Fetch   Decode   Execute   Memory   Writeback

clk
rst

Control

PC — Instruction Memory — Read Address

Instruction Memory

Instruction [15:0]

Register File

clk
rst
read1RegSel
read2RegSel
writeRegSel
writeData

writeEn
R0
R1
R2
R3
R4
R5
R6
R7 (Link Register for JAL and JALR instructions)

read1Data [15:0]
read2Data [15:0]

ALU

Data Memory

Address [15:0]
Write Data [15:0]
Read Data [15:0]

MemWrite   MemDump
MemRead

Extension Module

Instruction [4:0]   5
Instruction [7:0]   8
Instruction [10:0]   11

Zero-Extend [5:16]
Sign-Extend [5:16]
Zero-Extend [8:16]
Sign-Extend [8:16]
Sign-Extend [11:16]
immExtSel

Branch Control

zf   sf   of   cf

ALU Control

Instruction [1:0]

err

Control signals (from Control):
JumpImm
Link
Halt
RegDst
Jump
Branch
MemRead
MemtoReg
ALUOp
MemWrite
ALUSrc
RegWrite
immExtSel
InvB
Exception

Shift Left 1
PC+2 [15:9]
JumpImm
Jump
0x02
Exception
EPC

ADD

MUX / MemtoReg

OPCODES:
010XX = ALU Immediate,   I-Type1
101XX = BarrelShifter Immediate,   I-Type1
100XX = LD/ST/STU,   I-Type1
11001 = BTR (Bit Reverse),
11XXX = ALU/Shift Register,   R-Type
011XX = Branch Immediate,   I-Type2
11000 = LBI,   I-Type2
10010 = SLBI,   I-Type2
001X0 = Jump,   J-Type
001X1 = Jump Immediate,   I-Type2

R-Type
3 bits	3 bits	3 bits	3 bits	2 bits
Opcode	Rs	Rt	Rd	Op.Ext

I-Type 1
5 bit	3 bit	3 bit	5 bit
Opcode	Rs	Rd	Imm

I-Type 2
5 bit	3 bit	8 bit
Opcode	Rs	Imm

J-Type
5 bit	11 bit
Opcode	Displacement

Control Logic Table for Data Memory
Opcode	MemWrite	MemRead	MemtoReg
10000 – ST	1	0	0
10001 – LD	0	1	1
10011 – STU	1	0	0

Control Table

Instruction	Opcode	RegWrite	RegDst	Jump	Branch	MemRead	MemtoReg	MemWrite	Link	ALUOp??	ALUSrc	immExtSel	InvB
HALT	00000												
NOP	00001										Opcode		
ADDI	01000	1	01								1	001	
SUBI	01001	1	01								1	001	
XORI	01010	1	01								1	000	
ANDNI	01011	1	01								1	000	1
ROLI	10100	1	01								1	000 or 001	
SLLI	10101	1	01								1	000 or 001	
RORI	10110	1	01								1	000 or 001	
SRLI	10111	1	01								1	000 or 001	
ST	10000							1			1	001	
LD	10001	1	01			1	1				1	001	
STU	10011	1	01				1				1	001	
BTR	11001	1	00								0		
ADD	11001	1	00								0		
SUB	11001	1	00								0		
XOR	11001	1	00								0		
ANDN	11001	1	00								0		
ROL	11010	1	00								0		
SLL	11010	1	00								0		
ROR	11010	1	00								0		
SRL	11010	1	00								0		
SEQ	11100	1	00								0		
SLT	11101	1	00								0		
SLE	11110	1	00								0		
SCO	11111	1	00								0		
BEQZ	01100				Branch Control							011	
BNEZ	01101				Branch Control							011	
BLTZ	01110				Branch Control							011	
BGEZ	01111				Branch Control							011	
LBI	11000	1	10		Branch Control							011	
SLBI	10010	1	10		Branch Control							011	
J	00100			1									1XX
JR	00101			1									
JAL	00110		11	1					1				1XX
JALR	00111		11	1					1				011
EXC-REG	00010												
NOP-REG	00011												