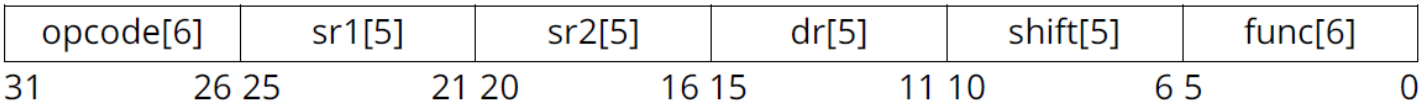
MIPS Instructions

R-type:

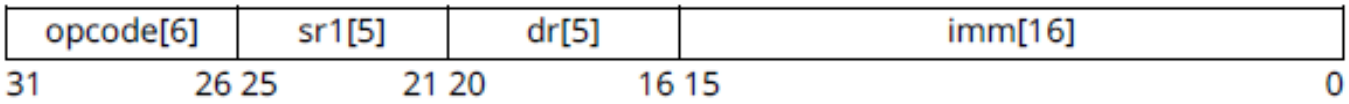
			Func:
add	R1, R2, R3	R1 = R2 + R3	100000
sub	R1, R2, R3	R1 = R2 - R3	100010
slt	R1, R2, R3	R1 = (R2 < R3) ? 1 : 0	101010
and	R1, R2, R3	R1 = R2 & R3	100100
or	R1, R2, R3	R1 = R2 | R3	100101

Machine:



I-type:

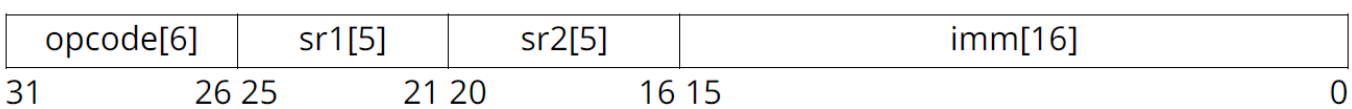
			Opcode:
addi	R1, R2, Num	R1 = R2 + Num	001000
stli	R1, R2, Num	R1 = (R2 < Num) ? 1 : 0	001010



Mem-type:

			Opcode:
lw	R1, Num(R2)	R1 = Mem[R2 + Num]	100011
sw	R1, Num(R2)	Mem[R2 + Num] = R1	101011

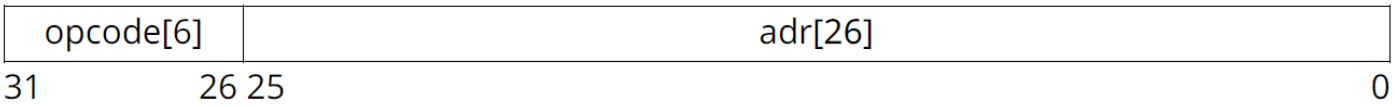
Machine:



Jump1:

		Opcode:
j Adr	PC = {(PC+4)[31:28], Adr << 2}	000010
jal Adr	j to Adr and R31 = PC + 4	000011

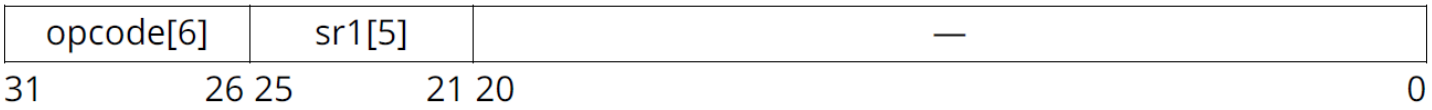
Machine:



Jump2:

		Opcode:
jr R1	PC = R1	111111

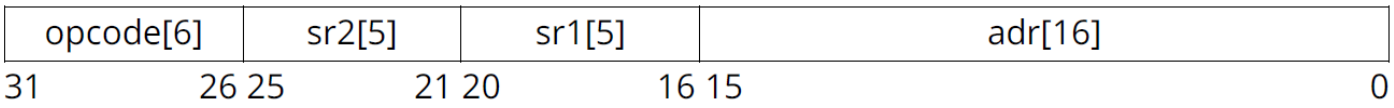
Machine:



