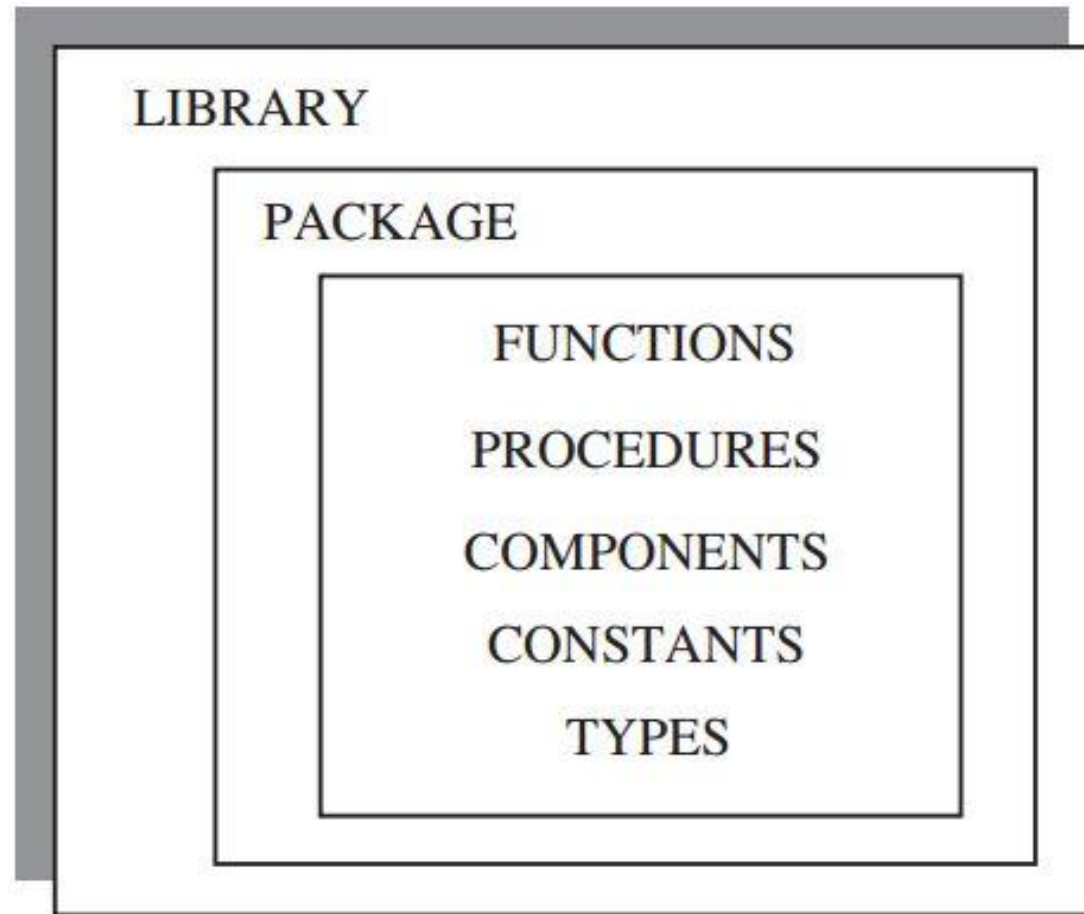


Fig.8: Fundamentals parts of a Library.

VHDL Code Structure




```
1  -- Library's  comment
2  library IEEE;  Library declaration
3  use IEEE.STD_LOGIC_1164.ALL;
4  use IEEE.numeric_std.all;  Packages
5                                     declaration
6
7  Library std;
8  use std.standard.all;
```

Fig.9: : **Library** section in VHDL code

VHDL Code Structure

```
11 -- entity declaration
12 entity NAND_gate is
13     Port (
14         a, b           : in  std_logic;
15         output         : out std_logic
16     );
17 end NAND_gate;
18
```

Fig.10: : **Entity** section in VHDL code

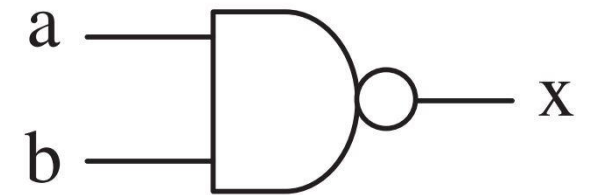


Figure 11
NAND gate.

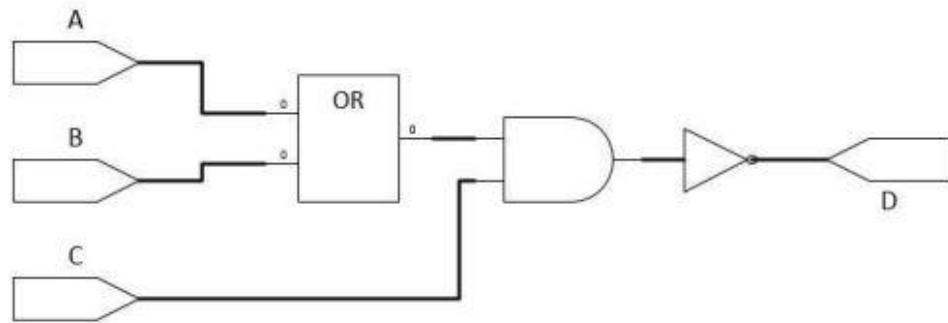
VHDL Code Structure

```
21  -- architecture declaration
22  architecture Behavioral of NAND_gate is
23
24  --no declarations in this example
25
26  begin
27
28      output <= (a nand b) ;
29
30  end Behavioral;
31
```

Fig.14: : **Architecture** section in VHDL code

Example

DIGITAL LOGIC CIRCUIT



VHDL EQUIVALENT

```
-- Digital Logic Circuit  
-- Udemy Example  
  
library IEEE;  
use IEEE.STD_LOGIC_1164.ALL;  
use IEEE.numeric_std.all;  
  
entity example is  
port (  
    D      : out std_logic;  
    A      : in  std_logic;  
    B      : in  std_logic;  
    C      : in  std_logic);  
end example;  
  
architecture behavior of example is  
begin  
    D <= not((A or B) and C);  
  
end behavior;
```

Assignments

- The assignments will be attached in your class room.

End of lecture 1

Any Questions ?