Digital Design and Computer Organization Laboratory

UE19CS206

3rd Semester, Academic Year 2020-21

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Week # : 8 Date: 18/11/2021

Title of the Program: Microprocessor Control Logic - 2

Code:

```
module nor5 (input wire [0:4] i, output wire o);
  wire t;
  or3 or3_0 (i[0], i[1], i[2], t);
  nor3 nor3_0 (t, i[3], i[4], o);
endmodule

module ir (input wire clk, reset, load, input wire [15:0] din, output wire [15:0] dout);
  dfrl dfrl_0 (clk, reset, load, din['h0], dout['h0]);
  dfrl dfrl_1 (clk, reset, load, din['h1], dout['h1]);
  dfrl dfrl_2 (clk, reset, load, din['h2], dout['h2]);
  dfrl dfrl_3 (clk, reset, load, din['h3], dout['h3]);
  dfrl dfrl_4 (clk, reset, load, din['h4], dout['h4]);
  dfrl dfrl_5 (clk, reset, load, din['h5], dout['h5]);
  dfrl dfrl_6 (clk, reset, load, din['h6], dout['h6]);
  dfrl dfrl_7 (clk, reset, load, din['h7], dout['h7]);
  dfrl dfrl_8 (clk, reset, load, din['h8], dout['h8]);
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  dfrl dfrl_9 (clk, reset, load, din['h9], dout['h9]);
  dfrl dfrl_a (clk, reset, load, din['ha], dout['ha]);
  dfrl dfrl_b (clk, reset, load, din['hb], dout['hb]);
  dfrl dfrl_c (clk, reset, load, din['hc], dout['hc]);
  dfrl dfrl_d (clk, reset, load, din['hd], dout['hd]);
  dfrl dfrl_e (clk, reset, load, din['he], dout['he]);
  dfrl dfrl_f (clk, reset, load, din['hf], dout['hf]);
endmodule

module control_logic (input wire clk, reset, input wire [15:0] cur_ins, output wire [2:0]
rd_addr_a, rd_addr_b, wr_addr,
  output wire [1:0] op, output wire sel, jump, pc_inc, load_ir, wr_reg);
