

20.2.0 DIGITAL ELECTRONICS

20.2.01 Introduction

This unit deals with study of circuits of signals that take only two different levels. It is intended to provide the trainee with the relevant knowledge skills and attitudes necessary to make the learner competent in design, installation and maintenance of digital equipment and devices. The trainers may use phased design projects (suitable for the level) to enhance skills and competence acquisition.

20.2.02 General Objectives

At the end of the module unit, the trainee should be able to:

- a) Understand number systems and perform binary arithmetic
- b) Design combination logic networks
- c) Design flip-flop circuits
- d) Design Register and Counter Circuits
- e) Understand the operation of data handling logic circuits
- f) Apply arithmetic circuits in electronic circuits
- g) Appreciate digital electronics as a foundation for industrial controls

20.2.03 Module Unit Summary and Time Allocation

Digital Electronics

Code	Sub Module Unit	Content	Time Hours
20.2.1	Number systems	<ul style="list-style-type: none">• Number systems• Binary systems• Conversion of numbers to binary and vice versa• 'Ones' and 'twos' complement s• Arithmetic• Numbers in octal• Conversion of octal numbers into other numbers and vice versa• Conversion of hexadecimal numbers to other number systems• Application of number systems	4
20.2.2	Binary codes	<ul style="list-style-type: none">• Importance of Binary codes• BCD arithmetic• BCD arithmetic• Binary numbers in grey code	6

		<ul style="list-style-type: none"> • Alphanumeric codes • Application of alphanumeric codes. • Error detection 	
20.2.3	Logic gates and Boolean algebra	<ul style="list-style-type: none"> • Operation of basic logic gates • Operation of hybrid (derived) logic gates • The Boolean algebra • Reduction of logic expression • Implementation of logic circuits 	6
20.2.4	Combinational logic design	<ul style="list-style-type: none"> • Definition of Combinational logic network operation • Derivations from Boolean • Designing combinational logic using Boolean algebra • Designing combinational circuits using tabular methods • Logic circuits for industrial interlock systems including time delay 	6
20.2.5	Logic families	<ul style="list-style-type: none"> • Transistor as a switch • Classifications of Logic Families • Operation of various logic families • Handling requirements of various logic Families • Interconnection of different logic families 	4
20.2.6	Flip flops	<ul style="list-style-type: none"> • Latches • Types of flip-flops • Edge triggered • Master/slave flip-flop • Manufacturers data sheets and catalogues 	8
20.2.7	Combinational logic circuits	<ul style="list-style-type: none"> • Definition of data handling logic circuits • Operation of data handling logic circuits • Applications • Similarities between decoder and demultiplexers 	6
20.2.8	Sequential logic circuits	<ul style="list-style-type: none"> • Shift register operation • Serial register operation 	8

		<ul style="list-style-type: none"> • Parallel register operation • Shift register modes • Use of manufacturers data sheets and catalogues to identify registers • Operation of ripple counters • Operation of synchronous counters • Comparison between ripple and synchronous • Feedback register • Application of counters • Use of manufacturers' data book and catalogue to identify counters 	
20.2.9	Arithmetic Circuits	<ul style="list-style-type: none"> • Serial Adders • Parallel adder • Serial and parallel adder • Arithmetic circuits 	6
20.2.10	Converters	<ul style="list-style-type: none"> • Operational amplifiers as Comparator • Terminologies • Operation of DAC • Operation of ADC • Application 	6
20.2.11	Memories	<ul style="list-style-type: none"> • Classification of memory devices • Terminologies • Operation of semiconductor RAM and ROM memory devices • Organization of ROM memory devices • Operation and organization of secondary storage memories • Mapping • Memory organization 	6
Total Time			66

20.2.1 NUMBER SYSTEMS

Theory

20.2.1T0 *Specific objectives*

By the end of the sub-module unit, the trainee should be able to:

- a) represent numbers in decimal
- b) represent numbers in binary
- c) convert binary numbers into other number systems and vice versa
- d) represent binary numbers into one's and two's complement
- e) perform binary arithmetic
- f) represent numbers in octal
- g) convert octal numbers into other number systems and vice versa
- h) represent numbers in hexadecimal
- i) convert hexadecimal numbers to other number systems and vice versa
- j) state the areas of application of number systems

