```
module Controller_Unit #(parameter W=4)(CLK,
            AccRight, AccParallel, AccCLR, // Acc register control
            ALUCtrl, ASrc, BSrc,  // ALU Controllers
            Stat, NFlag,    // Status bits
            LOAD,R1m, R0m,
            COMP, R1Clr, R1Src, R0WE, R1WE, R0Src,
            OP,  //ALP Operation
                QParallel, QSrc, QnCLR, RST, QRight, QzSrc, Qn, Qz,
            CLR, // reset registers
            ERR // Arithmetic overflow

              );
      input CLK,  CLR;
      input LOAD, COMP;
      input [2:0] OP;
      input [1:0] Stat;
       input R1m, R0m;
      output reg R1Clr=0, R1Src, R0WE=0, R1WE=0;
       output reg [1:0] R0Src, ASrc, BSrc;
       output reg [2:0] ALUCtrl;
      input NFlag , Qn, Qz;
      output reg ERR=0;
      output reg AccRight, AccParallel, AccCLR, QParallel, QSrc, QnCLR=0, RST=0,
      QRight, QzSrc;


       parameter [4:0] ST0 =0, ST1=1, ST2=2, ST3=3, ST4 =4, ST5=5, ST6=6,
                               ST7=7, ST8=8, ST9=9, ST10=10, ST11=11, ST12=12, ST13=13,
                               ST14=14, ST15=15, ST16=16, ST17=17, ST18=18, ST19=19,
                               ST20=20, ST21=21;

       integer k=0, Count=W;
       reg [1:0]r;
       reg NS, CS;

       initial
       begin
       CS = ST0;
       NS = ST0;
       end

       always @(CLK,CLR,LOAD, COMP, OP, Stat,R1m, R0m,NFlag ,r, Count, Qn, Qz)
             begin : COMB

             case(CS)
             ST0: begin

                     if(k>=2 && COMP)
                         case(OP)
                             3'b000 : NS = ST1;
                             3'b001 : NS = ST1;
                             3'b010 : NS = ST2;
                             3'b011 : NS = ST3;
                             3'b100 : NS = ST1;
                             3'b101 : NS = ST1;
                             3'b110 : NS = ST1;
                             3'b111 : NS = ST1;
                         endcase
                     else
                         NS = ST0;
                   end

             ST1: begin
                     NS = ST0;
                   end

             ST2: begin
                     case({Qz,Qn})
                         2'b00 : NS = ST6;

                         2'b01 : NS = ST4;

                         2'b10 : NS = ST5;
```

```
72
73                      2'b11 : NS = ST6;
74
75                endcase
76              end
77
78          ST3: begin
79                      if(R1m)
80                          NS = ST7;
81                      else if(R0m)
82                          NS = ST9;
83                      else if(NFlag)
84                          NS = ST12;
85                      else
86                          NS = ST11;
87              end
88
89          ST4: begin
90                NS = ST5;
91              end
92
93          ST5: begin
94                NS = ST0;
95              end
96
97          ST6: begin
98                      if(Count==0)
99                          NS = ST0;
100                     else
101                         case({Qz,Qn})
102                             2'b00 : NS = ST6;
103
104                             2'b01 : NS = ST4;
105
106                             2'b10 : NS = ST5;
107
108                             2'b11 : NS = ST6;
109
110                         endcase
111             end
112
113         ST7: begin
114               NS = ST8;
115             end
116
117         ST8: begin
118                     if(R0m)
119                         NS = ST9;
120                     else if(NFlag)
121                         NS = ST12;
122                     else
123                         NS = ST11;
124             end
125
126         ST9: begin
127               NS = ST10;
128             end
129
130         ST10: begin
131                     if(NFlag)
132                         NS = ST12;
133                     else
134                         NS = ST11;
135              end
136
137         ST11: begin
138               NS = ST13;
139              end
140
141         ST12: begin
142               NS = ST14;
143              end
144
```

```
145                 ST13: begin
146                             if(NFlag)
147                                 NS = ST16;
148                             else
149                                 NS = ST15;
150                        end
151
152                 ST14: begin
153                             if(NFlag)
154                                 NS = ST16;
155                             else
156                                 NS = ST15;
157                        end
158
159                 ST15: begin
160                             if(Count==0)
161                                  begin
162                                     if(NFlag)
163                                         NS = ST17;
164                                     else
165                                         NS = ST0;
166                                  end
167                             else
168                                     if(NFlag)
169                                         NS = ST12;
170                                     else
171                                         NS = ST11;
172                        end
173
174                 ST16: begin
175                             if(Count==0)
176                                  begin
177                                     if(NFlag)
178                                         NS = ST17;
179                                     else
180                                         NS = ST0;
181                                  end
182                             else
183                                     if(NFlag)
184                                         NS = ST12;
185                                     else
186                                         NS = ST11;
187                        end
188
189                 ST17: begin