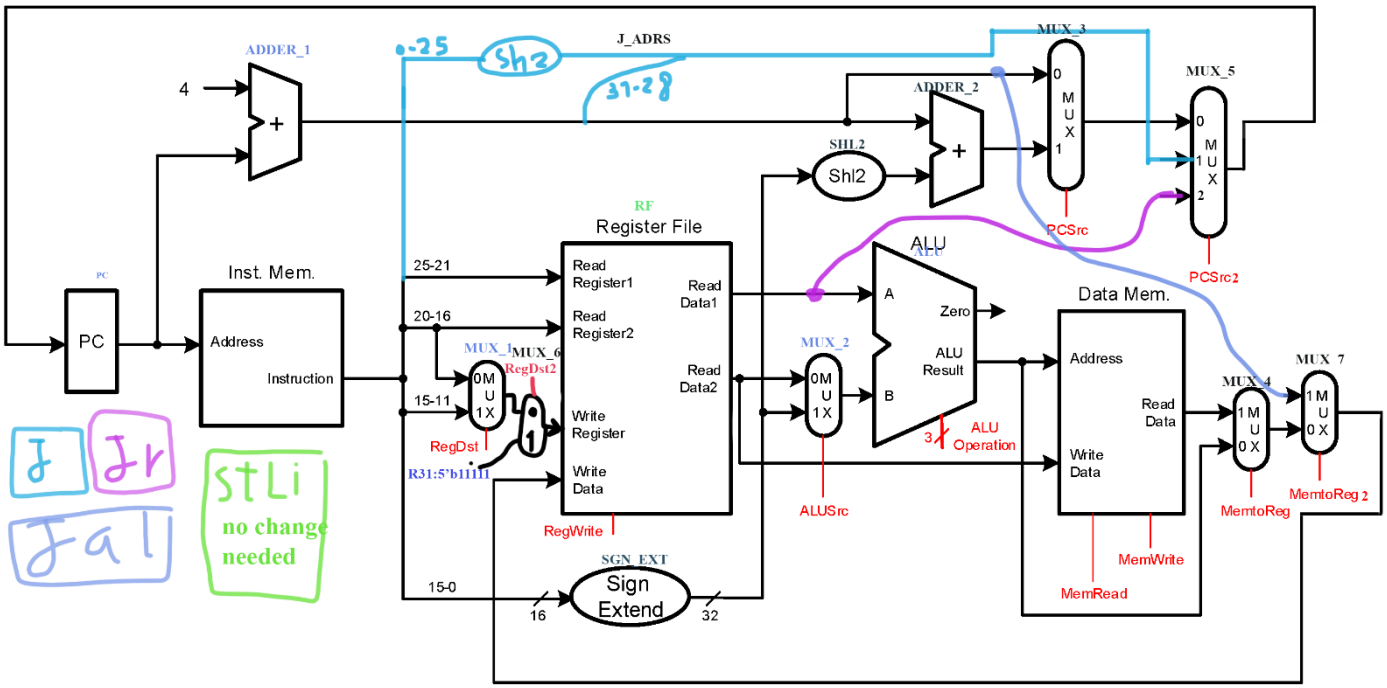
Branch:

		Opcode:
beq R1, R2, Adr	PC = (R1==R2) ? (PC + 4 + Adr<<2) : PC+4 ;	000100

Machine:



DataPath:



JR:

به ادرس ذخیره شده در R?? می رود.

J:

به adr می رود.

JAL:

به adr میرود و ادرس فعلی را در R31 ذخیره می کند.

SLTI:

مقدار R?? و یک عدد را مقایسه می کنه و در یک رجیستر دیگر R?? می ریزد.