Content

- 20.2.1T1 Number systems
- 20.2.1T2 Binary systems
- 20.2.1T3 Conversion of numbers to binary and vice versa
- 20.2.1T4 'Ones' and 'twos' complement s
- 20.2.1T5 Arithmetic
- 20.2.1T6 Numbers in octal

20.2.1T7 Conversion of octal numbers into other numbers and vice versa

20.2.1T8 Conversion of hexadecimal numbers to other number systems

20.2.1T9 Application of number systems

20.2.1C **Competence**

The trainee should have the ability to: number systems in programming

20.2.2 BINARY CODES

Theory

20.2.2T0 *Specific objectives*

By the end of the sub-module unit, the trainee should be able to:

- a) explain the importance of various binary codes
- b) represent decimal numbers in binary coded decimal (BCD)
- c) perform BCD arithmetic
- d) represent binary numbers in gray code
- e) represent characters in various alphanumeric codes.
- f) Identify the use of various alphanumeric codes in digital systems
- g) explain various methods of error detection and correction

	<i>Content</i>
20.2.2T1	Importance of Binary codes
20.2.2T2	Representation of decimal numbers in Binary Coded Decimal (BCD)
20.2.2T3	BCD arithmetic
20.2.2T4	Representation of binary numbers in gray code
20.2.2T5	Representation of characters in various alphanumeric codes
20.2.2T6	Use of alphanumeric codes in digital systems
20.2.2T7	Methods of error detection

20.2.3 LOGIC GATES AND BOOLEAN ALGEBRA

Theory

20.2.3T0	<i>Specific objectives</i> By the end of the sub module unit, the trainee should be able to:
a)	explain the operation of the basic logic gate
b)	explain the operation of hybrid (derived) logic gates
c)	understand the concepts of Boolean algebra
d)	minimize logic expressions using universal gates
e)	implement logic circuits using universal gates

	<i>Content</i>
20.2.3T1	Basic Logic gates AND, OR , INVERTER
20.2.3T2	Hybrid Gates NAND, NOR, Exclusive gates
20.2.3T3	Boolean algebra

	- Identities and Rules, De Morgans Theorems
20.2.3T4	Minimize logic expressions using: i) Boolean algebra ii) K-Map upto 4 variables
20.2.3T5	Implement logic circuits using i) NAND gates only ii) NOR gates only.

Practice

20.2.3P0	<i>Specific Objectives</i> By the end of the sub-module unit the trainee should be able to:
a)	identify pin configuration of logic gate ICs
b)	mount the logic gate IC on a breadboard
c)	verify the operation of logic gates

	<i>Content</i>
20.2.3P1	Identifying pin configuration
20.2.3P2	Mounting logic gate IC on a breadboard
20.2.3P3	Demonstrate operation of logic gates

20.2.3C	Competence The trainee should have the ability to: construct and test various logic gates
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Suggested teaching/Learning Activities

- Illustration
- Demonstration
- Note taking
- Practical exercise

Suggested Teaching and Learning Resources

- Digital trainer kit
- Assorted logic gate ICS
- Connecting wires
- Clock generator
- Breadboard
- DC power supply
- LED display

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests
- Project

20.2.4 COMBINATIONAL LOGIC DESIGN

Theory

- 20.2.4T0 *Specific objectives*
By the end of the sub-module unit, the trainee should be able to :
- define combinational logic networks
 - design combinational logic circuits using Boolean algebra
 - design combinational logic circuits up to 4 input variables using Karnaugh map
 - design combinational logic circuits up to 4-input variables using tabular method.
 - design combinational logic circuits for industrial interlock systems including time delay.

Content

- 20.2.4T1 Combination logic & Network design
- 20.2.4T2 Combinational logic circuits using Boolean algebra
- 20.2.4T3 Combinational logic circuits up to 4 input variables using Karnaugh map
- 20.2.4T4 Combinational logic circuits up to 4-input variables using tabular method
- 20.2.4T5 Combinational logic circuits for industrial interlock systems including time delay

Practice

- 20.2.4P0 *Specific objectives*
By the end of the sub-module unit, the trainee should be able to:
- use manufacturers' data sheets and catalogues to identify characteristics and pin connections of ICs.
 - interconnected different logic families

Content

- 20.2.4P1 Use of manufacturer's data book
- 20.2.4P2 Interconnection of different logic families

20.2.4C Competences

The trainee should have the ability to: use different logics gates in electronic circuit design

