Problem #01

. **[7 points]** An SDRAM module (DIMM) is made out of eight 64M×8 SDRAM chips that receive the same address and command. Each chip contributes 8 bits to the overall data word handled by the module. Suppose the module is connected to a bus clocked at 100MHz.

(a) Represent the size of the module in the form "$m \times n$".

(b) What is the maximum data transfer rate of the module (measured in MB/s)?

(c) Suppose a burst read command is issued while the burst length is set to 8 and the latency is set to 2. How much time is consumed between issuing the command and finishing the data transfer?

(d) If the same command in part (c) was issued to a DDR-SDRAM module with the same cell speed and bus frequency, how long does it take to finish the transfer in this case?

(a) Size of the module is 64M×64

2

(b) Max rate is acheived by producing 64 bit every cyle at 100 MHz speed.

2

$\Rightarrow$ Max rate = 64 b/cycle * 100 M cycle/s

= 6400 Mb/s = 800 MB/s

(c) # of cycles taken = 2 + 8 = 10 cycles

1.5

Time taken = 10 cycles * $\frac{1}{100 \text{ M cycle/s}}$

= 100 nS

(d) # of cycles taken = $2 + \frac{8}{2} = 6$ cycles

1.5

Time taken = 6 cycles * $\frac{1}{100 \text{ M cycle/s}}$

Problem #02

[4 points] A memory system is equipped with a Hamming code for single-error correction (SEC). Each location in the memory contains 16 bits of data and some check bits.
(a) How many check bits are stored in each memory location?
(b) How many legal codewords are possible?
(c) How many illegal codewords are possible?

3. (a) $M = 16$ & $M + K + 1 \leq 2^K \Rightarrow K = 5$
4
(b) # of legal codewords $= 2^M = 2^{16} = 64K$
(c) # of illegal codewords $= 2^{M+K} - 2^M = 2^{21} - 2^{16}$

Problem #03

[6 points] A simple (yet inefficient!) technique for error detection/correction is to create multiple copies of the data word and include these copies in the codeword as check bits. For instance, if the original data word is 1001, then we can use 2 extra copies of such data word as check bits, and hence the codeword becomes 100110011001. Generally speaking, if the original data word is m-bit long and the generated codeword is $i*m$-bit long, where i is an integer:
(a) What is the Hamming distance of the original code (*i.e.*, where no check bits are used, *i.e.*, i=1)?
(b) How many errors can be detected in the original code?
(c) How many errors can be corrected in the original code?
(d) What is the minimum value of i to be able to detect double errors?
(e) What is the minimum value of i to be able to correct double errors?
Hint: You might find it useful to work through a small example and write all the possible codewords for small values of m and i (m=2 and i=2 for instance).

3: (a) Hamming distance $d = 1 \leftarrow i$

(7) (b) # of errors detected $= 0 \leftarrow i-1$

(c) # of errors corrected $= 0 \leftarrow \frac{i-1}{2}$

(d) To detect double-errors $\Rightarrow d \geq 3 \Rightarrow i_{min} = 3$

(e) To correct double-errors $\Rightarrow d \geq 5 \Rightarrow i_{min} = 5$

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7. Which of the following is true about an error-correcting code that consists of the four codewords: 110000, 001111, 001100, and 000111?

(a) It could detect all single-bit errors
(b) It could correct all single-bit errors
(c) It could detect all double-bit errors
(d) All the above
(e) <u>None of the above</u>

7. Which of the following sets could contain the legal codewords of a SEC code?

(a) {000000, 010101, 101010, 111111}
(b) {000000, 000111, 111000, 111111}
(c) {00000, 00111, 11001, 11110}
(d) <u>All the above</u>
(e) Only (a) and (b)