190                             NS = ST18;
191                         end
192
193                 ST18: begin
194                             if(r[1])
195                                 NS = ST19;
196                             else if(r[0] ^ r[1])
197                                 NS = ST21;
198                             else
199                                 NS = ST0;
200                         end
201
202                 ST19: begin
203                             NS = ST20;
204                         end
205
206                 ST20: begin
207                             if(r[0] ^ r[1])
208                                 NS = ST21;
209                             else
210                                 NS = ST0;
211                         end
212                 ST21: begin
213                             NS = ST0;
214                         end
215                 endcase
216                 end
217
```

```
218
219         always @(posedge CLK or posedge CLR)
220               begin : SEQ
221                   if(CLR)
222                       CS <= ST0;
223                   else
224                       CS <= NS;
225               end
226
227       always @(CLK, CLR,LOAD, COMP, OP, Stat,R1m, R0m,NFlag ,r,Count, Qn, Qz)
228             begin: OUT
229                   ERR = Stat[1];
230                   RST = CLR;
231                   AccCLR = CLR;
232                   QnCLR = CLR;
233                   R1Clr = CLR;
234
235                   if (CLR!=1)
236
237                       begin
238
239                       case(CS)
240                           ST0 :
241                               if(LOAD==1)
242                                   begin
243                                       R0Src = 2'b11;
244                                       R1Src = 1'b0;
245                                       R0WE = 1'b1;
246                                       R1WE = 1'b1;
247                                       ASrc = 2'b11;
248                                       BSrc = 2'b01;
249                                       k = k + 1;
250                                   end
251
252                           ST1 : begin
253                                       ALUCtrl = OP;
254                                       R1Clr = 1'b1;
255                                       ASrc = 2'b11;
256                                       BSrc = 2'b10;
257                                       R0WE = 1'b1;
258                                       R1WE = 1'b0;
259                                       R0Src = 2'b10;
260                                   end
261
262                           ST2 : begin
263                                       AccCLR = 1'b1;
264                                       AccParallel = 1'b0;
265                                       QnCLR = 1'b1;
266                                       QParallel = 1'b1;
267                                       QSrc = 1'b0;
268                                       ASrc = 2'b11;
269                                       Count = W;
270                                       R0WE = 1'b0;
271                                       R1WE = 1'b0;
272                                   end
273
274                           ST3 : begin
275                                       r = 2'b00;
276                                       if(R1m)
277                                           begin
278                                           BSrc = 2'b10;
279                                           ASrc = 2'b00;
280                                           ALUCtrl = 3'b110;
281                                           R0WE = 1'b0;
282                                           R1WE = 1'b1;
283                                           R1Src = 1'b0;
284                                           r[1] = 1'b1;
285                                           end
286                                       else if(R0m)
287                                           begin
288                                           BSrc = 2'b11;
289                                           ASrc = 2'b00;
290                                           ALUCtrl = 3'b110;
```

```
291                                     R0WE = 1'b1;
292                                     R1WE = 1'b0;
293                                     R0Src = 2'b10;
294                                     r[0] = 1'b1;
295                                     end
296                                 else
297                                     begin
298                                     AccCLR = 1'b1;
299                                     AccParallel = 1'b0;
300                                     QnCLR = 1'b1;
301                                     QParallel = 1'b1;
302                                     QSrc = 1'b0;
303                                     ASrc = 2'b10;
304                                     Count = W;
305                                     R0WE = 1'b0;
306                                     R1WE = 1'b0;
307                                     end
308                             end
309
310                         ST4 : begin
311                                 BSrc = 2'b10;
312                                 ASrc = 2'b01;
313                                 ALUCtrl = 3'b000;
314                                 AccParallel = 1'b1;
315                             end
316
317                         ST5 : begin
318                                 BSrc = 2'b10;
319                                 ASrc = 2'b01;
320                                 ALUCtrl = 3'b001;
321                                 AccParallel = 1'b1;
322                             end
323
324                         ST6 : begin
325                                 AccParallel = 1'b0;
326                                 QParallel = 1'b0;
327                                 AccRight = 1'b1;
328                                 QRight = 1'b1;
