Project Team:

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1. ADD

111 → rf-a1 rf-d1 → Mem-a,alu Mem_d → IR +1 → alu alu →PC	IR
	Х
	X-X
	HKT
	GET_AB

ID (11.0) . ef o1	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	Х
$rf-d1 \rightarrow t1$	X-X
rf-d2 \rightarrow t2 IR_(0-7) \rightarrow SE(8) \rightarrow t4	GET_AB
"_\(\sigma\) \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \	SB

t1 → alu t2 →alu alu → t3	NONE
	ADD
	C-Z
	ALU
	RB

$t3 \rightarrow rf-d3$ $IR_{-}(5-3) \rightarrow rf-a3$	NONE
	Х
	X-X
	STORE_C
	ХВ

If IR_(5_3)==111

111 → rf_a3 PC → rf_d3	NONE
	Х
	X-X
	SET_PC
	IB

2. & 3. ADC/Z

111 → rf-a1 rf-d1 → Mem-a,alu Mem_d → IR +1 → alu alu →PC	IR
	Х
	X-X
	HKT
alu 71 O	GET_AB

ID (11.0) . rf o1	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	Х
$rf-d1 \rightarrow t1$	X-X
rf-d2 \rightarrow t2 IR_(0-7) \rightarrow SE(8) \rightarrow t4	GET_AB
	SB

If (C/Z==0)

111 → rf_a3 PC → rf_d3	NONE
	Х
	X-X
	SET_PC
	IB

If (C/Z==1)

	NONE
$IR_{(11-9)} \rightarrow rf-a1$	Х
IR_(8-6) → rf-a2 rf-d1 → t1 rf-d2 → t2	X-X
	GET_AB
	QB

t1 → alu t2 →alu alu → t3	NONE
	ADD
	C-Z
	ALU
	RB

$t3 \rightarrow rf-d3$ IR_(5-3) $\rightarrow rf-a3$	NONE
	X
	X-X
	STORE_C
	ХВ

EE-337 Project

Multi-cycle RISC

If IR_(5_3)==111

111 → rf_a3 PC → rf_d3	NONE
	Х
	X-X
	SET_PC
	IB

4. ADI

$111 ightarrow ext{rf-a1}$ $ ext{rf-d1} ightarrow ext{Mem-a,alu}$ $ ext{Mem_d} ightarrow ext{IR}$ $ ext{+1} ightarrow ext{alu}$ $ ext{alu} ightarrow ext{PC}$	IR
	Х
	X-X
	HKT
	GET_AB

ID (11.0) of a1	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	Х
$rf-d1 \rightarrow t1$	X-X
rf-d2 \rightarrow t2 IR_(0-7) \rightarrow SE(8) \rightarrow t4	GET_AB
II(_(0-1)	SB

$IR(5-0) \rightarrow sgn-10 \rightarrow alu$ $t2 \rightarrow alu$ $alu \rightarrow t3$	NONE
	ADD
	C-Z
	ADDI
	PB

$t3 \rightarrow rf -d3$ $IR_{(7-5)} \rightarrow rf -a3$	NONE
	Х
	X-X
	STORE_C
	ХВ

If IR_(5_3)==111

111 → rf_a3 PC → rf_d3	NONE
	Х
	X-X
	SET_PC
	IB

5. NDU

$111 ightarrow ext{rf-a1} - ext{rf-d1} ightarrow ext{Mem-a,alu} \ ext{Mem_d} ightarrow ext{IR} \ ext{+1} ightarrow ext{alu} \ ext{alu} ightarrow ext{PC}$	IR
	Х
	X-X
	HKT
	GET_AB

ID (44.0) of a4	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	Х
$rf-d1 \rightarrow t1$	X-X
rf-d2 \rightarrow t2 IR (0-7) \rightarrow SE(8) \rightarrow t4	GET_AB
II(_(0=1)	SB

t1 → alu t2 →alu alu → t3	NONE
	NAND
	X-Z
	ALU
	RB

$t3 \rightarrow rf -d3$ $IR_{(5-3)} \rightarrow rf -a3$	NONE
	Х
	X-X
	STORE_C
	XB

