

## Homework set 4

Date: 04/16/2019

- Develop an example of a 32-bit Hamming encoded word (39 bits total) and show a correctable SBE scenario. Show the data word in a table like Figure 5.6 in the book.

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
		pW	p01	p02	d01	p03	d02	d03	d04	p04	d05	d06	d07	d08	d09	d10	d11	p05	d12	d13	d14	d15	d16	d17	d18	d19	d20	d21	d22	d23	d24	d25	d26	p06	d27	d28	d29	d30	d31	d32		
Bit	D	x	x	x	1	x	1	0	1	x	0	0	0	1	1	1	0	x	0	1	0	0	0	1	0	1	1	0	1	1	0	1	0	x	1	0	1	1	0	0		
1	p01		0		1		1		1		0		0		1		0		0		0		0		0		1		1		0		0		1		1		0			
2	p02			0	1				0	1			0	0			1	0			1	0			1	0			0	1			1	0			0	1				
4	p03					1	1	0	1						1	1	1	0					0	0	1	0					1	0	1	0					1	0	0	
8	p04									0	0	0	0	1	1	1	0											1	1	0	1	1	0	1	0							
16	p05																	1	0	1	0	0	0	1	0	1	1	0	1	1	0	1	0			1	1	0	1	0	0	
32	p06																																		1	1	0	1	1	0	0	
ED		1	0	0	1	1	1	0	1	0	0	0	0	1	1	1	0	1	0	1	0	0	0	1	0	1	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0	
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
SYN		pW	p01	p02	d01	p03	d02	d03	d04	p04	d05	d06	d07	d08	d09	d10	d11	p05	d12	d13	d14	d15	d16	d17	d18	d19	d20	d21	d22	d23	d24	d25	d26	p06	d27	d28	d29	d30	d31	d32		
	ED	1	0	0	1	1	1	0	1	0	0	0	0	1	1	1	0	1	0	1	0	0	0	1	1	1	0	1	1	0	1	0	1	0	1	1	0	1	1	0	0	
c01	1		1		1		1		1		0		0		1		0		0		0		0		1		1		1		0		0		1		1		0			
c02	1			1	1			0	1			0	0			1	0			1	0			1	1			0	1			1	0			0	1		0			
c03	1					0	1	0	1						1	1	1	0					0	0	1	1					1	0	1	0				1	0	0		
c04	0									0	0	0	0	1	1	1	0											1	1	0	1	1	0	1	0							
c05	1																	0	0	1	0	0	0	1	1	1	0	1	1	0	1	0	1	0								
c06	0																																			1	1	0	1	1	0	0
pW2	0	1	0	0	1	1	1	0	1	0	0	0	0	1	1	1	0	1	0	1	0	0	0	1	1	1	0	1	1	0	1	0	1	0	1	1	0	1	1	0	0	
23	CD	1	0	0	1	1	1	0	1	0	0	0	0	1	1	1	0	1	0	1	0	0	0	1	0	1	1	0	1	1	0	1	0	1	0	1	1	0	1	1	0	0

Check bits is not equal to 0 and pw2 != pw, Hence there is SBE, we can correct. By check bits we found that there is a flip on 23<sup>rd</sup> bit from 0 to 1, Hence we corrected it to 0.

- For the foregoing problem, now show an uncorrectable MBE scenario.

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	
		pW	p01	p02	d01	p03	d02	d03	d04	p04	d05	d06	d07	d08	d09	d10	d11	p05	d12	d13	d14	d15	d16	d17	d18	d19	d20	d21	d22	d23	d24	d25	d26	p06	d27	d28	d29	d30	d31	d32	
Bit	D	x	x	x	1	x	1	0	1	x	0	0	0	1	1	1	0	x	0	1	0	0	0	1	0	1	1	0	1	1	0	1	0	x	1	0	1	1	0	0	
1 p01		0			1		1		1		0				1		0		0		0		0		0		1		1		0		0		1		1		0		
2 p02			0	1									0	0			1	0			1	0			1	0			0	1			1	0			0	1		0	
4 p03					1	1	0	1							1	1	1	0					0	0	1	0					1	0	1	0				1	0	0	
8 p04									0	0	0	0	1	1	1	0											1	1	0	1	1	0	1	0							
16 p05																		1	0	1	0	0	0	1	0	1	1	0	1	1	0	1	0								
32 p06																																		1	1	0	1	1	0	0	
ED		1	0	0	1	1	1	0	1	0	0	0	0	1	1	1	0	1	0	1	0	0	0	1	0	1	0	1	0	1	1	0	1	0	1	1	0	1	1	0	0

