

I1 I2 I3 I4 I5 I6

2. I1 -
I2 -
I3 WAW RAW -
I4 WAW WAR \ J T
I5 RAW RAW \
I6 RAW \

4. (1) $T_A = 1ns, CPI_A = N + 4 + \frac{N}{5}$

$T_B = 0.6ns, CPI_B = N + 11 + 3 \cdot \frac{N}{8}$

$S = \frac{T_A \cdot CPI_A}{T_B \cdot CPI_B} = \frac{6N + 20}{\frac{33}{8}N + 33} = \frac{4816}{33} \cdot \frac{1}{(N+8)}$

(2) $CPI_A = \frac{N + 4 + \frac{N}{5} + 2 \cdot N \cdot 20\% \cdot 5\%}{N} = 1.22N + 4$

$CPI_B = \frac{N + 11 + \frac{3N}{8} + 5N \cdot 20\% \cdot 5\%}{N} = 1.425N + 11$

6. (1) ① $ld\ a1, 0(a2); addi\ a1, a1, 1$ RAW

② $addi\ a1, a1, 1; sd\ a1, 0(a2)$ RAW

③ $sd\ a1, 0(a2); addi\ a2, a2, 4$ RAW

④ $addi\ a2, a2, 4; sub\ a4, a3, a2$ RAW

⑤ $sub\ a4, a3, a2; bnez\ a4, Loop$ RAW

⑥ $addi\ a2, a2, 4; \dots; ld\ a1, 0(a2)$ RAW



(2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ld a1, 0(a2)	IF	ID	EX	MEM	WB										
addi a1, a1, 1		IF	ID	S	S	EX	MEM	WB							
sd a1, 0(a2)			IF	ID	S	S	EX	S	MEM	WB					
addi a2, a2, 4				IF	ID	S	S	S	S	EX	S	MEM	WB		
sub a4, a3, a2					IF	ID	S	S	S	S	S	S	S	EX	S
bnez a4, Loop						IF	ID	S	S	S	S	S	S	S	S

	15	16	17	18	19	20	21	22
sub a4, a3, a2	S	MEM	WB					
bnez a4, Loop	S	S	S	EX	S	MEM	WB	

- 共 21 个 CLK

IF

7. (1)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ld a1, 0(a2)	IF	ID	EX	MEM	WB											
addi a1, a1, 1		IF	ID	S	EX	MEM	WB									
sd a1, 0(a2)			IF	ID	S	EX	MEM	WB								
addi a2, a2, 4				IF	ID	S	S	EX	MEM	WB						
sub a4, a3, a2					IF	ID	S	S	EX	MEM	WB					
bnez a4, Loop						IF	ID	S	S	EX	MEM	WB				

- 共 12 个 CLK

IF

(2) 下一周期在 bnez a4, Loop 完成 EX 后开启
故 CLK 变为 10



8.	1	2	3	4	5	6	7	8	9	10	11	12
ld a1, 0(a2)	IF1	IF2	ID1	ID2	EX1	EX2	M1	M2	WB1	WB2		
addi a1, a1, 1		IF1	IF2	ID1	ID2	S	S	S	EX1	EX2	M1	M2
sd a1, 0(a2)			IF1	IF2	ID1	ID2	S	S	S	EX1	EX2	M1
addi a2, a2, 4				IF1	IF2	ID1	ID2	S	S	S	S	S
sub a4, a3, a2					IF1	IF2	ID1	ID2	S	S	S	S
bnez a4, Loop						IF1	IF2	ID1	ID2	S	S	S
	13	14	15	16	17	18	19	20	21	22	23	
ld ..												
addi ..		WB1	WB2									
sd ..		M2	WB1	WB2								
addi ..		S	EX1	EX2	M1	M2	WB1	WB2				
sub ..		S	S	S	EX1	EX2	M1	M2	WB1	WB2		
bnez ..		S	S	S	S	S	EX1	EX2	M1	M2	WB1	WB2
ld a1, 0(a2)							IF1	IF2	-	-	-	-

- 共 ²⁰~~19~~ 个 CLK

$$(2) \quad 6(2): CPI = \frac{21}{6} = \frac{7}{2}$$

$$7(1): CPI = \frac{12}{6} = 2$$

$$7(2) \text{ 行}: CPI = \frac{10}{6} = \frac{5}{3}$$

$$8(1): CPI = \frac{19}{6}$$



(1) w add addi ld sd bne jal jalr
是 否 否 否 是 否 否

(2) 1 2 3 4 5 6 7 8 9 10 11 12

lw a4, 0(a3) IF ID EX MEM WB

addw a1, a4, a1 IF ID, ID S EX MEM WB

addiw a2, a2, -1 IF ID #S S EX MEM WB

addiw a3, a3, 4 IF ID S S EX MEM WB

bnez a2, Loop IF ID S S S EX MEM WB

- 共 12 个 CLK

(3) 1 2 3 4 5 6 7 8 9 10

lw a4, 0(a3) IF ID EX MEM WB

addw a1, a4, a1 IF ID S EX MEM WB

addiw a2, a2, -1 IF ID S EX MEM WB

addiw a3, a3, 4 IF ID S EX MEM WB

bnez a2, Loop IF ID S EX MEM WB

- 共 10 个 CLK