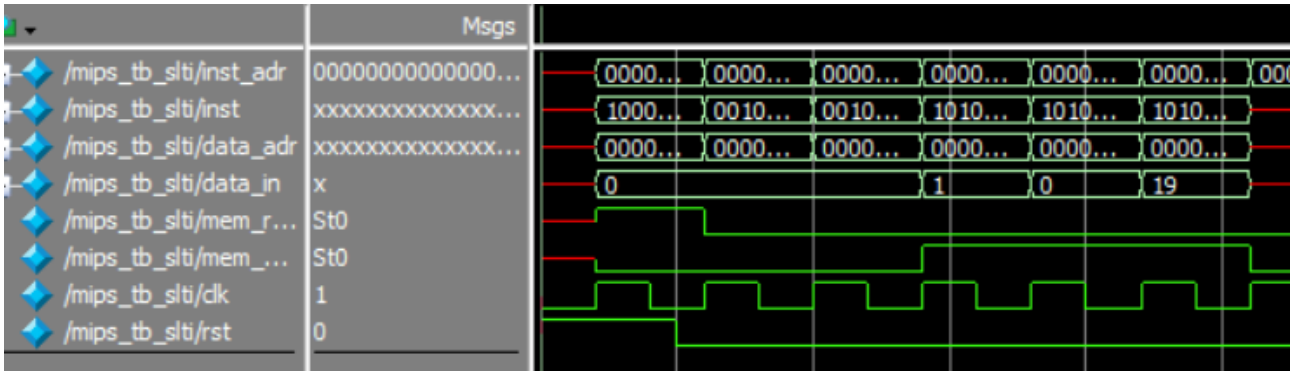
- اگر عدد بزرگتر از مقدار در رجیستر باشید خروجی یک ذخیره می شود
- در غیر اینصورت صفر ذخیره می شود

Controller:

	RegDst	RegDst2	RegWrite	ALUsrc	operation	PCsrc	PCsrc2	MemToReg	MemToReg2	MemWrite	MemRead	ALU_OP	Branch
or	1	0	1	0	001	0	00	0	0	0	1	10	0
and	1	0	1	0	000	0	00	0	0	0	0	10	0
addi	1	0	1	0	010	0	00	0	0	0	0	10	0
sub	1	0	1	0	110	0	00	0	0	0	0	10	0
slt	1	0	1	0	111	0	00	0	0	0	0	10	0
slti	0	0	1	1	111	0	00	0	0	0	0	11	0
addi	0	0	1	1	010	0	00	0	0	0	0	00	0
lw	0	0	1	1	010	0	00	1	0	0	1	00	0
sw	X	X	0	1	010	0	00	X	X	1	0	00	0
j	X	X	0	X	X	X	01	X	X	0	0	X	0
jal	X	1	1	X	X	0	01	X	1	0	0	X	0
jr	X	X	0	X	X	X	10	X	X	0	0	X	0
beq	X	X	0	0	110	1	00	X	X	0	0	01	1