wire u,w,s,wr_reg1,wr_reg2,alu_ins,ld_ins,ld_ins_,fi,fo,el,eo,ef ;
assign rd_addr_a=cur_ins[2:0];
assign rd_addr_b=cur_ins[5:3];
assign wr_addr=cur_ins[8:6];
assign op = cur_ins[10:9];

invert i1(cur_ins[15],u);
invert i2(cur_ins[10],w);
invert i3(cur_ins[14],s);
invert i4(ld_ins,ld_ins_);
and2 a1(cur_ins[15],s,ld_ins);
nor5 n5({cur_ins[15],cur_ins[14],cur_ins[13],cur_ins[12],cur_ins[11]},alu_ins);
and3 a2(cur_ins[14],u,ef,jump);

dfrl d1(clk,reset,1'b1,fo,eo);
and2 a3(ld_ins_,eo,ef);
and2 a4(ef,alu_ins,wr_reg1);
or2 o3(wr_reg1,wr_reg2,wr_reg);
and2 a5(eo,ld_ins,el);
```
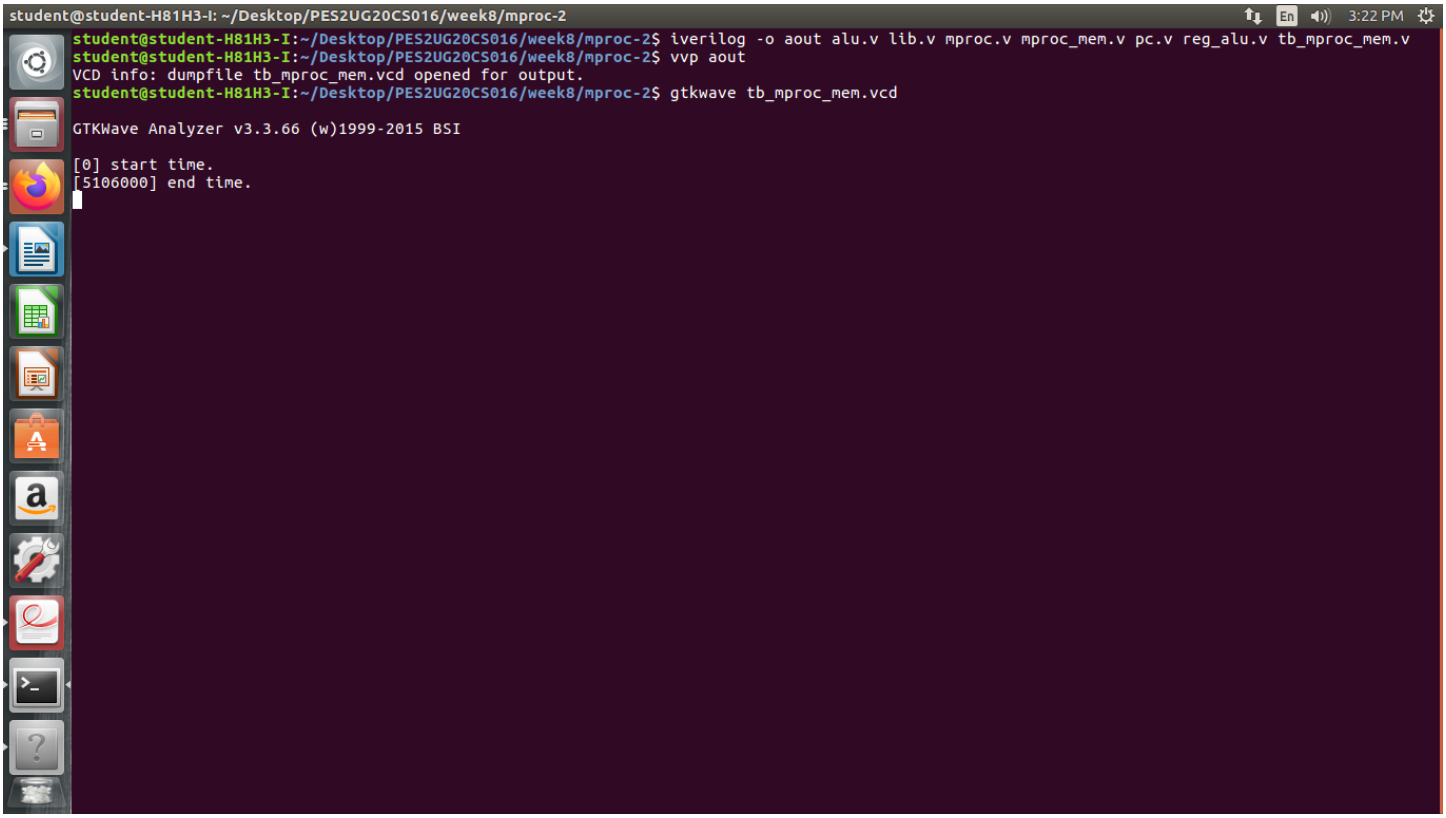

```
and2 a6(ld_ins,el,wr_reg2);

nand2 n1(el,ld_ins,sel);

dfrl d2(clk,reset,1'b1,el,lo);

or2 o1(lo,ef,fi);

dfsl d3(clk,reset,1'b1,fi,fo);

assign load_ir = fo;

or2 o2(load_ir,el,pc_inc);



endmodule


module mproc (input wire clk, reset, input wire [15:0] d_in, output wire [6:0] addr, output wire [15:0] d_out);

  wire pc_inc, cout, cout_, sub, sel, sel_addr; wire [2:0] rd_addr_a, rd_addr_b, wr_addr; wire [1:0] op; wire [8:0] _addr;

  wire [15:0] cur_ins, d_out_a, d_out_b;


  and2 and2_0 (jump, cout, sub);

  pc pc_0 (clk, reset, pc_inc, 1'b0, sub, {8'b0, cur_ins[7:0]}, {_addr, addr});

  ir ir_0 (clk, reset, load_ir, d_in, cur_ins);

  control_logic control_logic_0 (clk, reset, cur_ins, rd_addr_a, rd_addr_b, wr_addr, op, sel, jump, pc_inc, load_ir, wr_reg);

  reg_alu reg_alu_0 (clk, reset, sel, wr_reg, op, rd_addr_a, rd_addr_b, wr_addr, d_in, d_out_a, d_out_b, cout);

  assign d_out = d_out_a;

endmodule
```

