

1. (1) one set with 2 blocks, offset 0~6  $\Rightarrow$  5 bits word offset  $2^5 = 32$  words in a block  
 Index 5 bits  $\Rightarrow$  32 sets totally  
 tag 20 bits.  
 cache size =  $32 \times 2 \times (2 + 20 + 32 \times 32) = 66944$  bits

set 2 block block 32 word.  
 32 set.

(2)		word off	index	tag	miss/Hit
0	0	0	0	0	M
4	100	1	0	0	H
20	10100	101	0	0	H
136	10001000	10	1	0	M
232	11101000	11010	1	0	H
164	10100100	01001	1	0	H
1024	10000000000	0	1000	0	M
30	11110	00111	0	0	H
140	10001100	00011	1	0	H
3100	110000011100	00111	11000	0	M
176	10110000	01100	1	0	H
2180	100010000100	00001	10001	0	M

Hit ratio:  $\frac{7}{12}$

(3) Index	Tag	Data w <sub>0</sub> w <sub>1</sub> w <sub>2</sub> w <sub>3</sub> w <sub>4</sub> w <sub>5</sub> ... w <sub>7</sub> ... w <sub>9</sub> ... w <sub>12</sub> ... w <sub>26</sub> ... .. w <sub>31</sub>																																		
0	0	M[6]	M[1]	-	-	-	M[5]	M[7]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M[31]		
1	0	M[32]	...	M[34]	M[35]	.	.	.	M[41]	M[44]	M[58]	..	M[63]																							
8	0	M[256]	-			-			-			-																							M[287]	
24	0	M[768]	.	-	-	-	.	M[775]	-	-	-	-	M[799]																							
17	0	M[544]	M[545]	-	-	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	M[575]		

MHz 10<sup>6</sup>

2. (1)  $P_1$  clock time :  $1.18 \text{ ns} \Rightarrow \text{clock rate} = \frac{1}{1.18 \times 10^{-9}} = 847457627.1 \text{ Hz}$   
 $P_2$  clock time :  $2.22 \text{ ns} \Rightarrow \text{clock rate} = \frac{1}{2.22 \text{ ns}} = 450450450.5 \text{ Hz}.$

(2)  $\text{AMAT } P_1 = 1.18 + 4.3\% \cdot T_0 = 4.19 \text{ ns}$

$\text{AMAT } P_2 = 2.22 + 2.7\% \cdot T_0 = 4.11 \text{ ns}.$

(3)  $\text{CPI } P_1 = 1 + 36\% \cdot 4.3\% \cdot \frac{T_0}{1.18} = 1.918$

$\text{CPI } P_2 = 1 + 36\% \cdot 2.7\% \cdot \frac{T_0}{2.22} = 1.306$

Time  $P_1$ :  $1.918 \times 1.18 = 2.26 \text{ ns}$ , Time  $P_2 = 1.306 \times 2.22 = 2.92 \text{ ns}.$   $\therefore P_1$  is better

3 (1) 3 blocks per set, 2 words per block 24 words  $\Rightarrow$  4 sets.

27 tag, 2 set index, 1 word off, 2 byte off

index bits, tag bits, offset bits, H/M

3:	00	0	011	M	
180:	10.	101	100	M	
43:	01	1	011	M	
3:	00	0	011	H	
191:	11	101	111	M	
89:	11	10	001	M	b2
190:	11	101	110	H	
14:	01	0	110	M	b2.
181:	10	101	101	H	
44:	01	1	100	H	
186:	11	101	010	H	
252:	11	111	100	M	b3.

10 | 0 | 1 | 1

Index	Tag	W0	W1	Tag	W0	W1	Tag	W0	W1
00	27'b0	M[0]	M[1]						
01	(26'b0)1	M[10]	M[11]	27'b0	M[2]	M[3]			
10	(24'b0)101	M[44]	M[45]						
11	(24'b0)101	M[46]	M[47]	(25'b0)11	M[22]	M[23]	(24'b0)111	M[62]	M[63]

(2) 1 word per block, 8 blocks per set, 1 set.

index bits, tag bits, H/M

3:	/	0	M	b <sub>1</sub> ✓
180:	/	10110	M	b <sub>2</sub> ✓
43:	/	1010	M	b <sub>3</sub>
3:	/	0	H	
191:	/	10111	M	b <sub>4</sub> ✓
89:	/	10110	M	b <sub>5</sub>
196:	/	10111	H	
14:	/	11	M	b <sub>6</sub>
181:	/	10110	H	
44:	/	1011	M	b <sub>7</sub>
186:	/	10110	M	b <sub>8</sub>
252:	/	111111	M	replace b <sub>3</sub> . M[16] → M[63]

$$\text{miss rate} = \frac{9}{12} = \frac{3}{4}$$

Index 0	Tag	W	Tag	W	Tag	W	Tag	W
	30'b0	M[0]	(24'b0)10110	M[45]	(24'b0)11111	M[63]	(24'b0)10111	M[47]
	Tag	W	Tag	W	Tag	W	Tag	W
	(25'b0)10110	M[22]	(28'b0)11	M[3]	(26'b0)1011	M[11]	(24'b0)10110	M[46]

(3) one set, 4 blocks with 2 words.

	tag	word df.	H/M (LRU)	
3:	0	0	M	b <sub>1</sub>
180:	10110	1	M	b <sub>2</sub>
43:	101	0	M	b <sub>3</sub>
3:	0	0	H	b <sub>1</sub> ✓
191:	10111	1	M	b <sub>4</sub>
89:	101	0	M	b <sub>2</sub>
190:	10111	1	H	b <sub>4</sub> ✓
14:	1	1	M	b <sub>3</sub>
181:	10110	1	M	b <sub>1</sub>
44:	101	1	M	b <sub>2</sub>
186:	10111	0	H	b <sub>4</sub> ✓
252:	11111	1	M	b <sub>3</sub>

$$\text{miss rate} = \frac{9}{12} = 0.75$$

	tag	word df.	H/M (MRU)	
3:	0	0	M	b <sub>1</sub>
180:	10110	1	M	b <sub>2</sub>
43:	101	0	M	b <sub>3</sub>
3:	0	0	H	b <sub>1</sub> ✓
191:	10111	1	M	b <sub>4</sub>
89:	101	0	M	b <sub>4</sub>
190:	10111	1	M	b <sub>4</sub>
14:	1	1	M	b <sub>4</sub>
181:	10110	1	H	b <sub>2</sub>
44:	101	1	H	b <sub>3</sub>
186:	10111	0	M	b <sub>3</sub>
252:	11111	1	M	b <sub>3</sub>

$$\text{miss rate} = \frac{9}{12} = 0.75$$

If choosing LRU or MRU, miss rate will be 0.75, if combine LRU and MRU, we can have at most 5 hits, so miss rate will be  $\frac{7}{12} = 0.583$ .