EE214 boring Short Notes

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Ref: Prof's video lectures
Remark: If you ain't getting anything, we'll be best friends!

Digital Circuits Lab

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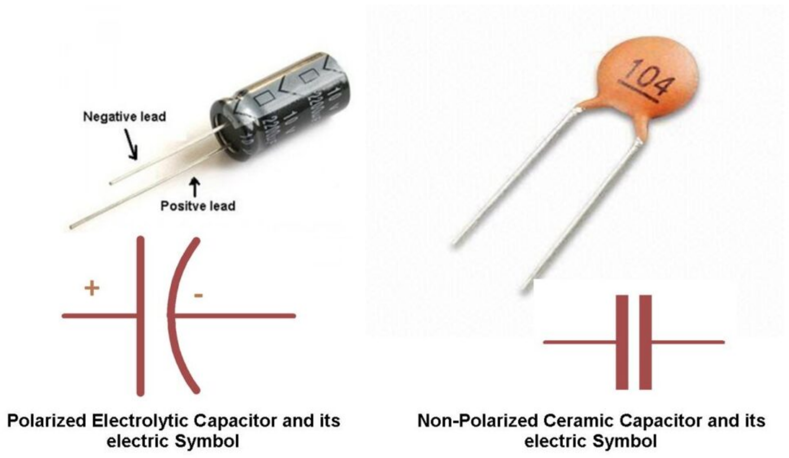
Contents

Introduction

- **ceramic capacitors** - a type of low capacitance capacitors that have no polarity
- **electrolytic capacitors** - these type of capacitors have higher capacitance values than ceramic capacitors and they do have polarity


Negative lead
Positve lead
+
-
104
Polarized Electrolytic Capacitor and its electric Symbol
Non-Polarized Ceramic Capacitor and its electric Symbol

- Single-turn and multi-turn potentiometers are variable resistances, also multi-turn potentiometers provide finer tuning of resistances
- **hardware description language (HDL)** - is a specialized computer language used to describe the structure and behaviour of electronic circuits, and most commonly, digital logic circuits
- Very High Speed Integrated Circuit HDL (VHDL) - is a hardware description language which uses the syntax of ADA
- Uses of HDL:
  - For describing hardware
  - As a modelling language
  - For simulation of hardware
  - For early performance estimation of system architecture
  - For synthesis of hardware
  - For fault simulation, test and verification of designs
- **entity** - represents a template for a hardware block, describing its interface with other modules in terms of input and output signals
- **testbench** - includes the circuit being designed, blocks which apply test signals to it and those which monitor its output
- **architecture** - describes how an entity operates. An architecture is always associates with an entity. There can be multiple architectures associated with an entity.

```
entity name is
   generic(list);
   port(list);
end entity name;
```

Figure : Entity declaration ($\geq$ VHDL 93)

```
architecture name of name_of_entity is
   (declarations)
begin     (concurrent statements)
end architecture name;
```

Figure : Architecture declaration ($\geq$ VHDL 93)

- The architecture inherits the port signals from its entity. Concurrent statements constituting the architecture can be placed in any order.
- Signals are carried by wires, variables are used for array indices, loop counters, etc.
- When you assign a value to a variable the assignment becomes effective immediately, however when you assign a value to a signal there is an associated delay for this assignment aas it is there in a real circuit
- **component** - an entity $\leftrightarrow$ architecture pair

```
component name is
   generic(list);
   port(list);
end component name;
```

Figure : Component declaration ($\geq$ VHDL 93)

- **configuration** - describes linkages between component types and entity $\leftrightarrow$ architecture pairs
- Related declarations and design elements like subprograms and procedures can be placed in a package for re-use. A package has a declarative part and an implementation part.
- Objects in a package can be referred to by a packagename.objectname syntax
- A description can include a use clause to incorporate the package in the design. Objects in the package then becomes visible to the description without having to use the dot reference as above.
- Many design elements such as packages, definitions and entire entity $\leftrightarrow$ architecture pairs can be placed in a library
- Any description invokes a library by first declaring it (For e.g. Library IEEE;)
- Objects in the library can then be incorporated in the design by a use clause (For e.g. Use IEEE.std_logic_1164.all;)
- Various types of objects in VHDL are constants, variables, signals and files.
- Declaration of objects include their object type as well as the data type of values that they can acquire (For e.g. signal Enable: BIT;)