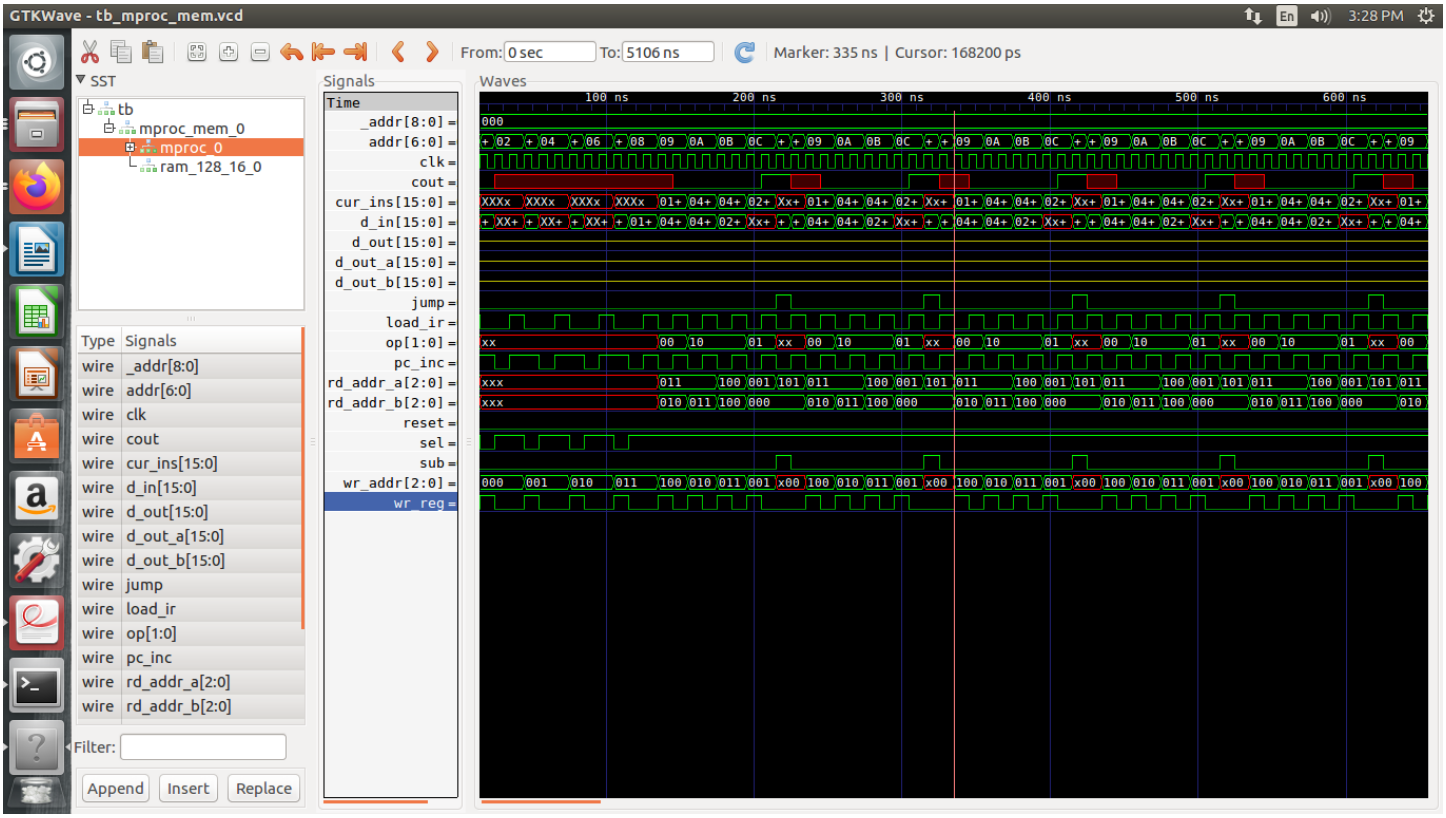
Output waveform

Terminal:

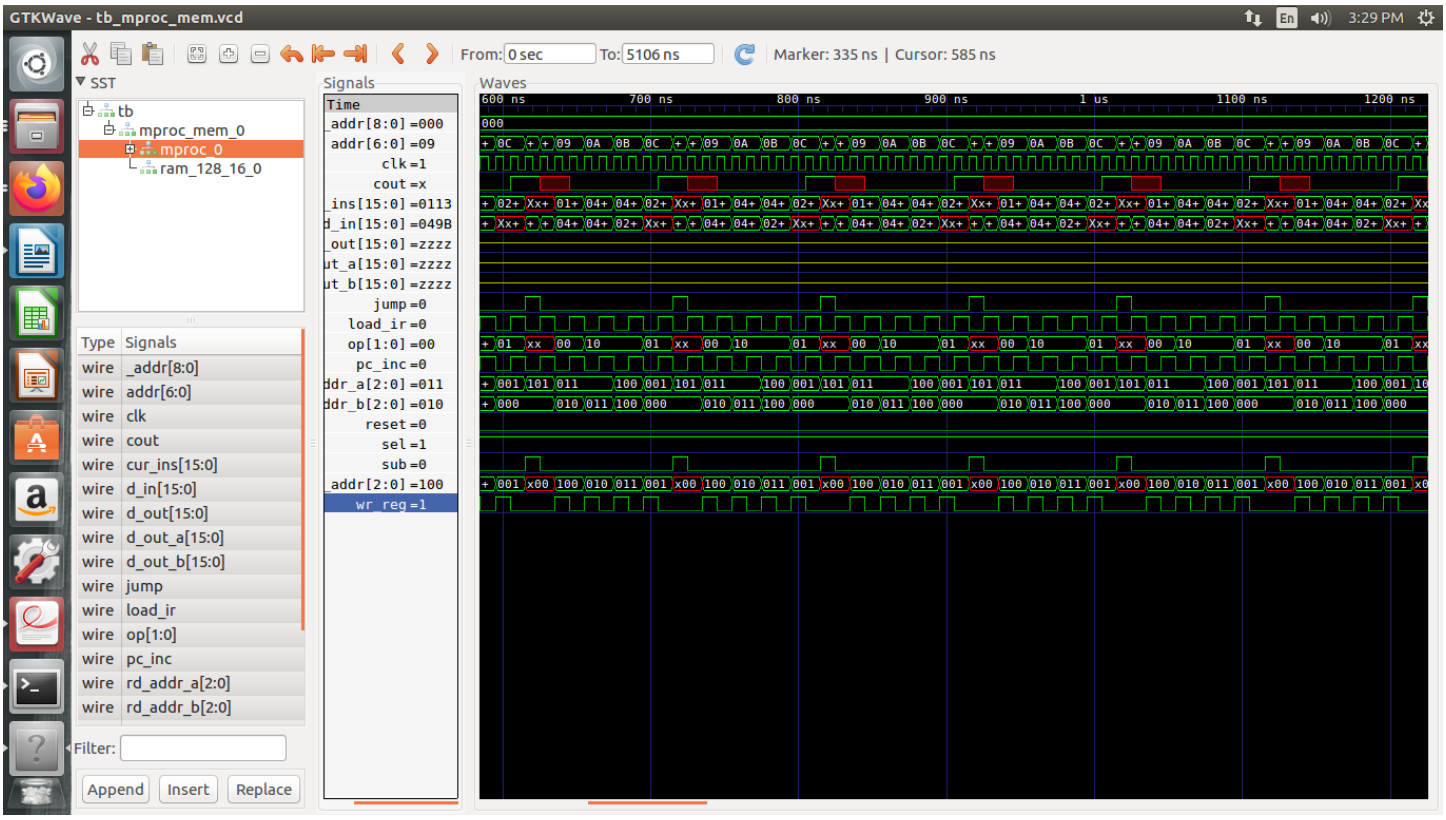


waveform:

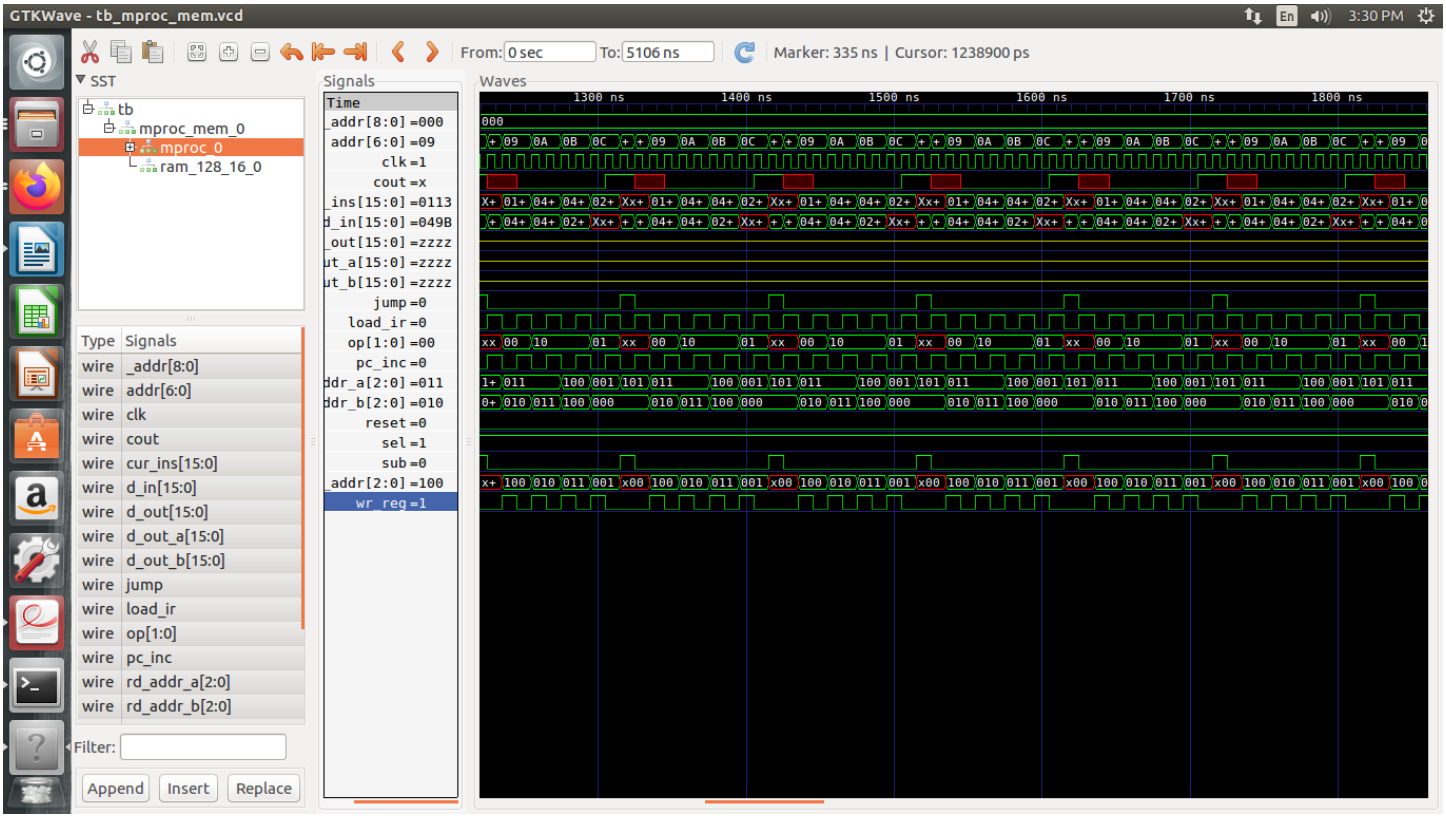
1


GTKWave - tb_mproc_mem.vcd
3:28 PM
From: 0 sec
To: 5106 ns
Marker: 335 ns | Cursor: 168200 ps
SST
tb
mproc_mem_0
mproc_0
ram_128_16_0
Signals
Waves
Time
_addr[8:0]
addr[6:0]
clk
cout
cur_ins[15:0]
d_in[15:0]
d_out[15:0]
d_out_a[15:0]
d_out_b[15:0]
jump
load_ir
op[1:0]
pc_inc
rd_addr_a[2:0]
rd_addr_b[2:0]
reset
sel
sub
wr_addr[2:0]
wr_reg
Type
Signals
wire _addr[8:0]
wire addr[6:0]
wire clk
wire cout
wire cur_ins[15:0]
wire d_in[15:0]
wire d_out[15:0]
wire d_out_a[15:0]
wire d_out_b[15:0]
wire jump
wire load_ir
wire op[1:0]
wire pc_inc
wire rd_addr_a[2:0]
wire rd_addr_b[2:0]
Filter:
Append
Insert
Replace

