20. Using structural modeling, write code for a Verilog module that uses only the nand gate primitive to implement the NAND-only circuit derived in step 4. [2]

```
module my_func (A,B,C,D,F);
    input A, B, C, D;
    output F;
    wire NOT_A, NOT_B, NOT_C;
    wire NOT_A_NAND_NOT_B, NOT_C_NAND_D, ABD, nand1, nand2;
    nand(NOT_A, A, A);
    nand(NOT_B, B, B);
    nand(NOT_C, C, C);
    nand(NOT_A_NAND_NOT_B, NOT_A, NOT_B);
    nand(NOT_C_NAND_D, NOT_C, D);
    nand(ABD, A, B, D);
    nand(nand1, NOT_A_NAND_NOT_B, NOT_A_NAND_NOT_B);
    nand(nand2, NOT_C_NAND_D, NOT_C_NAND_D);
    nand(F, nand1, nand2, ABD);
endmodule
```

21. Write code for a test bench module that tests the above module for all combinations of A, B, C and D. [1]

```
module test_my_func;
reg A, B, C, D;
wire F;
my_func func_1 (.A(A), .B(B), .C(C), .D(D), .F(F));
initial begin
  A = 0; B = 0; C = 0; D = 0; #100;
  A = 0; B = 0; C = 0; D = 1; #100;
  A = 0; B = 0; C = 1; D = 0; #100;
  A = 0; B = 0; C = 1; D = 1; #100;
  A = 0; B = 1; C = 0; D = 0; #100;
  A = 0; B = 1; C = 0; D = 1; #100;
  A = 0; B = 1; C = 1; D = 0; #100;
  A = 0; B = 1; C = 1; D = 1; #100;
```

A = 1; B = 0; C = 0; D = 0; #100;

A = 1; B = 0; C = 0; D = 1; #100;

A = 1; B = 0; C = 1; D = 0; #100;

A = 1; B = 0; C = 1; D = 1; #100;

A = 1; B = 1; C = 0; D = 0; #100;

A = 1; B = 1; C = 0; D = 1; #100;

A = 1; B = 1; C = 1; D = 0; #100;

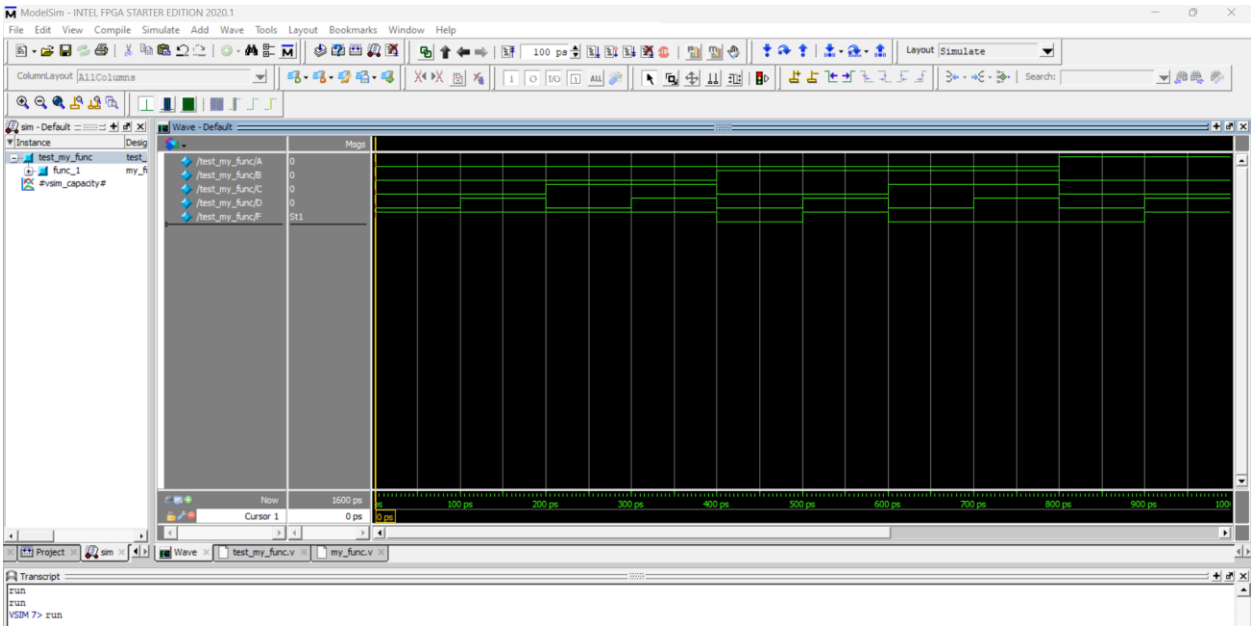
A = 1; B = 1; C = 1; D = 1; #100;

