Funkcionalna verifikacija MLP IP jezgra za klasifikaciju cifara

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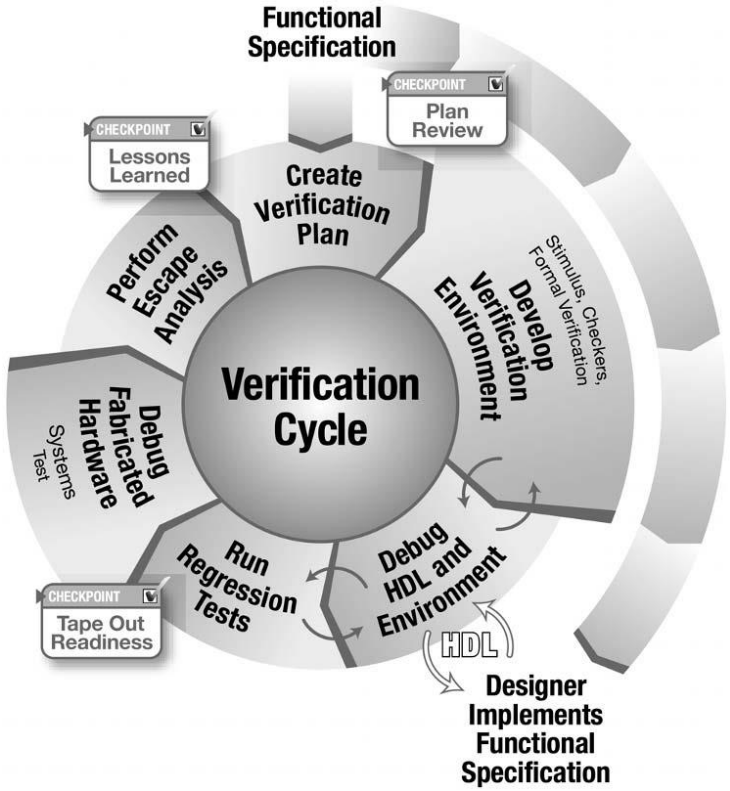
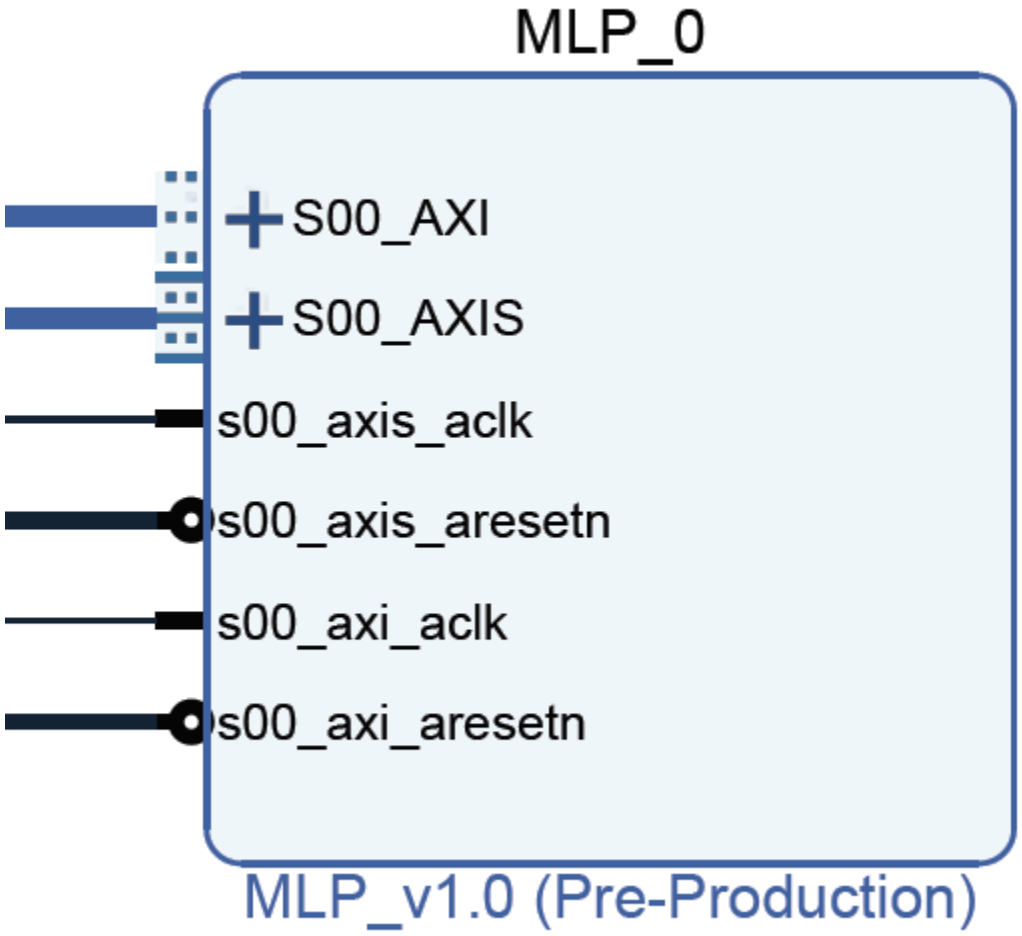
Verifikacioni ciklus