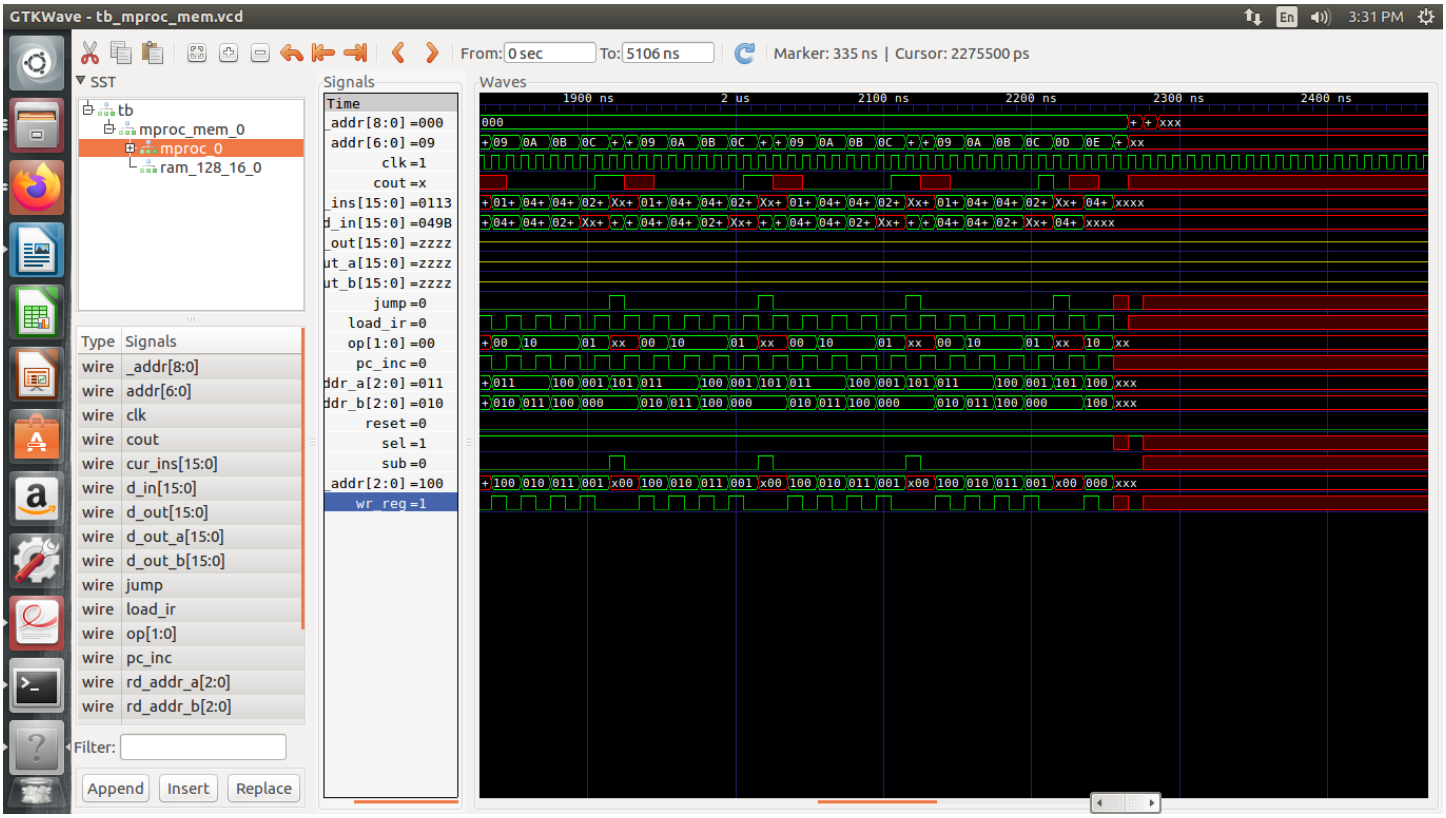
2


GTKWave - tb_mproc_mem.vcd
3:29 PM
From: 0 sec
To: 5106 ns
Marker: 335 ns | Cursor: 585 ns
SST
tb
mproc_mem_0
mproc_0
ram_128_16_0
Signals
Waves
Time
Type
Signals
wire _addr[8:0]
wire addr[6:0]
wire clk
wire cout
wire cur_ins[15:0]
wire d_in[15:0]
wire d_out[15:0]
wire d_out_a[15:0]
wire d_out_b[15:0]
wire jump
wire load_ir
wire op[1:0]
wire pc_inc
wire rd_addr_a[2:0]
wire rd_addr_b[2:0]
Filter:
Append
Insert
Replace

3


GTKWave - tb_mproc_mem.vcd
3:30 PM
From: 0 sec
To: 5106 ns
Marker: 335 ns | Cursor: 1238900 ps
SST
tb
mproc_mem_0
mproc_0
ram_128_16_0
Type Signals
wire _addr[8:0]
wire addr[6:0]
wire clk
wire cout
wire cur_ins[15:0]
wire d_in[15:0]
wire d_out[15:0]
wire d_out_a[15:0]
wire d_out_b[15:0]
wire jump
wire load_ir
wire op[1:0]
wire pc_inc
wire rd_addr_a[2:0]
wire rd_addr_b[2:0]
Filter:
Append
Insert
Replace
Signals
Time
_addr[8:0] =000
addr[6:0] =09
clk =1
cout =x
_ins[15:0] =0113