If IR_(5_3)==111

111 → rf_a3 PC → rf_d3	NONE
	Х
	X-X
	SET_PC
	IB

6. & 7. NDC/Z

111 → rf-a1 rf-d1 → Mem-a,alu Mem_d → IR +1 → alu alu →PC	IR
	X
	X-X
	HKT
	GET_AB

ID (44.0) wf o4	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	Х
$rf-d1 \rightarrow t1$ $rf-d2 \rightarrow t2$ $IR_{-}(0-7) \rightarrow SE(8) \rightarrow t4$	X-X
	GET_AB
	SB

If (C/Z==0)

111 → rf_a3 PC → rf_d3	NONE
	Х
	X-X
	SET_PC
	IB

If (C/Z==1)

t1 → alu t2 →alu alu → t3	NONE
	NAND
	X-Z
	ALU
	STORE_C

$t3 \rightarrow rf -d3$ IR_(5-3) $\rightarrow rf$ -a3	NONE
	X
	X-X
	STORE_C
	XB

If IR_(5_3)==111

111 → rf_a3 PC → rf_d3	NONE
	Х
	X-X
	SET_PC
	IB

8. LHI

$111 ightarrow ext{rf-a1}$ $ ext{rf-d1} ightarrow ext{Mem-a,alu}$ $ ext{Mem_d} ightarrow ext{IR}$ $ ext{+1} ightarrow ext{alu}$ $ ext{alu} ightarrow ext{PC}$	IR
	Х
	X-X
	HKT
	GET_AB

ID (44.0) of 64	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	Х
rf-d1 \rightarrow t1 rf-d2 \rightarrow t2 IR_(0-7) \rightarrow SE(8) \rightarrow t4	X-X
	GET_AB
	SB

IR(8-0) → trail_zero_7 → rf-d3 IR(9-11) → rf-a3	NONE
	Х
	X-X
	LHI
	XB

If IR_(5_3)==111

111 → rf_a3 PC → rf_d3	NONE
	X
	X-X
	SET_PC
	IB

9. LW

111 → rf-a1 rf-d1 → Mem-a,alu Mem_d → IR +1 → alu alu →PC	IR
	Х
	X-X
	HKT
	GET_AB

10. SW

111 . rf o1	IR
111 → rf-a1 rf-d1 → Mem-a,alu	Х
Mem_d → IR +1 → alu alu →PC	X-X
	HKT
	GET_AB

ID (44.0) who 4	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	Х
rf-d1 \rightarrow t1 rf-d2 \rightarrow t2 IR_(0-7) \rightarrow SE(8) \rightarrow t4	X-X
	GET_AB
"_(\(\text{0}\) \(\text{7}\) \(\text{0}\)	SB

ID (44.0) of a4	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	Х
$rf-d1 \rightarrow t1$	X-X
rf-d2 \rightarrow t2 IR_(0-7) \rightarrow SE(8) \rightarrow t4	GET_AB
	SB

IR(5-0) → sgn-10 → alu t2 → alu alu → t3	NONE
	ADD
	X-X
	ADDI
	РВ

	NONE
IR_(5-0) → sgn-10 → alu	ADD
t2 → alu	X-X
alu → t3	ADDI
	PB

$t3 \rightarrow mem_a$ $mem_d \rightarrow t2$ $0 \rightarrow t1$	NONE
	X
	X-X
	GET_MEM
	SET_MEM

	DW
t3 → mem_a	Х
t1 → mem_d 111 → rf a3	X-X
$PC \rightarrow rf_d3$	SW2
	IB

t1 → alu t2 →alu alu → t3	NONE
	ADD
	X-Z
	ALU
	RB

$t3 \rightarrow rf_d3$ $IR_(8-6) \rightarrow t3$	NONE
	Х
	X-X
	ST_MEM
	ХВ

If IR_(5_3)==111

111 → rf_a3 PC → rf_d3	NONE
	Х
	X-X
	SET_PC
	IB

11. LM

111	IR
111 → rf-a1 rf-d1 → Mem-a,alu	ADD
Mem_d → IR +1 → alu alu →PC	X-X
	HKT
	GET_AB

ID (44.0) of a4	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	Х
$rf-d1 \rightarrow t1$	X-X
rf-d2 \rightarrow t2 IR_(0-7) \rightarrow SE(8) \rightarrow t4	GET_AB
111 <u>(0-1)</u> 70 <u>L(0)</u> 714	SB

t1 → mem_a , alu	DR
mem_d → t2	ADD
+1 → alu alu → t3	X-X
$t4 \rightarrow pr.enc \rightarrow decoder$	LM2
decoder → t5	TB

