LOOP: subi r1, r1, 1 Fetch muld f0, f1, f1 addd f0, f2, f2 bne r1, r0, LOOP addd f1, f2, f3

	Tag	Value	Valid
f0		0	1
f1		1	1
f2		2	1
f3		3	1

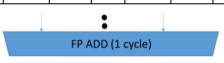
	Tag	Value	Valid
r0		0	1
r1		2	1

	Inst	Reg	Value	Valid
Α	ı	ı	ı	0
В	ı	ı	ı	0
С	-	-	-	0
D	-	-	-	0
Ε	-	-	-	0

ROB

Ta	ng	Value	Valid	Tag	Value	Valid	ROB
	-	ı	0	ı	ı	0	1
	-	-	0	-	-	0	-
:							
FP MUIT (4 cycles)							

Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	-	0	ī	ı	0	-



Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	ı	0	ī	ı	0	-

LOOP: subi r1, r1, 1 Dispatch
muld f0, f1, f1 Fetch
addd f0, f2, f2
bne r1, r0, LOOP
addd f1, f2, f3

	Tag	Value	Valid
f0		0	1
f1		1	1
f2		2	1
f3		3	1

	Tag	Value	Valid
r0		0	1
r1	Α	2	0

	Inst	Reg	Value	Valid
Α	subi	r1	-	0
В	-	-	-	0
С	-	-	-	0
D	-	-	-	0
Ε	1	-	-	0

ROB

	Tag	Value	Valid	Tag	Value	Valid	ROB	
	-	-	0	-	-	0	, i	
	-	-	0	-	-	0	1	
FP MULT (4 cycles)								

Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	-	0	ī	ı	0	ı

FP ADD (1 cycle)

Tag	Value	Valid	Tag	Value	Valid	ROB
-	2	1	ı	ı	0	Α
-	-	0	-	=	0	-

LOOP: subi r1, r1, 1 Issue (E1)
muld f0, f1, f1 Dispatch
addd f0, f2, f2 Fetch
bne r1, r0, LOOP
addd f1, f2, f3

	Tag	Value	Valid
f0		0	1
f1	В	1	0
f2		2	1
f3		3	1

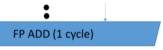
	Tag	Value	Valid
r0		0	1
r1	Α	2	0

	Inst	Reg	Value	Valid
Α	subi	r1	ľ	0
В	muld	f1	-	0
С	-	-	-	0
D	-	-	-	0
Ε	-	-	-	0

ROB

Tag	Value	Valid	Tag	Value	Valid	ROB	
1	0	1	1	1	1	В	
-	-	0	-	-	0	-	
<b>:</b>							
FP MULT (4 cycles)							

Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	ı	0	ī	ı	0	-



Tag	Value	Valid	Tag	Value	Valid	ROB
-	2	1	í	II	0	Α
-	-	0	-	-	0	-

LOOP: subi r1, r1, 1 WB

muld f0, f1, f1 Issue (E1) addd f0, f2, f2 Dispatch

bne r1, r0, LOOP Fetch (and predict as Taken)

addd f1, f2, f3

	Tag	Value	Valid
f0		0	1
f1	В	1	0
f2	C	2	0
f3		3	1

	Tag	Value	Valid
r0		0	1
r1	Α	2	0

	Inst	Reg	Value	Valid
Α	subi	r1	1	1
В	muld	f1	-	0
С	addd	f2	-	0
D	-	-	-	0
Ε	-	-	-	0

ROB

Tag	Value	Valid	Tag	Value	Valid	ROB	
-	0	1	-	1	1	В	
-	-	0	-	-	0	-	
1 1							
FP MULT (4 cycles)							

Tag	Value	Valid	Tag	Value	Valid	ROB
-	0	1	ı	2	1	С
-	-	0	ī	ı	0	-

FP ADD (1 cycle)

Tag	Value	Valid	Tag	Value	Valid	ROB
ı	-	0	-	ı	0	-
ī	-	0	-	-	0	-

LOOP: subi r1, r1, 1 Commit
muld f0, f1, f1 Issue (E2)
addd f0, f2, f2 Issue (E1)
bne r1, r0, LOOP Dispatch
LOOP: subi r1, r1, 1 Fetch

	Tag	Value	Valid
f0		0	1
f1	В	1	0
f2	С	2	0
f3		3	1

	Tag	Value	Valid
r0		0	1
r1	-	1	1

	Inst	Reg	Value	Valid	T/NT
Α	-			0	0
В	muld	f1	ı	0	0
С	addd	f2	-	0	0
D	bne	-	-	0	Т
Ε	-	-	-	0	

