Engineering License Exam Preparation: Digital Logic and Microprocessor (AExE02)

2.1 Digital Logic

Number Systems

Description:
Number systems define how numbers are represented. Common number systems include:

- **Binary (Base 2)**: Uses digits 0 and 1.
- **Decimal (Base 10)**: Uses digits 0 to 9.
- **Hexadecimal (Base 16)**: Uses digits 0-9 and A-F.
- **Octal (Base 8)**: Uses digits 0-7.

Conversions:

- **Binary to Decimal**: Multiply each binary digit by (2^n), where (n) is its position from the right.
- **Decimal to Binary**: Divide the number by 2, noting remainders.

Probable Questions:

- Convert 101101 (binary) to decimal.
- Convert 47 (decimal) to binary.

Solution Example:

- **Binary to Decimal**:
  (101101_2 = 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 45_{10})
- **Decimal to Binary**:
  (47_{10} = 101111_2)

Logic Levels and Gates

Description:
Logic gates perform basic logical functions in digital circuits. The basic gates are:

- **AND** gate: Output is high if both inputs are high.
- **OR** gate: Output is high if at least one input is high.
- **NOT** gate: Inverts the input (output is opposite of input).
- **NAND**, **NOR**, **XOR**, **XNOR** gates are derived from basic gates.

Truth Tables:

- **AND Gate**:

A	B	A AND B

A	B	A AND B
0	0	0
0	1	0
1	0	0
1	1	1

Probable Questions:

- What is the output of an XOR gate when both inputs are 1?
- Draw the truth table of a NAND gate.

Answer Example:

- **XOR Gate**:
  When both inputs are 1, the XOR gate outputs 0.

Boolean Algebra

Description:
Boolean algebra simplifies logical expressions. Basic rules include:

- **A + 0 = A**
- **A + A = A**
- **A · 1 = A**
- **A · 0 = 0**
- **(\overline{A + B} = \overline{A} \cdot \overline{B})** (De Morgan's Law)

Probable Questions:

- Simplify the Boolean expression (A \cdot \overline{A} + B).

Solution:

- (A \cdot \overline{A} + B = 0 + B = B)

Sum-of-Products (SOP) and Product-of-Sums (POS) Methods

Description:

- **SOP**: A logical expression is written as a sum (OR) of product (AND) terms.
- **POS**: A logical expression is written as a product (AND) of sum (OR) terms.

Probable Questions:

- Convert the truth table into SOP form.

Karnaugh Maps (K-map)

Description:
Karnaugh maps are used to simplify Boolean expressions. Group 1's in the K-map to form the simplest expression.

2.2 Combinational and Arithmetic Circuits

Multiplexers and Demultiplexers

Description:

- **Multiplexer (MUX)**: Selects one input from multiple inputs and passes it to a single output.
- **Demultiplexer (DEMUX)**: Takes one input and directs it to one of several outputs.

Probable Questions:

- Design a 4-to-1 multiplexer circuit using logic gates.

Binary Addition and Subtraction

Description:

- **Binary Addition**: Follows the same rules as decimal addition but uses base 2.
  - Example: (101_2 + 110_2 = 1011_2)
- **Binary Subtraction**: Involves borrowing, similar to decimal subtraction.

Probable Questions:

- Perform binary addition of (1011_2 + 1101_2).

Solution:

- (1011_2 + 1101_2 = 11000_2)

Signed and Unsigned Binary Numbers

Description:

- **Unsigned** numbers represent only positive values.
- **Signed** numbers use the most significant bit (MSB) as the sign bit (0 for positive, 1 for negative).

2.3 Sequential Logic Circuits

Flip-Flops

Description:
Flip-flops store binary data. Types include:

- **RS Flip-Flop**: Stores a bit based on Set and Reset inputs.
- **D Flip-Flop**: Data input is stored at the clock's edge.

- **JK Flip-Flop**: Enhanced version of RS, where inputs can toggle the output.

Probable Questions:

- Describe the operation of a JK Flip-Flop.

Shift Registers

Description:
Shift registers store and shift data bits in a sequence. They are classified as:

- **Serial-In Serial-Out (SISO)**
- **Serial-In Parallel-Out (SIPO)**

Probable Questions:

- What is the application of a shift register in digital circuits?

Counters

Description:

- **Asynchronous Counters**: Count without synchronized clock inputs (also called ripple counters).
- **Synchronous Counters**: All flip-flops are triggered by the same clock signal.

Probable Questions:

- Explain the difference between synchronous and asynchronous counters.

2.4 Microprocessor

Internal Architecture and Features

Description:

- The microprocessor has components like ALU (Arithmetic Logic Unit), control unit, and registers.
- Examples: 8085 microprocessor.

Probable Questions:

- Draw the block diagram of the 8085 microprocessor.

Assembly Language Programming

Description:

- Assembly language is a low-level programming language that directly interfaces with the microprocessor's hardware.

2.5 Microprocessor System

Memory Device Classification and Hierarchy

Description:

- **Primary Memory**: Includes RAM and ROM.
- **Secondary Memory**: Hard drives, SSDs.
- **Memory Hierarchy**: From fastest (registers) to slowest (secondary storage).

Interfacing I/O and Memory

Description:

- **I/O Interface**: Mechanism through which the processor communicates with external devices.
- **Memory Interface**: Mechanism to connect RAM, ROM, and storage devices.

Programmable Peripheral Interface (PPI)

Description:
A PPI allows a microprocessor to interface with peripheral devices, like keyboards and displays.

Direct Memory Access (DMA)

Description:
DMA allows peripherals to directly transfer data to/from memory without the CPU.

2.6 Interrupt Operations

Interrupts

Description:

- **Interrupt**: A signal that halts the current execution of a program to execute an Interrupt Service Routine (ISR).
- **Interrupt Processing**: The steps taken when an interrupt is raised, which includes saving the program state, executing the ISR, and restoring the state.

Probable MCQs for Digital Logic and Microprocessor

Understanding-Based MCQs

Q1: In Boolean algebra, the complement of (A + B) is:
A) (A \cdot B)
B) (\overline{A \cdot B})
C) (\overline{A} + \overline{B})

D) (\overline{A} \cdot \overline{B})
Answer: D) (\overline{A} \cdot \overline{B})

Q2: The Karnaugh Map method is used to:
A) Solve truth tables
B) Minimize Boolean expressions
C) Maximize truth tables
D) Multiply Boolean expressions
Answer: B) Minimize Boolean expressions

Numerical-Based MCQs

Q3: Convert the decimal number 27 to binary:
A) (11100_2)
B) (11011_2)
C) (10001_2)
D) (10110_2)
Answer: B) (11011_2)

Q4: Perform binary addition: (1011_2 + 1101_2):
A) (11000_2)
B) (10101_2)
C) (10100_2)
D)

(11100_2)
Answer: A) (11000_2)

Skills-Based MCQs

Q5: In a 4-to-1 multiplexer, how many select lines are required?
A) 1
B) 2
C) 3
D) 4
Answer: B) 2

Q6: The memory hierarchy from fastest to slowest is:
A) Cache > Registers > RAM > Secondary Storage
B) Registers > Cache > RAM > Secondary Storage
C) RAM > Registers > Cache > Secondary Storage
D) Secondary Storage > RAM > Cache > Registers
Answer: B) Registers > Cache > RAM > Secondary Storage