There is MBE as we can see that Check bits !=0 and pw2=pw, Hence it is uncorrectable.

3. For the following Nand flash block update history for 2 sectors that contain 4 blocks each (e.g. 16K sectors, with 4K blocks), fill in the missing WRITE operations as needed and compute write-amplification.

	#1 - Start	#2	#3	#4	#5	#6	#7
Sector Erased (S0, S1)	0,0	1,1	1,1	1,1	1,1	2,1	2,1
S1							
PB7	FREE	FREE	FREE	LB3	LB3	LB3	LB3
PB6	FREE	FREE	LB2	LB2	INVLD	INVLD	INVLD
PB5	FREE	LB3	LB3	INVLD	INVLD	INVLD	INVLD
PB4	FREE	LB2	INVLD	INVLD	INVLD	INVLD	INVLD
S0							
PB3	FREE	FREE	FREE	LB1	LB1	FREE	LB1
PB2	FREE	FREE	LB0	LB0	INVLD	FREE	FREE
PB1	FREE	LB1	LB1	INVLD	INVLD	FREE	LB2
PB0	FREE	LB0	INVLD	INVLD	INVLD	FREE	LB0
FS LBs Updated		0,1,2,3	0,2	1,3	0,2	0,2	0,2
FS LBs Cached					0,2	0,2	
Sector LBs Buffered						1	
Sectors Erased (S0, S1)	2,1	2,1	2,2	2,2	2,2	3,2	3,2
S1							
LB3	INVLD	FREE	FREE	LB2	LB2	LB2	LB2
INVLD	INVLD	FREE	FREE	LB0	LB0	LB0	LB0
INVLD	INVLD	FREE	LB3	LB3	INVLD	INVLD	INVLD
INVLD	INVLD	FREE	LB1	LB1	INVLD	INVLD	INVLD
S0							
LB1	INVLD	INVLD	INVLD	INVLD	INVLD	FREE	FREE
FREE	FREE	FREE	FREE	FREE	FREE	FREE	FREE
LB2	LB2	LB2	LB2	INVLD	INVLD	FREE	LB3
LB0	LB0	LB0	LB0	INVLD	INVLD	FREE	LB1
FS LBs Updated	0,2	1,3	1,3	1,3	0,2	1,3	1,3
FS LBs Cached		1,3	1,3			1,3	1,3
Sector LBs Buffered							

- #1 - All blocks FREE  
 #2 - Erase S0 & S1, WRITE: - LB 0,1,2,2  
 #3 - Read LB 0, 2, Modify, WRITE: - LB 0,2  
 #4 - Read LB 1, 3, Modify, WRITE: - LB 1,3  
 #5 - Read LB 0, 2, Modify and Cache  
 #6 - Buffer LB 0, 1, 2, Erase S0  
 #7 - WRITE- LB 0,1,2 to S0

Write Amplification =  $\frac{11}{10} = 1.1$

- #8 - Read LB 1, 3, Modify and Cache  
 #9 - Erase S1  
 #10 - WRITE- LB 1,3 to S1  
 #11 - Read LB 0, 2, Modify, WRITE LB 0,2  
 #12 - Read LB 1, 3, Modify and Cache  
 #13 - Erase S0  
 #14 - WRITE - LB 1,3

Write Amplification =  $\frac{17}{16} = 1.0625$

Total sector erases for both S0 and S1 = 5 Erases