ROB

Tag	Value	Valid	Tag	Value	Valid	ROB		
-	0	1	-	1	1	В		
-	-	0	-	-	0	1		
: 1								
FP MULT (4 cycles)								

Tag	Value	Valid	Tag	Value	Valid	ROB
ı	0	1	-	2	1	С
-	ı	0	-	-	0	-

FP ADD (1 cycle)

Tag	Value	Valid	Tag	Value	Valid	ROB
-	1	1	ı	0	1	D
-	-	0	-	-	0	-

#### LOOP: subi r1, r1, 1

muld f0, f1, f1 Issue (E3)

addd f0, f2, f2 WB

bne r1, r0, LOOP Issue (E1)

LOOP: subi r1, r1, 1 Dispatch

muld f0, f1, f1 Fetch

	Tag	Value	Valid
f0		0	1
f1	В	1	0
f2	C	2	0
f3		3	1

	Tag	Value	Valid
r0		0	1
r1	Е	1	0

	Inst	Reg	Value	Valid	T/NT
Α	ľ	ı	ľ	0	0
В	muld	f1	ľ	0	0
С	addd	f2	2	1	0
D	bne	-	=	0	Т
Ε	subi	r1	-	0	0

**ROB** 

Tag	Value	Valid	Tag	Value	Valid	ROB	
-	0	1	-	1	1	В	
_	ı	0	-	ı	0	1	
<b>:</b>							
FD MULT (A evalue)							

Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	-	0	-	-	0	-

## FP ADD (1 cycle)

Tag	Value	Valid	Tag	Value	Valid	ROB			
-	1	1	-	0	1	D			
-	1	1	-	-	0	Е			
	•								

#### LOOP: subi r1, r1, 1

muld f0, f1, f1 Issue (E4)
addd f0, f2, f2 Waiting
bne r1, r0, LOOP WB(Taken)
LOOP: subi r1, r1, 1 Issue (E1)
muld f0, f1, f1 Dispatch
addd f0, f2, f2 Fetch

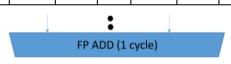
	Tag	Value	Valid
f0		0	1
f1	F	1	0
f2	С	2	0
f3		3	1

	Tag	Value	Valid
r0		0	1
r1	E	1	0

	Inst	Reg	Value	Valid	T/NT
Α	ı	ı	1	0	0
В	muld	f1	ı	0	0
С	addd	f2	2	1	0
D	bne	-	-	1	Т
Ε	subi	r1	-	0	0
F	muld	f1	-	0	0

Tag	Value	Valid	Tag	Value	Valid	ROB		
-	0	1	-	1	1	В		
-	0	1	В	-	0	F		
FP MULT (4 cycles)								

Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	-	0	-	-	0	-



Tag	Value	Valid	Tag	Value	Valid	ROB	
-	ı	0	-	-	0	ı	
-	1	1	-	-	0	Е	
<b>:</b>							
INT ALL (1 cycle)							

#### LOOP: subi r1, r1, 1

muld f0, f1, f1 WB addd f0, f2, f2 Waiting bne r1, r0, LOOP Waiting

LOOP: subi r1, r1, 1 WB

muld f0, f1, f1 Waiting addd f0, f2, f2 Dispatch

bne r1, r0, LOOP Fetch (and predict as taken)

	Tag	Value	Valid
f0		0	1
f1	F	1	0
f2	G	2	0
f3		3	1

	Tag	Value	Valid
r0		0	1
r1	E	1	0

	Inst	Reg	Value	Valid	T/NT
Α	ï	ı	ľ	0	0
В	muld	f1	0	1	0
С	addd	f2	2	1	0
D	bne	ı	ľ	1	T
Ε	subi	r1	0	1	0
F	muld	f1	=	0	0
G	addd	f2	-	0	0

ROB

Tag	Value	Valid	Tag	Value	Valid	ROB	
-	-	0	-	-	0	-	
-	0	1	-	0	1	F	
•							
FP MULT (4 cycles)							

Tag	Value	Valid	Tag	Value	Valid	ROB
ı	0	1	ı	2	1	G
-	-	0	-	-	0	-

## FP ADD (1 cycle)

Tag	Value	Valid	Tag	Value	Valid	ROB	
-	-	0	-	-	0	-	
-	-	0	-	-	0	-	
:							
INT ALU (1 cycle)							

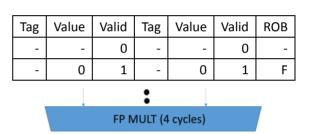
#### LOOP: subi r1, r1, 1

muld f0, f1, f1 Commit addd f0, f2, f2 Waiting bne r1, r0, LOOP Waiting LOOP: subi r1, r1, 1 Waiting muld f0, f1, f1 Issue(E1) addd f0, f2, f2 Issue(E1) bne r1, r0, LOOP Dispatch LOOP: subi r1, r1, 1 **Fetch** 

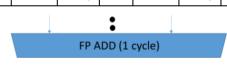
	Tag	Value	Valid
f0		0	1
f1	F	0	0
f2	G	2	0
f3		3	1

	Tag	Value	Valid
r0		0	1
r1	Ε	1	0

	Inst	Reg	Value	Valid	T/NT
Α	-	-	-	0	0
В	-	-	-	0	0
С	addd	f2	2	1	0
D	bne	-	-	1	Т
Ε	subi	r1	0	1	0
F	muld	f1	-	0	0
G	addd	f2	-	0	0
Н	bne	-	-	0	Т



Tag	Value	Valid	Tag	Value	Valid	ROB
-	0	1	-	2	1	G
-	-	0	-	-	0	-
	1		•			



	Tag	Value	Valid	Tag	Value	Valid	ROB
	-	0	1	-	0	1	I
	-	ı	0	ī	ı	0	-
	•						
INT ALU (1 cycle)							

#### LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2 Commit
bne r1, r0, LOOP Waiting
LOOP: subi r1, r1, 1 Waiting
muld f0, f1, f1 Issue(E2)
addd f0, f2, f2 WB

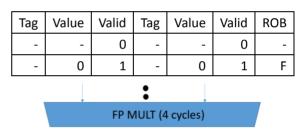
bne r1, r0, LOOP Issue(E1)
LOOP: subi r1, r1, 1 Dispatch
muld f0, f1, f1 Fetch

	Tag	Value	Valid
f0		0	1
f1	F	0	0
f2	G	2	0
f3		3	1

	Tag	Value	Valid
r0		0	1
r1	1	1	0

	Inst	Reg	Value	Valid	T/NT
Α	ı	ı	ı	0	0
В	ı	ı	ı	0	0
С	-	-	-	0	0
D	bne	-	1	1	T
Ε	subi	r1	0	1	0
F	muld	f1	1	0	0
G	addd	f2	2	1	0
Н	bne	ı	ı	0	T
I	subi	r1	-	0	0

... ROB



Tag	Value	Valid	Tag	Value	Valid	ROB	
-	1	0	-	1	0	-	
-	-	0	-	-	0	-	
•							

FP ADD (1 cycle)

Tag	Value	Valid	Tag	Value	Valid	ROB
-	0	1	-	0	1	Н
-	0	1	-	-	0	- 1
•						

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP Commit

LOOP: subi r1, r1, 1 Waiting

muld f0, f1, f1 Issue(E3)

addd f0, f2, f2 Waiting

bne r1, r0, LOOP WB (not taken!)

LOOP: subi r1, r1, 1 | Issue(E1)

muld f0, f1, f1 Dispatch

addd f0, f2, f2 Fetch

	Tag	Value	Valid
f0		0	1
f1	J	0	0
f2	G	2	0
f3		3	1

	Tag	Value	Valid
r0		0	1
r1	I	1	0

	Inst	Reg	Value	Valid	T/NT
Α	-	-	-	0	0
В	ı	ı	ı	0	0
С	ı	ı	ı	0	0
D	-	-	-	0	0
Ε	subi	r1	0	1	0
F	muld	f1	1	0	0
G	addd	f2	2	1	0
Н	bne	ı	•	1	NT
I	subi	r1	-	0	0
J	muld	f1	-	0	0

Tag	Value	Valid	Tag	Value	Valid	ROB	
-	0	1	F	-	0	J	
-	0	1	-	0	1	F	
<b>:</b> 1							
FP MULT (4 cycles)							

Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	-	0	-	-	0	-
			•			

## FP ADD (1 cycle)

Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	0	1	-	-	0	_
	ļ		:	1		
INT ALU (1 cycle)						

## Cycle 11 (Frozen for recovery)

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP

LOOP: subi r1, r1, 1 Waiting

muld f0, f1, f1 Issue(E3)

addd f0, f2, f2 Waiting

bne r1, r0, LOOP WB (not taken!)