If V = 0

111 → rf_a3 PC → rf_d3	NONE
	Х
	X-X
	SET_PC
	IB

If V = 1

אט ייל אט	NONE
t2 \rightarrow rf_d3 t4 \rightarrow rf_a3,alu	Х
t3 → t1 t5 → alu alu → t4	X-X
	LM3
	LM2

12. SM

$111 ightarrow ext{rf-a1}$ $ ext{rf-d1} ightarrow ext{Mem-a,alu}$ $ ext{Mem_d} ightarrow ext{IR}$ $ ext{+1} ightarrow ext{alu}$ $ ext{alu} ightarrow ext{PC}$	IR
	ADD
	X-X
	HKT
	GET_AB

ID (44.0) who 4	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	X
rf-d1 \rightarrow t1 rf-d2 \rightarrow t2 IR_(0-7) \rightarrow SE(8) \rightarrow t4	X-X
	GET_AB
\(\(\(\begin{array}{c} \(\begin{array}{c} \\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	SB

$t1 ightarrow mem_a$, alu $mem_d ightarrow t2 \\ +1 ightarrow alu \\ alu ightarrow t3 \\ t4 ightarrow pr.enc ightarrow decoder$	DR
	ADD
	X-X
	LM2
decoder → t5	TB

if V = 0

111 → rf_a3 PC → rf_d3	NONE
	X
	X-X
	SET_PC
	IB

if V = 1

$t4 \rightarrow pr.enc \rightarrow rf_a1$ $rf_d1 \rightarrow t4$ $t3 \rightarrow t1$	NONE
	Х
	X-X
	SM
	LM5

t4 → mem_d t1 → mem_a	DW
	Х
	X-X
	LM5
	LM6

t4 → alu t5 → alu alu → t4	NONE
	XOR
	X-Z
	LM6
	LM2

13. BEQ

111 → rf-a1 rf-d1 → Mem-a,alu Mem_d → IR +1 → alu alu →PC	IR
	ADD
	X-X
	HKT
	GET_AB

ID (44.0) -f -4	NONE
$IR_{-}(11-9) \rightarrow \text{rf-a1}$ $IR_{-}(8-6) \rightarrow \text{rf-a2}$ $\text{rf-d1} \rightarrow \text{t1}$ $\text{rf-d2} \rightarrow \text{t2}$ $IR_{-}(0-7) \rightarrow \text{SE}(8) \rightarrow \text{t4}$	Х
	X-X
	GET_AB
	SB

T1 → ALU T2 → ALU ALU → T3	NONE
	SUB
	C-Z
	ALU
	SB

IF (Z = 0)

111 → rf_a3 PC → rf_d3	NONE
	Х
	X-X
	SET_PC
	IB

14. JAL

$111 ightarrow ext{rf-a1}$ $ ext{rf-d1} ightarrow ext{Mem-a,alu}$ $ ext{Mem_d} ightarrow ext{IR}$ $ ext{+1} ightarrow ext{alu}$ $ ext{alu} ightarrow ext{PC}$	IR
	Х
	X-X
	HKT
	GET_AB

ID (44.0) of a4	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	Х
$rf-d1 \rightarrow t1$	X-X
rf-d2 \rightarrow t2 IR (0-7) \rightarrow SE(8) \rightarrow t4	GET_AB
II(_(0=1)	SB

ID (0 11) \ DE A3	NONE				
$IR_{-}(9_{-}11) \rightarrow RF_{-}A3$	ADD				
$PC \rightarrow RF_D3$, ALU $IR_(8_0) \rightarrow SE7 \rightarrow ALU$	X-X				
ALU → T3	SE7-PC				
	T3-PC				

	NONE
444 85 40	Х
$111 \rightarrow RF_A3$ $T3 \rightarrow RF D3$	X-X
50	T3-PC
	IB

IF (Z = 1)