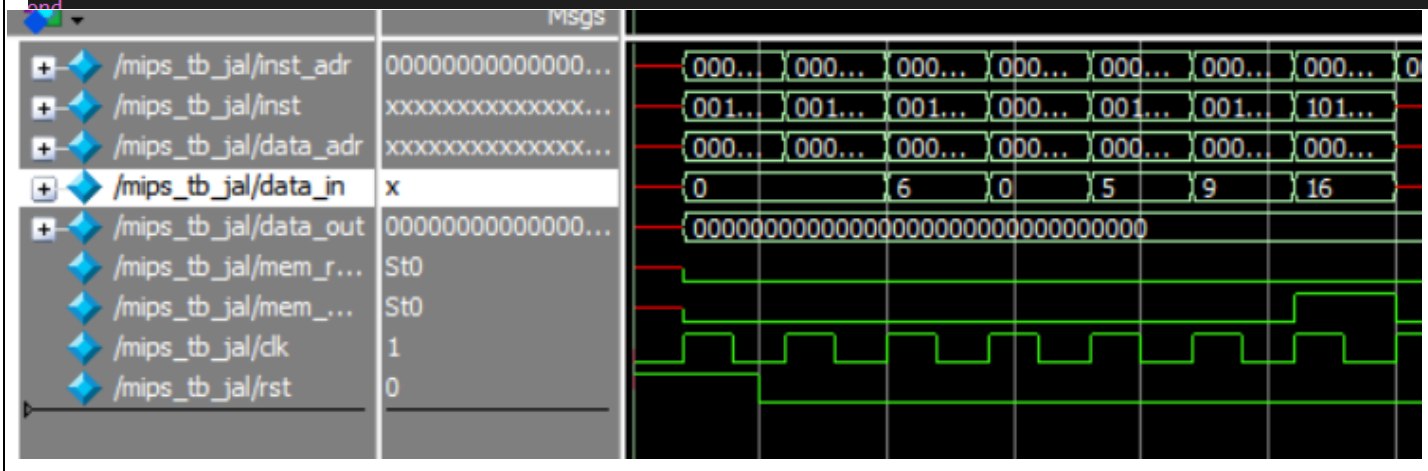
تست SLTI (R3=19)

```
begin
  {mem[3], mem[2], mem[1], mem[0]}     = {6'h23, 5'd0, 5'd3, 16'd1000};   // LW R3 1000(R0)
  {mem[7], mem[6], mem[5], mem[4]}     = {6'b001010, 5'd3, 5'd1, 16'd20}; //SLTi R1, R3, 20
  {mem[11], mem[10], mem[9], mem[8]}   = {6'b001010, 5'd3, 5'd2, 16'd10}; //SLTi  R2, R3, 10
  {mem[15], mem[14], mem[13], mem[12]} = {6'h2B, 5'd0, 5'd1, 16'd2000};   //SW R1, 2000(R0)
  {mem[19], mem[18], mem[17], mem[16]} = {6'h2B, 5'd0, 5'd2, 16'd2004};   //SW R2, 2004(R0)
  {mem[23], mem[22], mem[21], mem[20]} = {6'h2B, 5'd9, 5'd3, 16'd1000};   //SW R3 1000(R9)
```



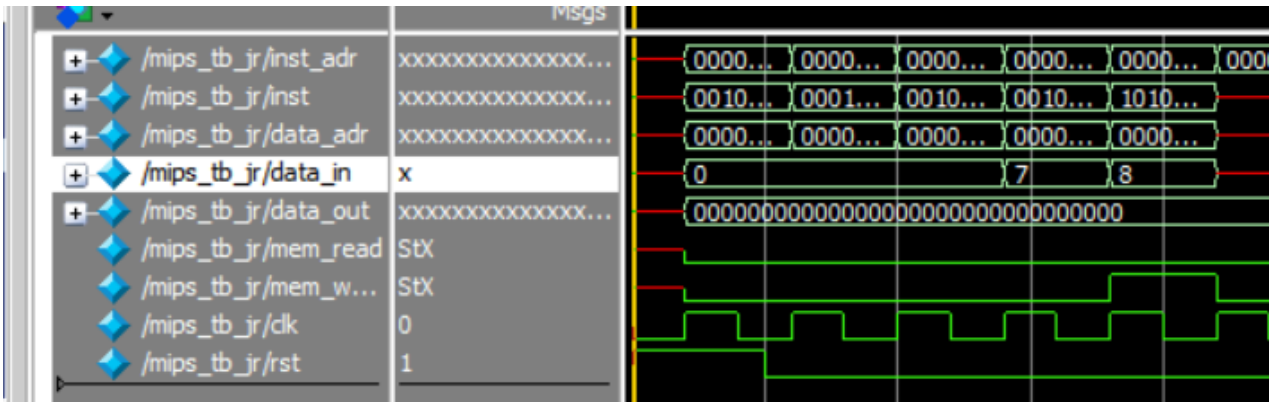
تست JAL

```
{mem[3], mem[2], mem[1], mem[0]}     = {6'h09, 5'd0, 5'd1, 16'd16};     //addi R1, R0, 3
{mem[7], mem[6], mem[5], mem[4]}     = {6'h09, 5'd0, 5'd2, 16'd6};      //addi R2, R0, 6
{mem[11], mem[10], mem[9], mem[8]}   = {6'h09, 5'd0, 5'd2, 16'd5};      //addi R2, R0, 5
{mem[15], mem[14], mem[13], mem[12]} = {6'b000011,  26'd6};             //jump here and save mem[16] in R31
{mem[19], mem[18], mem[17], mem[16]} = {6'h09, 5'd0, 5'd2, 16'd7};      //addi R2, R0, 7  //ignore
{mem[23], mem[22], mem[21], mem[20]} = {6'h09, 5'd0, 5'd2, 16'd8};      //addi R2, R0, 8 //ignore
{mem[27], mem[26], mem[25], mem[24]} = {6'h09, 5'd0, 5'd2, 16'd9};      //addi R2, R0, 9 //jump here
{mem[31], mem[30], mem[29], mem[28]} = {6'h09, 5'd31, 5'd2, 16'd0};     //addi R2, R31, 0 see what saved in R31
{mem[35], mem[34], mem[33], mem[32]} = {6'h2B, 5'd0, 5'd2, 16'd2000};   //SW R2, 2000(R0)
```