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

	Tag	Value	Valid
f0		0	1
f1	F	0	0
f2	G	2	0
f3		3	1

	Tag	Value	Valid
r0		0	1
r1	Е	1	0

	Inst	Reg	Value	Valid	T/NT
Α	ï	ı	ľ	0	0
В	ï	ı	ľ	0	0
С	ï	ı	ľ	0	0
D	ī	ı	ľ	0	0
Ε	subi	r1	0	1	0
F	muld	f1	-	0	0
G	addd	f2	2	1	0
Н	bne	ı	Ü	1	NT
Ι	ı	ı	1	0	0
J	-	-	-	0	0

Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	0	1	-	0	1	F
1 1						
FP MULT (4 cycles)						

Tag	Value	Valid	Tag	Value	Valid	ROB
1	-	0	-	-	0	-
-	-	0	-	-	0	-
	1		_			

FP ADD (1 cycle)

Tag	Value	Valid	Tag	Value	Valid	ROB
-	ı	0	ı	1	0	ı
-	-	0	-	-	0	-
			:			
		INT	ALU (1	cycle)		

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP

LOOP: subi r1, r1, 1 Commit

muld f0, f1, f1 Issue(E4)

addd f0, f2, f2 Waiting

bne r1, r0, LOOP Waiting

addd f1, f2, f3 Fetch

	Tag	Value	Valid
f0		0	1
f1	F	0	0
f2	G	2	0
f3		3	1

	Tag	Value	Valid
r0		0	1
r1		0	1

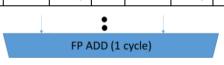
	Inst	Reg	Value	Valid	T/NT
Α	ī	ı	1	0	0
В	ī	ı	•	0	0
С	1	ı	1	0	0
D	ï	ı	ı	0	0
Ε	1	1	1	0	0
F	muld	f1	ı	0	0
G	addd	f2	2	1	0
Н	bne	ı	ı	1	NT
Ι	1	1	-	0	0
J	-	-	-	0	0

 Tag
 Value
 Valid
 Tag
 Value
 Valid
 ROB

 0
 0

 0
 1
 0
 1
 F

Tag	Value	Valid	Tag	Value	Valid	ROB	
-	-	0	-	-	0	-	
-	-	0	-	-	0	-	



	Tag	Value	Valid	Tag	Value	Valid	ROB	
	-	I	0	1	II	0	ı	
Ī	-	-	0	-	-	0	-	
	:							
	INT ALU (1 cycle)							

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP

LOOP: subi r1, r1, 1

muld f0, f1, f1 WB

addd f0, f2, f2 Waiting bne r1, r0, LOOP Waiting

addd f1, f2, f3 Dispatch

	Tag	Value	Valid
f0		0	1
f1	F	0	0
f2	G	2	0
f3	1	3	0

	Tag	Value	Valid
r0		0	1
r1		0	1

	Inst	Reg	Value	Valid	T/NT
Α	-	1	-	0	0
В	-	1	1	0	0
С	-	ı	1	0	0
D	-	1	-	0	0
Ε	-	-	-	0	0
F	muld	f1	0	1	0
G	addd	f2	2	1	0
Н	bne	-	-	1	NT
1	addd	f3	-	0	0
J	-	-	-	0	0

ROB

Tag	Value	Valid	Tag	Value	Valid	ROB	
-	-	0	-	-	0	-	
-	-	0	-	-	0	-	
• ·							
FP MULT (4 cycles)							

Tag	Value	Valid	Tag	Value	Valid	ROB
1	0	1	1	2	1	- 1
-	-	0	-	-	0	1

# FP ADD (1 cycle)

Tag	Value	Valid	Tag	Value	Valid	ROB	
-	-	0	-	-	0	-	
-	ı	0	ī	ı	0	-	
:							

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP

LOOP: subi r1, r1, 1

muld f0, f1, f1 Commit

addd f0, f2, f2 Waiting bne r1, r0, LOOP Waiting

addd f1, f2, f3 | Issue(E1)

	Tag	Value	Valid
f0		0	1
f1		0	1
f2	G	2	0
f3	I	3	0

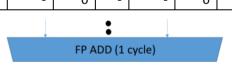
	Tag	Value	Valid
r0		0	1
r1		0	1

	Inst	Reg	Value	Valid	T/NT
Α	ï	-	-	0	0
В	ı	1	1	0	0
С	ı	ı	1	0	0
D	ï	ı	ı	0	0
Ε	-	-	-	0	0
F	-	-	-	0	0
G	addd	f2	2	1	0
Н	bne	-	-	1	NT
1	addd	f3	-	0	0
J	ı	-	-	0	0
•	addd -	f3 -	-	_	