Suggested teaching/Learning Resources

- Logic gates
- Electronic tool kit
- Electrical measuring instruments
- Bread board

Suggested teaching/Learning Activities

- Illustration
- Demonstration
- Note taking
- Observation
- Practical exercise
- Project work

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests
- Project

20.2.5 LOGIC FAMILIES

Theory

20.2.5T0 Specific objectives

- By the end of the sub-module unit, the trainee should be able to:
- explain the use of a transistor as a switch
 - state classifications of logic families
 - explain the general operation and characteristics of various logic families
 - state the handling requirements for various logic families

Content

- 20.2.5T1 Transistor as a switch
- BJT
 - MOSFET
 - Synchronous sequential logic
- 20.2.5T2 Classifications of Logic Families
- BJT logic families
 - MOSFET logic families
 - SSI
 - MSI
 - LSI
 - VLSI
- 20.2.5T3 Operation of various logic families
- 20.2.5T4 Characteristics of various logic families in terms of
- Loading rules
 - Wired AND operation
 - Unused inputs
 - Protection
 - Interfacing between logic families
 - Tri-state TTLs
- Use of manufacturers Datasheets
- 20.2.5T5 How to connect different logic families
- TTL-CMOS
 - MOS-TTL

Practice

20.2.5P0 Specific Objectives

- By the end of the sub-module unit, the trainee should be able to:
- select a particular logic gate IC using data sheets or catalogs
 - demonstrate the operation of logic gates ICs

- c) interface different logic gates
- d) interconnect various logic families

Content

- 20.2.5P1 Selecting a particular logic gate IC from a catalogue
- 20.2.5P2 Demonstrating the operation of logic gate ICS
- 20.2.5P3 Interfacing different logic gates

20.2.5C Competence

The trainee should have the ability to: construct and test logic circuits from different logic families

Suggested teaching/Learning Activities

- Illustration
- Demonstration
- Note taking
- Observation
- Practical exercise
- Project work

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests
- Project

20.2.6 FLIP-FLOPS

Theory

20.2.6T0 Specific objectives

By the end of the sub module unit, the trainee should be able to:

- a) explain the operation of latches

- b) explain the operation of various flip-flop circuits.
- c) explain the operation of edge triggered flip-flops
- d) explain characteristics of master/slave flip-flops
- e) use manufacturers' data sheets and catalogues to select flip-flops.

Content

- 20.2.6T1 Explanation of operation of latches
 - i) Transistor latch
 - ii) NAND latch
 - iii) NOR latch
 - iv) 20.2.6T2 Flip-flops
 - v) S-R
 - vi) J-K
 - vii) D Type
 - viii) T-type
- 20.2.6T3 Explanation operation of the following using transition tables and
 - i) wave forms:
 - ii) Edge triggered
 - iii) Master/slave flip-flop
- 20.2.6T4 Characteristics of master/slave flip flops
- 20.2.6T5 Use manufacturers data sheets and catalogues to identify:
 - i) Pin connection
 - ii) Characteristics of IC flip-flops

Practice

20.2.6P0 Specific Objectives

By the end of the sub-module unit, the trainee should be able to:

- a) select a particular flip flop IC using data sheets or catalogs

- b) demonstrate the operation of various flip flops

Content

- 20.2.6P1 Selecting a particular flip flop IC for using data sheets or catalogues
- 20.2.6P2 Demonstrating the operation of various flip flops

20.2.6C Competence

The trainee should have the ability to: construct and test logic circuits from different flip flops.

Suggested teaching/Learning Activities

- Illustration
- Demonstration
- Note taking
- Observation
- Practical exercise

Suggested teaching/Learning Resources

- Logic circuits
- Flip flops
- Electrical measuring instruments

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests
- Project

20.2.7 COMBINATION LOGIC DESIGN

Theory

20.2.7T0 *Specific objectives*

By the end of the sub-module unit, the trainee should be able to:

- a) define data handling combinational logic circuits
- b) explain the operation of combinational logic circuits
- c) describe applications combinational logic circuits
- d) state similarities between decoder and demultiplexers

Content

- 20.2.7T1 Definition of combinational logic circuits
 - i) Decoders
 - ii) Encoders
 - iii) Multiplexers
 - iv) Demultiplexers

- 20.2.7T2 Explanation of the operation of combinational logic circuits
 - i) Decoders
 - ii) Encoders
 - iii) Multiplexers
 - iv) Demultiplexers

- 20.2.7T3 Application of
 - i) Decoders
 - ii) Encoders

- 20.2.7T4 Similarities of Multiplexers and Demultiplexers

Practice

20.2.7P0 *Specific Objectives*

By the end of the sub - module unit, the trainee should be able to:

- a) construct various combinational logic circuits
- b) demonstrate the operation of various combinational logic circuits

Content

- 20.2.7P1 Constructing various combinational logic circuits
- 20.2.7P2 Demonstrating operation of various combinational logic circuits

20.2.7C **Competence**

The trainee should have the ability to: construct and test various combinational logic circuits.

Suggested teaching/Learning Activities

- Discussion
- Question and answer
- Demonstration
- Note taking
- Observation
- Practical exercise

Suggested teaching/Learning Resources

- i) Electrical measuring instruments
- ii) Electronic tool kit
- iii) Dc Power supply
- iv) Ac power supply
- v) Logic gates
- vi) Electronic components

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests
- Project

20.2.8 SEQUENTIAL LOGIC CIRCUITS

Theory

20.2.8T0 *Specific objectives*

By the end of the sub-module unit, the trainee should be able to :

- a) explain the basic operation of a shift register
- b) describe serial shift register operation
- c) describe parallel shift register operation
- d) explain the practical IC shift modes of operation
- e) use manufacturers data sheets and catalogues to identify ICs
- f) describe the operation of asynchronous (ripple through) counters
- g) describe the operation of synchronous counters
- h) compare synchronous with asynchronous counters
- i) describe operation of feedback register
- j) describe the applications of counters
- k) use manufacturer's data sheets and catalogues to identify and select counters.

- Content*
- 20.2.8T1 Operation of a shift register using
i) Transition tables
ii) Waveforms
- 20.2.8T2 Describe serial shift register operation
i) Shift right
ii) Shift left
iii) Shift around
- 20.2.8T3 Describe parallel shift operation
- 20.2.8T4 Explain the practical IC shift register modes
i) SISO
ii) SIPO
iii) PIPO
iv) PISO
- 20.2.8T5 Use manufacturers data sheets and catalogues to identify
i) Pin connection
ii) Characteristics of IC flip-flop
- 20.2.8T6 Describe the operation of the Ripple counter
i) Modulus number
ii) Stage and state numbers
iii) Shortened mod
iv) Decoding outputs
v) Waveforms
vi) Limitations
- 20.2.8T7 Describe the operation of synchronous counters
- 20.2.8T8 Compare asynchronous and synchronous counter
- 20.2.8T9 Describe the operation of the feedback register
i) Ring counter
ii) Twisted ring counter
iii) Random sequence generator
- 20.2.8T10 Describe applications of counters

- 20.2.8T11 Use manufacturer's data sheets and catalogues to identify:
i) Pin connection
ii) IC characteristics

Practice

- 20.2.8P0 *Specific Objectives*
By the end of the sub-module unit the trainee should be able to:
a) construct various sequential logic circuits
b) operate various sequential logic circuits

Content

- 20.2.8P1 Constructing various sequential logic circuits
- 20.2.8P2 Operation of various sequential logic circuits

20.2.8C Competence

The trainee should have the ability to: construct and test various sequential logic circuits

Suggested teaching/Learning Activities

- Discussion
- Question and answer
- Demonstration
- Note taking
- Observation
- Practical exercise
- Project work

Suggested teaching/Learning Resources

- Electrical measuring instruments
- Electronic tool kit
- Dc Power supply
- Sequential logic circuits

- Electronic components
- Assorted cables and other electrical materials

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests
- Project

20.2.9 ARITHMETIC CIRCUITS

20.2.9T0 *Specific Objectives*

By the end of the sub-module unit, the trainee should be able to :

- describe the operation of a serial adder
- describe the operation of a parallel adder
- compare serial and parallel adders
- describe the application of arithmetic circuits

Content

- 20.2.9T1 Description of operation of serial adders
- Operation
 - Modification to perform subtraction
 - Limitation
- 20.2.9T2 Description of parallel adder
- Operation
 - Use and operation of a look-ahead carry
- 20.2.9T3 Explanation of comparison of serial and parallel adders
- Operation
 - Complexity

20.2.9T4 Description of arithmetic circuits

- Applications of adders e.g. ALU

Practice

20.2.9P0 *Specific Objectives*

By the end of the sub module unit the trainee should be able to:

- construct various arithmetic circuits
- demonstrate the operation of various arithmetic circuits

Content

- 20.2.9P1 Constructing various arithmetic circuits
- 20.2.9P2 Demonstrating operation of various arithmetic circuits

20.2.9C **Competence**

The trainee should have the ability to: construct and test various arithmetic circuits.

Suggested teaching/Learning Activities

- Discussion
- Question and answer
- Illustration
- Demonstration
- Note taking
- Observation
- Practical exercise
- Project work

Suggested teaching/Learning Resources

- Electrical measuring instruments
- Electronic tool kit
- Electrical tool kit

- Dc Power supply
- Ac power supply
- Three phase power supply
- Arithmetic circuits
- Electronic components
- Assorted cables and other electrical materials

- 20.2.10T4 Analogue to Digital Converter
- i) Types
 - ii) Analysis
- 20.2.10T5 Applications

Practice

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests
- Project
- Project Report writing and presentation

- 20.2.10P0 *Specific Objectives*
- By the end of the sub-module unit the trainee should be able to:
- a) construct various converter circuits
 - b) demonstrate operation of various converter circuits

20.2.10 CONVERTERS

Theory

- 20.2.10T0 *Specific Objectives*
- By the end of the sub-module unit, the trainee should be able to :
- a) describe Operational Amplifier as comparator
 - b) define the terminologies used in converter circuits
 - c) describe the operation of DAC
 - d) describe the operation of ADC
 - e) explain the applications of converter circuits

Content

- 20.2.10P1 Constructing various converter circuits
- 20.2.10P2 Operation of various converter circuits

- 20.2.10C **Competence**
- The trainee should have the ability to: construct and test various converter circuits.

Suggested teaching/Learning Activities

- Demonstration
- Note taking
- Observation
- Practical exercise
- Project work

- Content*
- 20.2.10T1 Operational Amplifier as Comparator
- 20.2.10T2 Definition of DAC's and ADC's terminologies
- 20.2.10T3 Digital to Analogue Converter
- i) Types
 - ii) Analysis
 - iii) Application

Suggested teaching/Learning Resources

- i) Electrical measuring instruments
- ii) Electronic tool kit
- iii) Dc Power supply
- iv) Signal generators
- v) Electronic devices
- vi) Electronic components

- vii) Assorted cables and other electrical materials

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests
- Project

20.2.11 MEMORIES

Theory

20.2.11T0 *Specific Objectives*

By the end of the sub module unit, the trainee should be able to:

- a) classify memories into various categories
- b) define memory terminologies
- c) describe the operations of semiconductor RAM and ROM memories
- d) describe the organization of semiconductor ram and ROM
- e) describe the operation and organization of secondary storage memories
- f) explain memory map
- g) describe memory organization

Content

- 20.2.11T1 Classification of Memories into various categories in a computer system
- 20.2.11T2 Stating the meaning of various memory terminologies

20.2.11T3 Description of operation of Semiconductor RAM and ROM

- i) Memory cell
- ii) Dynamic & Static memories
- iii) Erasable and non-erasable memories
- iv) Access timing of memories
- v) Memory capacity

20.2.11T4 Description of organization of Semiconductor RAM and ROM

- i) Register representation in memories
- ii) Memory timing
- iii) Memory expansion
- iv) Memory address decoding
- v) Memory pages
- vi) Cache memories
- vii) Storage capacity

20.2.11T5 Description of organization and operation of Secondary storage devices

- i) Need for secondary storage
- ii) Magnetic bubble memories
- iii) Floppy & hard disks
- iv) Recording surfaces
- v) Accessing & timing
- vi) Formats
- vii) Disk drives
- viii) Storage capacity
- ix) Hard disk
- x) CD ROM
- xi) CCD
- xii) Data stick/Flash Disc

20.2.11T6 Description of memory mapping

- i) Address decoders
- ii) Address allocation
- iii) System ROM, RAM, I/O, Expansion
- iv) Expansion slots
- v) Timing
- vi) Pages

20.2.11T7 Description of memory organization

- i) Hierarchy
- ii) Timing
- iii) Formats
- iv) Capacity
- v) Functions

20.2.11C **Competence**
Ability to manage computer memories

easytvvet.com