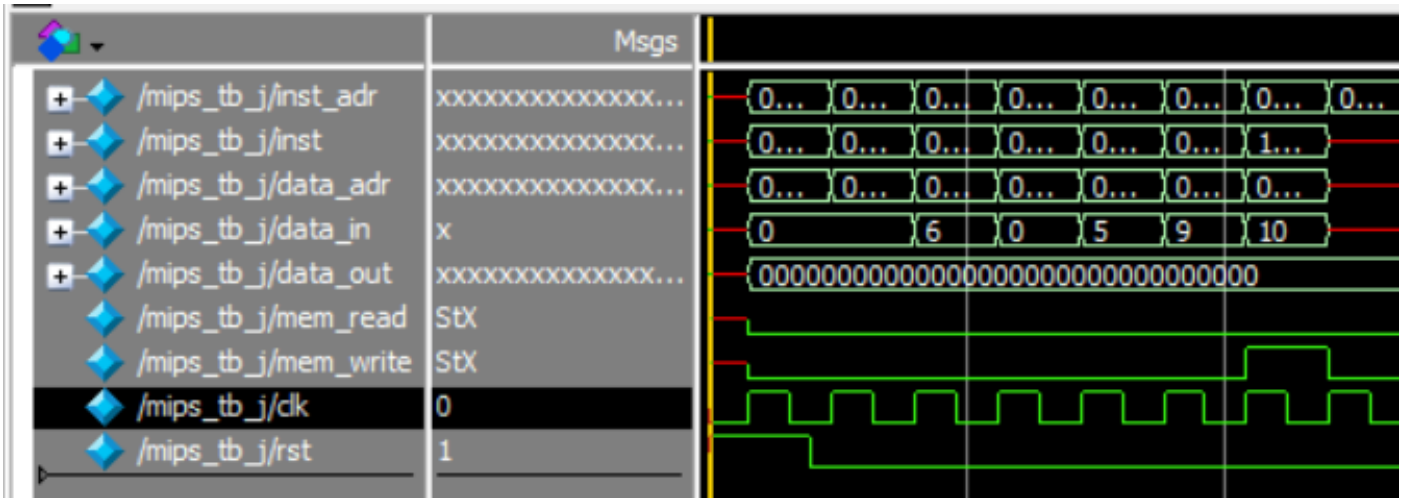
تست JR

```
{mem[3], mem[2], mem[1], mem[0]}     = {6'h09, 5'd0, 5'd1, 16'd16};      //addi R1, R0, 3
{mem[7], mem[6], mem[5], mem[4]}     = {6'b000110, 5'd1, 21'd0};         //Jr R1
{mem[11], mem[10], mem[9], mem[8]}   = {6'h09, 5'd0, 5'd2, 16'd5};       //addi R2, R0, 5 //ignore
{mem[15], mem[14], mem[13], mem[12]} = {6'h09, 5'd0, 5'd2, 16'd6};       //addi R2, R0, 6 //ignore
{mem[19], mem[18], mem[17], mem[16]} = {6'h09, 5'd0, 5'd2, 16'd7};       //addi R2, R0, 7 //jump here
{mem[23], mem[22], mem[21], mem[20]} = {6'h09, 5'd0, 5'd2, 16'd8};       //addi R2, R0, 8
{mem[27], mem[26], mem[25], mem[24]} = {6'h2B, 5'd0, 5'd2, 16'd2000};    //SW R2, 2000(R0)
```