329                                 Count = Count -1;
330                                 if(Count==0)
331                                     begin
332                                     R0WE = 1'b1;
333                                     R1WE = 1'b1;
334                                     R0Src = 2'b01;
335                                     R1Src = 1'b1;
336                                     end
337                             end
338
339                         ST7 : begin
340                                 BSrc = 2'b00;
341                                 ASrc = 2'b10;
342                                 ALUCtrl = 3'b000;
343                                 R0WE = 1'b0;
344                                 R1WE = 1'b1;
345                                 R1Src = 1'b0;
346                             end
347
348                         ST8 : begin
349                                 if(R0m)
350                                     begin
351                                     BSrc = 2'b11;
352                                     ASrc = 2'b00;
353                                     ALUCtrl = 3'b110;
354                                     R0WE = 1'b1;
355                                     R1WE = 1'b0;
356                                     R0Src = 2'b10;
357                                     r[0] = 1'b1;
358                                     end
359                                 else
360                                     begin
361                                     AccCLR = 1'b1;
362                                     AccParallel = 1'b0;
363                                     QnCLR = 1'b1;
```

```
364                                 QParallel = 1'b1;
365                                 QSrc = 1'b0;
366                                 ASrc = 2'b10;
367                                 Count = W;
368                                 R0WE = 1'b0;
369                                 R1WE = 1'b0;
370                                 end
371                         end
372
373                     ST9 : begin
374                             BSrc = 2'b00;
375                             ASrc = 2'b11;
376                             ALUCtrl = 3'b000;
377                             R0WE = 1'b1;
378                             R1WE = 1'b0;
379                             R0Src = 2'b10;
380                         end
381
382                     ST10 : begin
383                             AccCLR = 1'b1;
384                             AccParallel = 1'b0;
385                             QnCLR = 1'b1;
386                             QParallel = 1'b1;
387                             QSrc = 1'b0;
388                             ASrc = 2'b10;
389                             Count = W;
390                             R0WE = 1'b0;
391                             R1WE = 1'b0;
392                           end
393
394                     ST11 : begin
395                             AccParallel = 1'b0;
396                             QParallel = 1'b0;
397                             AccRight = 1'b0;
398                             QRight = 1'b0;
399                           end
400
401                     ST12 : begin
402                             AccParallel = 1'b0;
403                             QParallel = 1'b0;
404                             AccRight = 1'b0;
405                             QRight = 1'b0;
406                           end
407
408                     ST13 : begin
409                             BSrc = 2'b11;
410                             ASrc = 2'b01;
411                             ALUCtrl = 3'b001;
412                             AccParallel = 1'b1;
413                           end
414
415                     ST14 : begin
416                             BSrc = 2'b11;
417                             ASrc = 2'b01;
418                             ALUCtrl = 3'b000;
419                             AccParallel = 1'b1;
420                           end
421
422                     ST15 : begin
423                             QSrc = 1'b1;
424                             QzSrc = 1'b1;
425                             QParallel = 1'b1;
426                             Count = Count - 1;
427                             if((Count == 0) && NFlag)
428                                 begin
429                                 R0WE = 1'b1;
430                                 R1WE = 1'b1;
431                                 R0Src = 2'b01;
432                                 R1Src = 1'b1;
433                                 end
434                           end
435
436                     ST16 : begin
```

```
437                                     QSrc = 1'b1;
438                                     QzSrc = 1'b0;
439                                     QParallel = 1'b1;
440                                     Count = Count - 1;
441                                     if((Count == 0) && NFlag)
442                                         begin
443                                         R0WE = 1'b1;
444                                         R1WE = 1'b1;
445                                         R0Src = 2'b01;
446                                         R1Src = 1'b1;
447                                         end
448                                 end
449
450                             ST17 : begin
451                                     BSrc = 2'b11;
452                                     ASrc = 2'b01;
453                                     ALUCtrl = 3'b000;
454                                     AccParallel = 1'b1;
455
456                                     R0WE = 1'b1;
457                                     R1WE = 1'b1;
458                                     R0Src = 2'b01;
459                                     R1Src = 1'b1;
460                                 end
461                         endcase
462                         end
463                         end
464
465     endmodule
466
```