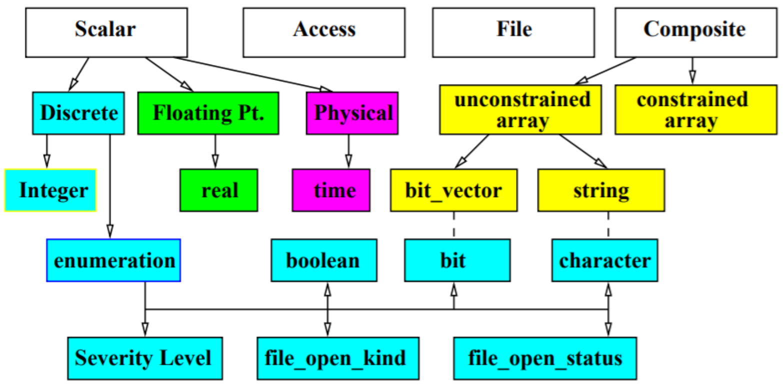


Figure : VHDL Data types

- VHDL enumeration types allow us to define a set of values that a variable of this type can acquire. For example, we can define a data type by the following declaration:
  type instr **is** (add, sub, adc, sbb, rotl, rotr);
- Enumeration types pre-defined in the language are:
  - **type** bit **is** (‘0’, ‘1’);
  - **type** boolean **is** (false, true);
  - **type** severity_level **is** (note, warning, error, failure);
  - **type** file_open_kind **is** (read_mode, write_mode, append_mode);
  - **type** file_open_status **is** (open_ok, status_error, name_error, mode_error);
  - In addition to the above types, the character type enumerates all the ASCII characters
- **std_logic -** is a signal which can take 1 of 9 possible values. It is defined by:
  type std_logic **is** (‘U’, ‘X’, ‘0’, ‘1’, ‘Z’, ‘W’, ‘L’, ‘H’, ‘-’);
- Object which are declared to be of Physical type, carry a value as well as a unit. These are used to represent physical quantities such as time, resistance and capacitance. Time is the only physical type, which is pre-defined in the language. We can define other physical types when required.
- Composite data types are collections of scalar types. VHDL recognizes records and arrays as composite data types. Records are like structures in C. Arrays are indexed collections of scalar types.
- Arrays can be constrained or unconstrained:
  - In constrained arrays, the type definition itself places bounds on index values
  - In unconstrained arrays, no bounds are placed on index values
- VHDL defines two built-in types of arrays:
  - bit_vector
    type bit_vector **is array** (natural range <>) **of** bit;
  - strings
    type string_vector **is array** (positive range <>) **of** character;

Structural description in VHDL

- Structural style describes a design in terms of components and their interconnections. Each component declares its ports and the type and direction of signals that it expects through them.
- A purely structural architecture for an entity will consist of:
  - **Component declarations:** to associate component types with their port lists.
  - **Signal declarations:** to declare the signals used.
  - **Component instantiations:** to place component instances and to portmap their ports to signals. Signals can be internal or port signals declared by the entity.
  - **Configurations:** to bind component types to entity $\leftrightarrow$ architecture pairs.
  - **Repetition grammar:** for describing multiple instances of the same component type – for example, memory cells or bus buffers.

- When we associate a component type with a previously defined entity $\leftrightarrow$ architecture pair, the chosen architecture could itself contain other components - and these components in turn would be associated with other entity $\leftrightarrow$ architecture pairs. This hierarchical association can be described by a standalone design unit called a configuration.

```
configuration config-name of name_of_entity is
   for name_of_architecture
      for componentinstance-namelist: componenttype-name
         use entity name_of_entity(name_of_architecture);
      end for
   end for
end configuration config-name;
```

Figure : Simplified configuration construct

- In VHDL, as we describe entities and architectures, these are compiled into a special library called work. This library is always included and does not have to be declared.

File I-O in VHDL

- In VHDL, in order to use files, we use a two step procedure:
  - We declare a file type first. This associates a file type with the kind of objects that files of this type will contain.
  - We can then declare files of this file type. The file declaration associates a VHDL filename with a file type and optionally, with a Physical file name and file mode (read, write or append).
- File type declaration:
  type FileType **is file of** DataType;
- If a file has not been opened during its declaration, it can be opened later by specific statements
- Opening files:
  procedure file_open(**file** f: FileType;
  Phys_name: in string;
  open_kind: in file_open_kind:=read_mode);
- Closing files:
  procedure file_close(**file** f: FileType);
- Reading from files:
  procedure read(**file** f: FileType; value: out Data_type);
- Writing to files:
  procedure write(**file** f: FileType; value: in Data_type);

Behavioural description in VHDL

- Behavioural style describes a design in terms of its behaviour, and not in terms of a netlist of components. We describe behaviour through “if-then-else” type of constructs, loops, sequential and concurrent assignment statements. Statements like “if-then-else” are inherently sequential. These must therefore occur only inside sequential bodies like processes.

- A concurrent assignment can be made conditionally by using 'when' clauses:

  name <= [delay-mechanism]
      waveform **when** Boolean-expression **else**
      waveform **when** Boolean-expression;

- VHDL operators:
  - **Logical operators:** AND, OR, NAND, NOR, OR, XNOR and NOT
  - **Relational operators:** =, /, <, <=, >, >=
  - **Shift operators:** SLL (logical left), SLA (arithmetic left) SRL (logical right), SRA (Arithmetic right), ROL (rotate left) and ROR (rotate right)

- Sequential constructs need to be placed inside a process. A process uses the syntax:

  [process-label:] **process** [(sensitivity-list)][**is**]
  [declarations]
  begin
      [sequential statements]
  end process [process-label];

  Sequential statements include "if" constructs, case statements, looping constructs, assertions, wait statements etc.

JTAG and Scanchain

JTAG:

- Joint Test Action Group
- Industry standard for verifying designs and testing PCBs
- Connects to an on-chip Test Access Port (TAP) controller
- TAP controller implements a protocol to access a set of registers or pins of a system
- Response is then stored into Flip-Flops and then compared with a golden response

Scanchain:

- Scan chain is a technique used in design for testing. The objective is to make testing easier by providing a simple way to set and observe every flip-flop in an IC.