	NONE
PC → ALU	ADD
$IR_(5-0) \rightarrow SE10 \rightarrow ALU$	X-X
ALU → PC	SE10-PC
	SET_PC

	NONE
PC → ALU	ADD
$IR_{-}(5-0) \rightarrow SE10 \rightarrow ALU$	X-X
ALU → PC	SE10-PC
	SET_PC

	NONE			
	X X-X SET_PC			
$111 \rightarrow rf_a3$ $PC \rightarrow rf_d3$	X-X			
	SET_PC			
	IB			

15. JLR

111	IR
111 → rf-a1 rf-d1 → Mem-a,alu	Х
$Mem_d \rightarrow IR$	X-X
+1 → alu alu →PC	HKT
aiu →i O	GET_AB

ID (44.0) who 4	NONE
IR_(11-9) \rightarrow rf-a1 IR (8-6) \rightarrow rf-a2	Х
$rf-d1 \rightarrow t1$	X-X
rf-d2 \rightarrow t2 IR_(0-7) \rightarrow SE(8) \rightarrow t4	GET_AB
	SB

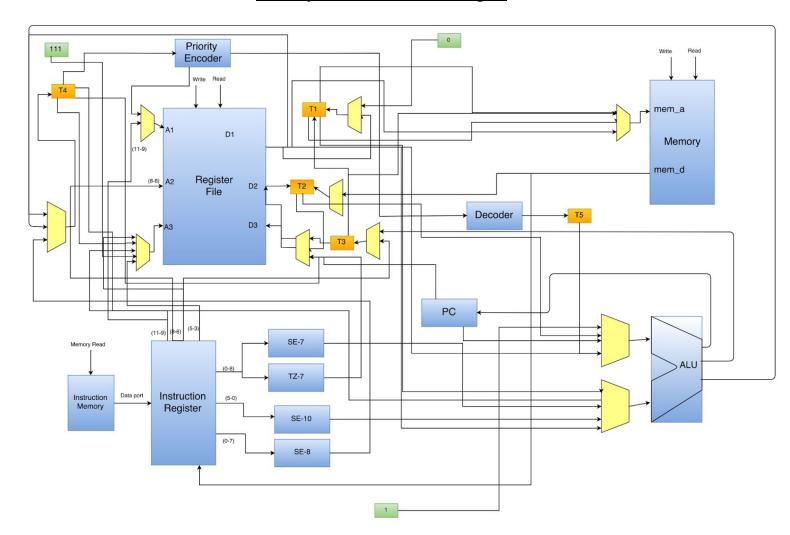
$PC \rightarrow RF_D3$ $IR_(9_11) \rightarrow RF_A3$ $IR_(6_8) \rightarrow rf_a2$ $rf_d2 \rightarrow t2$	NONE
	Х
	X-X
	PC-REG
	T2-PC

	NONE
	Х
$T2 \rightarrow RF_D3$ $111 \rightarrow RF A3$	X-X
111 -> 101 <u>-</u> 740	T2-PC
	IB

Control Word:

0	Encod ing	PC	T	1	T2 T3 T4 T5 IR Memory					ALU		R	egist	er Fil	e	Туре	Next Address						
		c0	c1	c2	c3	c4	с5	c6	с7	с8	с9	c10	c11	c12	c13	c14	c15	c16	c17	c18	c19		
1	d001	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	IR	SB
2	d002	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	NA	IB
3	d003	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DR	S4
4	d004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	IR	S2
5	d005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	IR	S6
6	d006	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	DW	IB
7	d007	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	IR	S8
8	d008	0	1	0	1	0	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0	NA	HKT1
9	d009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	IR	S2
10	d010	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	1	0	1	1	1	DR	S11
11	d011	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	NA	HK1
12	d012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	DW	S13
13	d013	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	NA	HKT1
14	d014	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	NA	S15
15	d015	0	1	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	IR	S2
16	d016	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	NA	НКТ1
17	d017	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	NA	ВС
18	d018	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	1	0	0	1	DW	S19
19	d019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	NA	S20
20	d020	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0		

Datapath of the design:



FSM Diagram:

Here is the FSM diagram of our microprocessor:

