

1. (1) 5 bit index $\Rightarrow 32$ sets

$32 \text{ sets} \times 2 \text{ ways} = 64 \text{ blocks}$

each block 1'b Valid, 1'b dirty, 20'b tag
 $32 \times 32 \text{'b word}$

data size: $64 \times 32 \times 32 = 65536 \text{ bits}$

other size: $64 \times (1+1+20) = 1408 \text{ bits}$

overall size: $65536 + 1408 = 66944 \text{ bits}$

(2) address: index data h/m

0 00000 - 0 00000 miss

4 00000 - 0 00001 hit

20 00000 - 0 00101 hit

136 00001 - 0 00010 miss

232 00001 - 0 11010 hit

164 00001 - 0 01001 hit

1024 01000 - 0 00000 miss

30 00000 - 0 00111 hit

140 00001 - 0 00011 hit

360 11000 - 0 00111 miss

176 00001 - 0 01100 hit

2180 10001 - 0 00001 miss

hit ratio: $7 \div 12 = 58.33\%$

(3) index	V	Tag	Data
00000	1	00000	mem[0] - mem[127]
	0	/	/
00001	1	00000	mem[128] - mem[255]
	0	/	/
⋮			
01000	1	00000	mem[1024] - mem[1151]
	0	/	/
⋮			
10001	1	00000	mem[2176] - mem[2303]
	0	/	/
⋮			
11000	1	00000	mem[3272] - mem[3199]
	0	/	/

2. (1) clock rate $P1 = 1/1.18ns = 0.848 \text{ GHz}$

$P2 = 1/2.22ns = 0.451 \text{ GHz}$

(2) $AMAT_{P1} = 1.18 + 4.3\% \times 70 = 4.19ns$

$AMAT_{P2} = 2.22 + 2.7\% \times 70 = 4.11ns$

(3) for $P1$, miss penalty = $70 \div 1.18 = 60 \text{ cycles}$

$act_CPI_{P1} = 1 + 36\% \times 4.3\% \times 60 = 1.9288ns$

for $P2$, miss penalty = $70 \div 2.22 = 32 \text{ cycles}$

$act_CPI_{P2} = 1 + 36\% \times 2.7\% \times 32 = 1.31604ns$

$P2$ is faster

3. (1) 27'b tag 2'b index 1'b word of 2'b byte offset

address	index	tag	data	h/m
3	00-0	000	0	miss
180	10-0	101	1	miss
43	01-0	001	0	miss
3	00-0	000	0	hit
191	11-0	101	1	miss
89	11-1	010	0	miss
190	11-0	101	1	hit
14	01-1	000	1	miss
181	10-0	101	1	hit
44	01-0	001	1	hit
186	11-0	101	0	hit
252	11-2	111	1	miss

index	v	Tag	Data
00	1	000	mem[0] - mem[7]
	0	/	/
	0	/	/
01	1	001	mem[8] - mem[15]
	1	000	mem[16] - mem[23]
	0	/	/
10	1	101	mem[24] - mem[31]
	0	/	/
	0	/	/
11	1	101	mem[32] - mem[39]
	1	010	mem[40] - mem[47]
	1	111	mem[48] - mem[55]

(2) 30'b tag 0'b index 0'b word offset 2'b byte offset

address	tag	h/m
3	000000	miss
180	101101	miss
43	001010	miss
3	000000	hit
191	101111	miss
89	010110	miss
190	101111	hit
14	000011	miss
181	101101	hit
44	001011	miss
186	101110	miss
252	111111	miss

V	Tag	Data
1	000000	mem[0] - mem[3]
1	101101	mem[180] - mem[183]
1	111111	mem[252] - mem[255]
1	101111	mem[188] - mem[191]
1	010110	mem[88] - mem[91]
1	000011	mem[12] - mem[15]
1	001011	mem[44] - mem[47]
1	101110	mem[184] - mem[187]

C3) 29'b tag 0'b index 1'b word offset 2'b byte offset

address:	tag	data	LRU h/m	MRU h/m
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3	00000	0	miss	miss
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180	10110	1	miss	miss
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43	00101	0	miss	miss
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3	00000	0	hit	hit
---	-------	---	-----	-----

191	10111	1	miss	miss
-----	-------	---	------	------

89	01011	0	miss	miss
----	-------	---	------	------

190	10111	1	hit	miss
-----	-------	---	-----	------

14	00001	1	miss	miss
----	-------	---	------	------

181	10110	1	miss	hit
-----	-------	---	------	-----

44	00101	1	miss	hit
----	-------	---	------	-----

186	10111	0	hit	miss
-----	-------	---	-----	------

252	11111	1	miss	miss
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rate: $9/12 = 75\%$ $9/12 = 75\%$

They are equivalent

Best strategy: remember which tag needs access again

miss rate: $\frac{7}{12} = 58.3\%$