d_in[15:0] =049B
_out[15:0] =zzzz
ut_a[15:0] =zzzz
ut_b[15:0] =zzzz
jump =0
load_ir =0
op[1:0] =00
pc_inc =0
ddr_a[2:0] =011
ddr_b[2:0] =010
reset =0
sel =1
sub =0
addr[2:0] =100
wr_reg =1
Waves
1300 ns
1400 ns
1500 ns
1600 ns
1700 ns
1800 ns

4


GTKWave - tb_mproc_mem.vcd
3:31 PM
From: 0 sec
To: 5106 ns
Marker: 335 ns | Cursor: 2275500 ps
SST
tb
mproc_mem_0
mproc_0
ram_128_16_0
Type Signals
wire _addr[8:0]
wire addr[6:0]
wire clk
wire cout
wire cur_ins[15:0]
wire d_in[15:0]
wire d_out[15:0]
wire d_out_a[15:0]
wire d_out_b[15:0]
wire jump
wire load_ir
wire op[1:0]
wire pc_inc
wire rd_addr_a[2:0]
wire rd_addr_b[2:0]
Filter:
Append
Insert
Replace
Signals
Time
_addr[8:0] =000
addr[6:0] =09
clk =1
cout =x
_ins[15:0] =0113
d_in[15:0] =049B
_out[15:0] =zzzz
ut_a[15:0] =zzzz
ut_b[15:0] =zzzz
jump =0
load_ir =0
op[1:0] =00
pc_inc =0
ddr_a[2:0] =011
ddr_b[2:0] =010
reset =0
sel =1
sub =0
addr[2:0] =100
wr_reg =1
Waves
1900 ns
2 us
2100 ns
2200 ns
2300 ns
2400 ns