Digital Electronics

Theory Exam

Short Questions
(definitions and theoretical comments)

CHAPTER 1&2:

1. What is the difference between a digital system and an analog system?
2. Is the function NAND / NOR / XOR / NXOR associative?
3. What is a minterm of a Boolean function?
4. What is a maxterm of a Boolean function?
5. What is the relation between a minterm $m_i$ and the corresponding maxterm $M_i$? Give an example for an expression with 3 binary variables.
6. What do we call a prime implicant of a Boolean function?
7. What do we call an essential prime implicant of a Boolean function?
8. What is a buffer circuit? What is it used for?
9. What is an even/odd binary function? Give its expression in the form of a sum of products and the corresponding truth table for the particular case of the even/odd function with 4 variables.
10. What is a parity bit?
11. What is an integrated circuit?
12. What is the noise margin of a logical gate?
13. What is the difference between ‘positive’ logic and ‘negative’ logic?
14. What do we call a transmission gate?
15. What do we call a universal gate?

CHAPTER 3:

16. What is a combinational circuit?
17. What is a decoder in combinational logic? Explain briefly how it works.
18. What is an encoder in combinational logic? Explain briefly how it works.
19. What is a priority encoder in combinational logic? Explain briefly how it works.
20. What is a multiplexer in combinational logic? Explain briefly how it works.
21. What is a half-adder in combinational logic?
22. What is a full-adder in combinational logic?
23. How do we detect the overflow of a binary adder?

CHAPTER 4&5:

24. What is a sequential circuit?
25. What is a synchronous / asynchronous sequential circuit?
26. What is a latch? What are the characteristics of a D-latch?
27. What is a flip-flop?
28. What is the main difference between a latch and a flip-flop?
29. What is a master-slave flip-flop?
30. Give the truth table of a D flip-flop.
32. Give the excitation table of a JK flip-flop.
33. What is a direct (asynchronous) input of a flip-flop useful for?
34. What do we call an internal state of a sequential circuit?
35. How many internal states can we represent at most in a sequential system containing n flip-flops?
36. What are Moore and Mealy state machines? What is their main difference?
37. What is an unused state in a sequential circuit? What problem can it cause?
38. What is the propagation time of a digital device? What is the difference between $t_{PHL}$ and $t_{PLH}$?
39. Which characteristic times is it necessary to respect in order to ensure that a flip-flop will work correctly? Sketch a figure if needed.

CHAPTER 6:

40. What is a register?
41. What is a counter?
42. What is a synchronous / asynchronous counter?
43. What is a shift register? Give sequential and combinatorial ways to implement a shifter.
44. What is a data path in the RTL description?
45. What do we call a microoperation in the RTL description?
46. What do we call BUS in the RTL description?
47. What do we call ALU in the RTL description?
48. What is a three-state buffer?

CHAPTER 7:

49. What does the acronym RAM/ROM stand for?
50. What do we call static/dynamic memory?
51. What do we call refreshment of a dynamic memory?
52. What do we call volatile memory?
53. What is a word and an address in the description of a memory?

OTHER

54. What is a PLA circuit? What are its advantages?
55. What is a PAL? What are its characteristics and qualities?
56. What is a processor?
Longer Questions
(open questions, applications, ...)

1. Give as many ways as possible to implement a combinational function, indicating when it is interesting to look for a simplification of the function.

2. Give several hardware implementation methods of a combinational function.

3. a) Draw the circuit of a specified* latch using specified* gates.
    b) Explain its functioning and give its state table. Illustrate its functioning with a time diagram.
    c) When and how can we observe a race condition?

4. Based on the provided* circuit of an SR master-slave flip-flop, define and explain the two operating modes observed depending on the value of the control input C.

5. Draw the combinational circuit to add to a D flip-flop in order to form a JK flip-flop.

6. Draw the scheme of a specified* binary counter built with specified* flip-flops.

7. Draw the circuit of an asynchronous modulo 8 counter (ripple counter). Describe its functioning and show that there exist transient states induced by flip-flops propagation delays.

8. What are the characteristics (number of bits, synchronous/asynchronous, serial/parallel, operation modes, control inputs role) of a given counter? (Based on a provided* scheme)

9. Based on the provided* scheme of a memory chip, describe the addressing principle of a memory word for that particular circuit.

10. Considering an AxB memory (for specified* values of A and B):
    a) What is the size of the line-decoder and column-decoder?
    b) For the word stored at a specified* address, determine the output selected by the line-decoder and the output selected by the column-decoder.

11. A (very primitive) computer has a central memory formed by 32 bits. Its instructions set comprises a specified* number of operations, all implemented within the same format stored in one memory word: one field for operational code and one field for direct addressing.
    How many bits are necessary at minimum to store the operational code? ............... 
    What is then the maximum number of addressable words? ................
    What would then be the maximum size of the memory? .................... (in Kbytes)
    What is the largest integer (non-signed) representable in one memory word? ............

12. For the simple computer represented on the provided* scheme, describe briefly the function of specified* fields of a control word at the output of the instruction decoder (in the provided* Table).

13. For the simple programmable system described by provided* Figures and Tables, justify the decoding scheme of the different bits of an instruction, located in a specified* register, into a control word.
14. a) For the simple programmable system described by provided* Figures and Tables, give the content of a specified* register and the state bits after the execution of a given* control word.
b) For the same system, give the symbolic micro-instruction that performs a specified* task (e.g. change the value of a specified register).
c) For the same system, write the microprogram that performs a specified* sequence of tasks (e.g. compare values in registers and store the result).

15. A simple programmable system is described by provided* Figures and Tables:
a) Describe briefly the function of the fields of the control word (listed in a provided* Table), obtained at the output of the instruction decoder.
b) Explain which operation is performed by a given* sequence of instructions.
c) In provided* Table, fill in the instruction fields and control words for a given* instruction (binary values).
d) For a given* instruction, draw the path followed by the information on the provided* diagram.

*Italic elements = specified/provided at the exam