Ph.D. Qualifying Exam – Microprocessor Apps. (Jan’05)

1. Using 8K×4 SRAM devices with CE* (chip enable), OE* (output enable), and R/W* (read/write) control pins, where * denotes active low, design the configuration and interface for a 16KB memory subsystem starting at address $4000 (i.e. 4000_{16}) for a microprocessor with A15:A0, D7:D0, R/W*, and DS* (data strobe) bus lines. Then, add a single byte-wide output port for this system mapped redundantly to addresses $1800:1BFF (i.e. saving logic via partial decoding) using quad D flip-flop devices with OE* and CLK control pins. Use simple gates as needed to complete the interfaces. Include with the solution a detailed memory map. Show all your work neatly, and clearly state any assumptions made in solving this problem.

2. Given an excerpt from the programming model for a simple microprocessor as listed below, write an assembly-language program with comments for each of the following three problems: (a) clear all memory in a 16KB memory subsystem starting at address $4000 (i.e. 4000_{16}); (b) write then read back the test value 10101010_2 with each of the addresses in the subsystem and calculate the number of errors detected and store the result at $1000:1001; and (c) repeatedly read sensor values from an 8-bit input device interfaced at address $F000 to fill the aforementioned memory subsystem, while simultaneously determining the maximum value of these unsigned integers, and when finished store the result for maximum at $1002. Include with the solution a flowchart for each program. Show all your work neatly, and clearly state any assumptions made in solving this problem.

8-bit accumulator registers: A, B, C, D
16-bit address/index/counter registers: X, Y, Z
Control instructions: JE, JNE, JLE, JGE, HALT
Instructions^2 for 8-bit operands: MOV, ADD, SUB, CMP, MUL
Instructions^3 for 16-bit operands: MOVW, INCW, DECW, CMPW

Addressing modes (examples show particular mode in use via bold font):
- Immediate – e.g. MOV A, #5 or MOVW X, #5$1000
- Register – e.g. MOV A, B or INCW Y
- Direct – e.g. MOV A, $1000 or MOVW $1000, Z
- Indirect – e.g. MOV A, [X] or CMP A, [X]

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1 JE = Jump Equal, JNE = Jump Not Equal, JLE = Jump Less or Equal, JGE = Jump Greater or Equal
2 MOV = Move, ADD = Add, SUB = Subtract, CMP = Compare, MUL = Multiply
3 MOVW = Move Word, INCW = Increment Word, DECW = Decrement Word, CMPW = Compare Word