ROB

Tag	Value	Valid	Tag	Value	Valid	ROB	
-	-	0	-	-	0	-	
-	-	0	-	-	0	-	
<b>:</b>							
FP MULT (4 cycles)							

Tag	Value	Valid	Tag	Value	Valid	ROB
-	0	1	-	2	1	1
-	ı	0	ī	ı	0	-



Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	-	0	-	-	0	-

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2

bne r1, r0, LOOP

LOOP: subi r1, r1, 1

muld f0, f1, f1

addd f0, f2, f2 Commit

bne r1, r0, LOOP Waiting

addd f1, f2, f3 WB

	Tag	Value	Valid
f0		0	1
f1		0	1
f2		2	1
f3	I	3	0

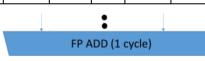
	Tag	Value	Valid
r0		0	1
r1		0	1

	Inst	Reg	Value	Valid	T/NT
Α	1	ı	ı	0	0
В	ī	ı	1	0	0
С	Ī	ı	1	0	0
D	ı	ı	ı	0	0
Ε	ı	ı	ı	0	0
F	ı	ı	ı	0	0
G	1	1	1	0	0
Н	bne	ı	ı	1	NT
I	addd	f3	2	1	0
J	-	-	-	0	0

ROB

Tag	Value	Valid	Tag	Value	Valid	ROB	
-	-	0	-	-	0	-	
-	-	0	-	-	0	-	
:							
FP MULT (4 cycles)							

Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	-	0	-	-	0	-



Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	ı	0	ī	ı	0	-

LOOP: subi r1, r1, 1 muld f0, f1, f1 addd f0, f2, f2 bne r1, r0, LOOP LOOP: subi r1, r1, 1 muld f0, f1, f1 addd f0, f2, f2

bne r1, r0, LOOP Commit addd f1, f2, f3 Waiting

	Tag	Value	Valid
f0		0	1
f1		0	1
f2		2	1
f3	ı	3	0

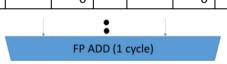
	Tag	Value	Valid
r0		0	1
r1		0	1

	Inst	Reg	Value	Valid	T/NT
Α	-	ı	ı	0	0
В	-	ı	Ü	0	0
С	-	ı	ı	0	0
D	-	1	-	0	0
Ε	-	-	-	0	0
F	-	-	-	0	0
G	-	-	-	0	0
Н	-	-	-	0	0
I	addd	f3	2	1	0
J	-	-	-	0	0

ROB

Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	-	0	-	-	0	-
<b>.</b>						
FP MULT (4 cycles)						

0 - 0 - 0 0 -	Tag	Value	Valid	Tag	Value	Valid	ROB
0 0 -	-	-	0	-	-	0	-
	-	-	0	-	-	0	-



Tag	Value	Valid	Tag	Value	Valid	ROB
-	-	0	-	-	0	-
-	ı	0	ī	ı	0	-
			:			

LOOP: subi r1, r1, 1 muld f0, f1, f1 addd f0, f2, f2 bne r1, r0, LOOP LOOP: subi r1, r1, 1 muld f0, f1, f1 addd f0, f2, f2 bne r1, r0, LOOP

addd f1, f2, f3 Commit

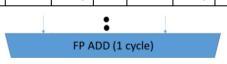
	Tag	Value	Valid
f0		0	1
f1		0	1
f2		2	1
f3		2	0

	Tag	Value	Valid
r0		0	1
r1		0	1

	Inst	Reg	Value	Valid	T/NT
Α	-	-	-	0	0
В	-	-	-	0	0
С	ı	ı	ı	0	0
D	ı	ı	ľ	0	0
Ε	ı	ı	ľ	0	0
F	ı	ı	ľ	0	0
G	ı	ı	ľ	0	0
Н	ı	ı	ľ	0	0
1	-	-	-	0	0
J	-	-	=	0	0

Tag	Value	Valid	Tag	Value	Valid	ROB
ı	-	0	-	-	0	-
-	-	0	-	-	0	-
<b>:</b>						
FP MULT (4 cycles)						

Tag	Value	Valid	Tag	Value	Valid	ROB
Í	I	0	ı	I	0	ı
-	-	0	-	-	0	-
	1		_			



Tag	Value	Valid	Tag	Value	Valid	ROB
-	I	0	í	II	0	ı
-	ı	0	ī	ı	0	-
<b>.</b>						
INT ALU (1 cycle)						