

# NATIONAL METAL & ENGINEERING CURRICULUM

**MODULE:** DIGITAL SUBSYSTEMS 2 (NE17)

**PURPOSE:** This module aims to provide the student with knowledge and skills in the area of D/A converters, A/D converters, basic microprocessor concepts, memory devices and PLA devices.

**NOMINAL DURATION:** One module

*A full module is designed on the assumption that most of the students will achieve the competencies specified in 35 to 40 hours. (The length of time taken to complete a module will vary depending on factors such as teaching method used, knowledge and skills at entry and individual students ability.)*

**PREREQUISITES:** Digital Subsystems 1 (NE16)

**LEARNING OUTCOMES:** On completion of this module, the student will be able to:

1. Describe the operation of D/A converters and list typical applications.
2. Describe the operation of A/D converters and list typical applications.
3. Identify and describe the hardware and interface techniques used to interface logic circuits to facilitate level translation and/or isolation.
- 4.a. Describe the basic function of each block in a microprocessor minimum system consisting of MPU, RAM, ROM, I/O and bus architecture.
- 4.b. Explain the relationship between the programming model, instruction set and program execution.
5. List and describe typical memory devices used in digital systems and their interface requirements.
6. Define types, applications and programming requirements for programmable array devices.

***STUDENTS SHOULD BE MADE AWARE OF OCCUPATIONAL HEALTH AND SAFETY ISSUES IN ALL SITUATIONS AND BE EXPECTED TO DEMONSTRATE SAFE WORKING PRACTICES AT ALL TIMES.***

## **OUTLINE OF CONTENT:**

**This module contains:**

- 1. Digital to analog conversion**
  - typical applications
  - DA performance characteristics
  - types
    - summing type DA converter
    - R2R ladder DA converter
  
- 2. Analog to digital conversion**
  - typical applications
  - AD performance characteristics
  - types
    - digital ramp AD converter
    - successive approximation AD converter
    - dual slope AD converter
    - simultaneous (flash) AD converter
  
- 3. Interface chips and techniques**
  - logic interface circuits
    - level translations
    - driving a load (sink and source) from a logic circuit
    - transistor switches
    - relays
    - opto input and output isolation, driver IC's
  - sensor interfacing
  
- 4. Introduction to microprocessors**
  - minimum system components
    - MPU, RAM, ROM, I/O and bus structure
  - microprocessor block diagram
    - ALU (arithmetic logic unit)
    - accumulators
    - registers
    - instruction decoder and control unit
    - program counter
    - MPU status register
    - address and data registers
    - data format
  - stored program concepts
    - MPU programming model
    - MPU instruction set
    - fetch/execute cycle
  - bus transfers and interface logic
    - data bus latches and buffers
    - address bus latches and buffers

**Memory devices**

- typical applications
- memory cell concepts
- RAM (random access memory)
  - SRAM (static RAM)
  - DRAM (dynamic RAM)
- read-only memory
  - PROM (programmable ROM)
  - MROM (mask programmed ROM)
  - EEPROM (electrically erasable ROM)
  - EPROM (electrically programmable ROM)
- memory accessing and mapping

**6. Programmable array devices**

- applications
- types
  - PLA (programmable logic array)
  - PAL (programmable array logic)
  - PEEL (programmable electrically erasable logic)
- circuit operation
- programming requirements

**ON THE JOB TRAINING:**

For consolidation the material in this module should be linked and complemented by the relevant on-the-job skill practice or other relevant experience.

- PERFORMANCE CRITERIA:**
1. All theoretical and practical learning outcomes should be completed in accordance with checklists provided.
  2. All assignments, laboratory reports, records and other documentation should be complete, accurate and legible.
  3. All practical exercises should be conducted in accordance with the manufacturer's component specifications, particular emphasis should be placed on the demonstration of correct ESD prevention work practices.
  4. All performance objectives related to occupational health and safety should be completed observing all safety procedures described in the course notes and all state and federal regulations where applicable.

**Learning Outcome 1**

Describe the operation of DA converters and list typical applications.

**Assessment:** Objective written test  
Assignment  
Practical exercises

- Performance:**
- a. List typical applications of DA converters.
  - b. List and describe the performance characteristics of DA converters.
  - c. Describe and verify the operation of R2R and summing type DA given circuit diagram.
  - d. Describe and verify the operation of a typical DAC IC.

**Learning Outcome 2**

Describe the operation of AD converters and list typical applications.