تست J

```
{mem[3], mem[2], mem[1], mem[0]}     = {6'h09, 5'd0, 5'd1, 16'd16};      //addi R1, R0, 3
{mem[7], mem[6], mem[5], mem[4]}     = {6'h09, 5'd0, 5'd2, 16'd6};       //addi R2, R0, 6
{mem[11], mem[10], mem[9], mem[8]}   = {6'h09, 5'd0, 5'd2, 16'd5};       //addi R2, R0, 5
{mem[15], mem[14], mem[13], mem[12]} = {6'b000010,  26'd6};              //J mem[24]
{mem[19], mem[18], mem[17], mem[16]} = {6'h09, 5'd0, 5'd2, 16'd7};       //addi R2, R0, 7  //ignore
{mem[23], mem[22], mem[21], mem[20]} = {6'h09, 5'd0, 5'd2, 16'd8};       //addi R2, R0, 8 //ignore
{mem[27], mem[26], mem[25], mem[24]} = {6'h09, 5'd0, 5'd2, 16'd9};       //addi R2, R0, 9 //jump here
{mem[31], mem[30], mem[29], mem[28]} = {6'h09, 5'd0, 5'd2, 16'd10};      //addi R2, R0, 10
{mem[35], mem[34], mem[33], mem[32]} = {6'h2B, 5'd0, 5'd2, 16'd2000};    //SW R2, 2000(R0)
```