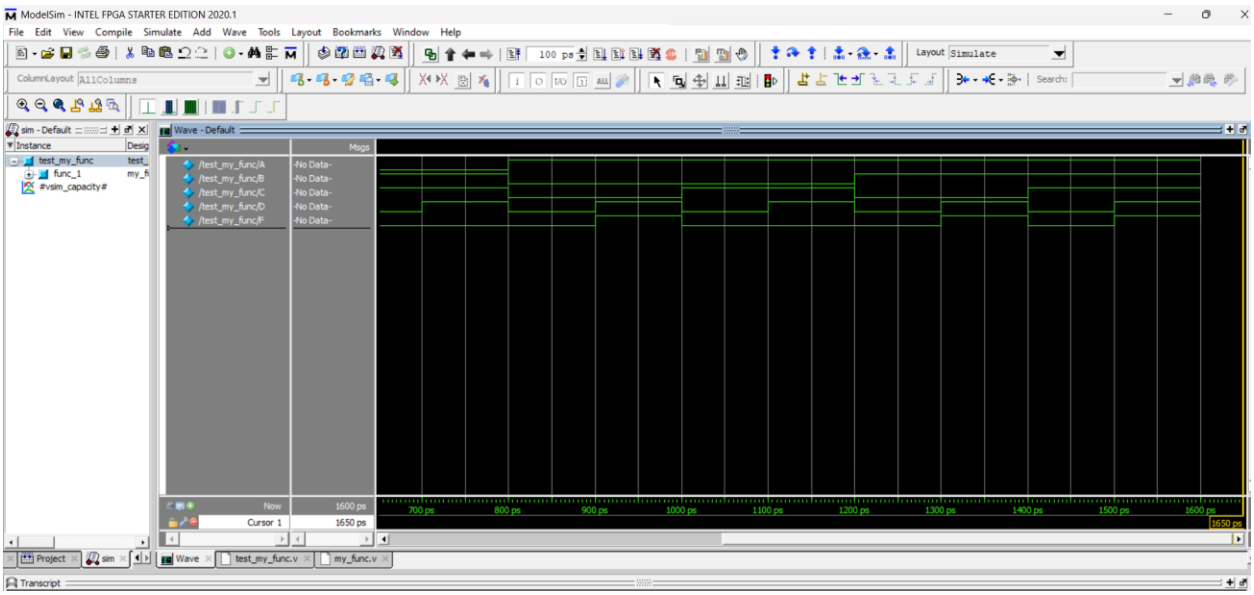
end

endmodule

22. Fill in the truth table of G in Table 4.2 according to the timing waveforms obtained after running the simulation. Verify that the truth table corresponds to the minterms of G. Show simulation results to the lab engineer to obtain credit.[2]

23. Take clear screenshots of code of all modules of this task and the simulation timing waveforms and paste them in your WORD file such that all fit on no more than two pages. Make sure that screenshots are legible.




ModelSim - INTEL FPGA STARTER EDITION 2020.1
File Edit View Compile Simulate Add Wave Tools Layout Bookmarks Window Help
Wave - Default
/test_my_func/A
/test_my_func/B
/test_my_func/C
/test_my_func/D
/test_my_func/F
-No Data-
Now
1600 ps
Cursor 1
1650 ps
700 ps
800 ps
900 ps
1000 ps
1100 ps
1200 ps
1300 ps
1400 ps
1500 ps
1600 ps
Project
sim
Wave
test_my_func.v
my_func.v
Transcript