**Assessment:** Objective written test  
Assignment  
Practical exercises

- Performance:**
- a. List typical applications of AD converters.
  - b. List and describe the performance characteristics of AD converters.
  - c. Describe the operation of the following AD converters:
    - digital ramp
    - dual slope
    - successive approximation
    - simultaneous (flash).
  - d. Describe and verify the operation of a typical ADC IC.

### Learning Outcome 3

Identify and describe the hardware and interface techniques used to interface logic circuits to facilitate level translation and/or isolation.

#### Assessment:

Objective written test  
Assignment  
Practical exercises

#### Performance:

- a. Sketch circuit diagrams showing how a load can be interfaced to a digital logic circuit with a bipolar junction transistor or a field effect transistor.
- b. List the advantages and disadvantages of a relay compared to a solid state switch when used to interface logic circuit to a variety of load conditions.
- c. Explain the principle of operation of an opto-isolator and its use in isolating a digital circuit from an input signal or an output load.
- d. Describe the operation of a level translator circuit eg. RS232 interface.

### Learning Outcome 4a

Describe the basic function of each block in a microprocessor minimum system consisting of MPU, RAM, ROM, I/O and bus architecture.

#### Assessment:

Objective written test  
Assignment  
Practical exercises

#### Performance:

Describe the basic function of each block in a microprocessor minimum system consisting of MPU, RAM, ROM, I/O and bus architecture.

### Learning Outcome 4b

Explain the relationship between the programming model, instruction set and program execution.

#### Performance:

- a. Explain the relationship between the programming model, instruction set and program execution.
- b. Write a simple inline program for a specified task given all relevant documentation.

### Learning Outcome 4c

Describe how and why data and address bus latches and buffers are used in microprocessor systems.

#### Performance:

- a. List reasons why data and address bus latches and buffers are used in microprocessor systems.
- b. Describe the operation of a circuit containing latches and/or buffers.

### **Learning Outcome 5**

List and describe typical memory devices used in digital systems and their interface requirements.

#### **Assessment:**

Objective written test  
Assignment  
Practical exercises

#### **Performance:**

- a. Define the operational characteristics for the following memory devices  
- SRAM, DRAM, ROM, PROM, EEPROM and EPROM
- b. Describe the pin designations (functions) for the following  
- SRAM, DRAM, ROM, PROM, EEPROM and EPROM
- c. List typical applications for all of the above memory devices.
- d. Determine the memory map of a microprocessor system given a circuit schematic and relevant documentation.

### **Learning Outcome 6**

Define types, applications and programming requirements for programmable array devices.

#### **Assessment:**

Objective written test  
Assignment  
Practical exercises

#### **Performance:**

- a. List the functions and applications of the following:  
- PAL, PLA and PEEL
- b. Describe the operation of a typical PAL device.
- c. Describe the differences and list advantages/disadvantages for the array devices.
- d. Describe the basic process performed in programming array devices.

**ADDITIONAL INFORMATION:            MODULE - (NE17)**

**Suggested Resources:**

**Tocci, "Digital Systems" Prentice Hall**  
**Floyd, "Digital Fundamentals" Merrill**  
**Bogart, "Introduction to Digital Circuits" McGraw Hill**  
**Tokheim, "Digital Electronics" McGraw Hill**  
**Jones, "Principles and Applications of Digital Electronics" McGraw Hill**  
**Brey, "Microprocessor/Hardware Interface and Applications" Merrill**  
**Tocci, "Microprocessors and Microcomputers" Prentice Hall**  
**Sams, "Microcomputer Primer" Sams**  
**Gilmore, "Microprocessor: Principles and Applications" McGraw Hill**  
**Larry Long, "Microcomputers" Prentice Hall**  
**David Terrell, "Microprocessor Technology" Prentice Hall**  
**Barry Brey, "The Z80 Microprocessor: Hardware, Software Programming and Interfacing" Prentice Hall**  
**Slater, "Microprocessor Based Design" Mayfield**  
**Levanthal, "6809 Assembly Language Programming"**  
**Motorola, "MC6809 Programming Manual" Motorola**  
**Rodney Zaks, "Microprocessor Interfacing Techniques" Sybex**  
**Andrews, "Programming Microprocessor Interfaces for Control and Instrumentation" Prentice Hall**  
**Staugaard, "6809 Microcomputer Programming and Interfacing with Experiments".**