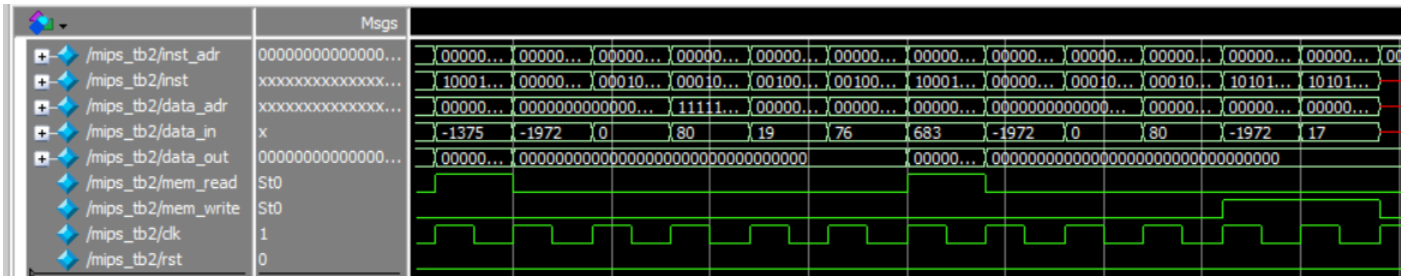


برنامه‌ای بنویسید که کوچک‌ترین عنصر یک آرایه‌ی ۲۰ عنصری با آدرس شروع ۱۰۰۰ را پیدا کند و مقدار کوچک‌ترین عنصر و اندیس آن را به ترتیب در خانه‌های ۲۰۰۰ و ۲۰۰۴ حافظه بنویسد.

```c
int main()
{
    int A[20] ={450   ,-64   ,-679,  1779 , 69 ,
                -1595 , 1678 , 1884 , -649 , 18 ,
                 337 , -1764 , 1725 , 919 , 758 ,
                -584 , 82 , -1972 , -1375 , 683 };

    int index = 0;
    int min_value = 0;

    for(int i =0 ; i < 20; i++){
        if(A[i] < min_value){
            min_value = A[i];
            index =i;
        }
    }

    printf("%d %d", min_value , index);

    return 0;
}
```

```
////...
//{mem[1003], mem[1002], mem[1001], mem[1000]} =  32'd19;    //A[0]
//{mem[1007], mem[1006], mem[1005], mem[1004]} = -32'd64;     //A[1]
//{mem[1011], mem[1010], mem[1009], mem[1008]} = -32'd679;    //A[2]
//{mem[1015], mem[1014], mem[1013], mem[1012]} = 32'd1779;    //A[3]
//{mem[1019], mem[1018], mem[1017], mem[1016]} = 32'd69;      //A[4]
//{mem[1023], mem[1022], mem[1021], mem[1020]} = -32'd1595;   //A[5]
//{mem[1027], mem[1026], mem[1025], mem[1024]} = 32'd1678;    //A[6]
//{mem[1031], mem[1030], mem[1029], mem[1028]} = 32'd1884;    //A[7]
//{mem[1035], mem[1034], mem[1033], mem[1032]} = -32'd649;    //A[8]
//{mem[1039], mem[1038], mem[1037], mem[1036]} = 32'd18;      //A[9]
//{mem[1043], mem[1042], mem[1041], mem[1040]} = 32'd337;     //A[10]
//{mem[1047], mem[1046], mem[1045], mem[1044]} = -32'd1764;   //A[11]
//{mem[1051], mem[1050], mem[1049], mem[1048]} = 32'd1725;    //A[12]
//{mem[1055], mem[1054], mem[1053], mem[1052]} = 32'd919;     //A[13]
//{mem[1059], mem[1058], mem[1057], mem[1056]} = 32'd758;     //A[14]
//{mem[1063], mem[1062], mem[1061], mem[1060]} = -32'd584;    //A[15]
//{mem[1067], mem[1066], mem[1065], mem[1064]} = 32'd82;      //A[16]
//{mem[1071], mem[1070], mem[1069], mem[1068]} = -32'd1972;   //A[17]
//{mem[1075], mem[1074], mem[1073], mem[1072]} = -32'd1375;   //A[18]
//{mem[1079], mem[1078], mem[1077], mem[1076]} = 32'd683;     //A[19]
//{mem[1083], mem[1082], mem[1081], mem[1080]} = 32'd1470;    //A[20]
//{mem[1087], mem[1086], mem[1085], mem[1084]} = 32'd1595;    //A[21]
//{mem[1091], mem[1090], mem[1089], mem[1088]} = -32'd971;    //A[22]
$readmemb("bits.txt",mem,1000);
```

```
// First:   lw     R1,1000(R0)          A[0]                                          0
//          add   R2,  R0, R0           index                                         4
//          add   R3,  R0, R0           4(i)                                          8
//          addi   R5, R0,80           (20*4)                                        12
//          add   R6, R0,R0            for loop variable 1(i)                        16
// Loop:    beq    R3,  R5, END        check if the for loop is finished             20
//          addi   R3,  R3,4           i += 4                    4(i)                24
//          addi   R6, R6,1            index +=1            1(i)                     28
//          lw     R10,1000(R3)        A[i+1]                                        32
//          slt    R4,R10,R1           check which one is the least new or saved     36
//          beq    R4,R0,LOOP          if smaller then new num back to loop          40
//          add    R1, R0, R10         update new least num                          44
//          add    R2, R0, R6          update new index                              48
//          j      LOOP                get back to the loop                          52
// END:     sw     R1, 2000(R0)        save the least item                           56
//          sw     R10, 2004(R0)       save the index of least                       60
//          j     R10, 2004(R0)        j First                                       64
```



همانطور که در مقادیر می بینید بیست خانه اول(از A[0] تا A[19]) را چک می کند و در ارایه ۱۷ ام مقدار -۱۹۷۲ که کوچکترین مقدار است را ذخیره می کند.