MLP IP jezgro



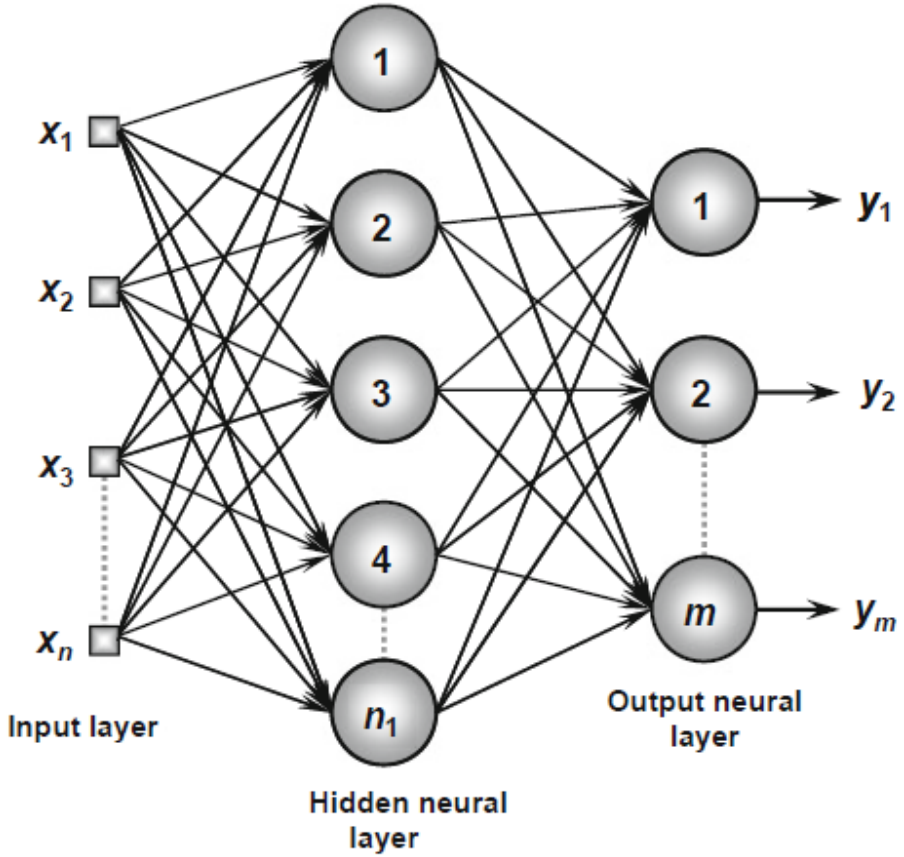


Tabela 1: Registri MLP IP jezgra

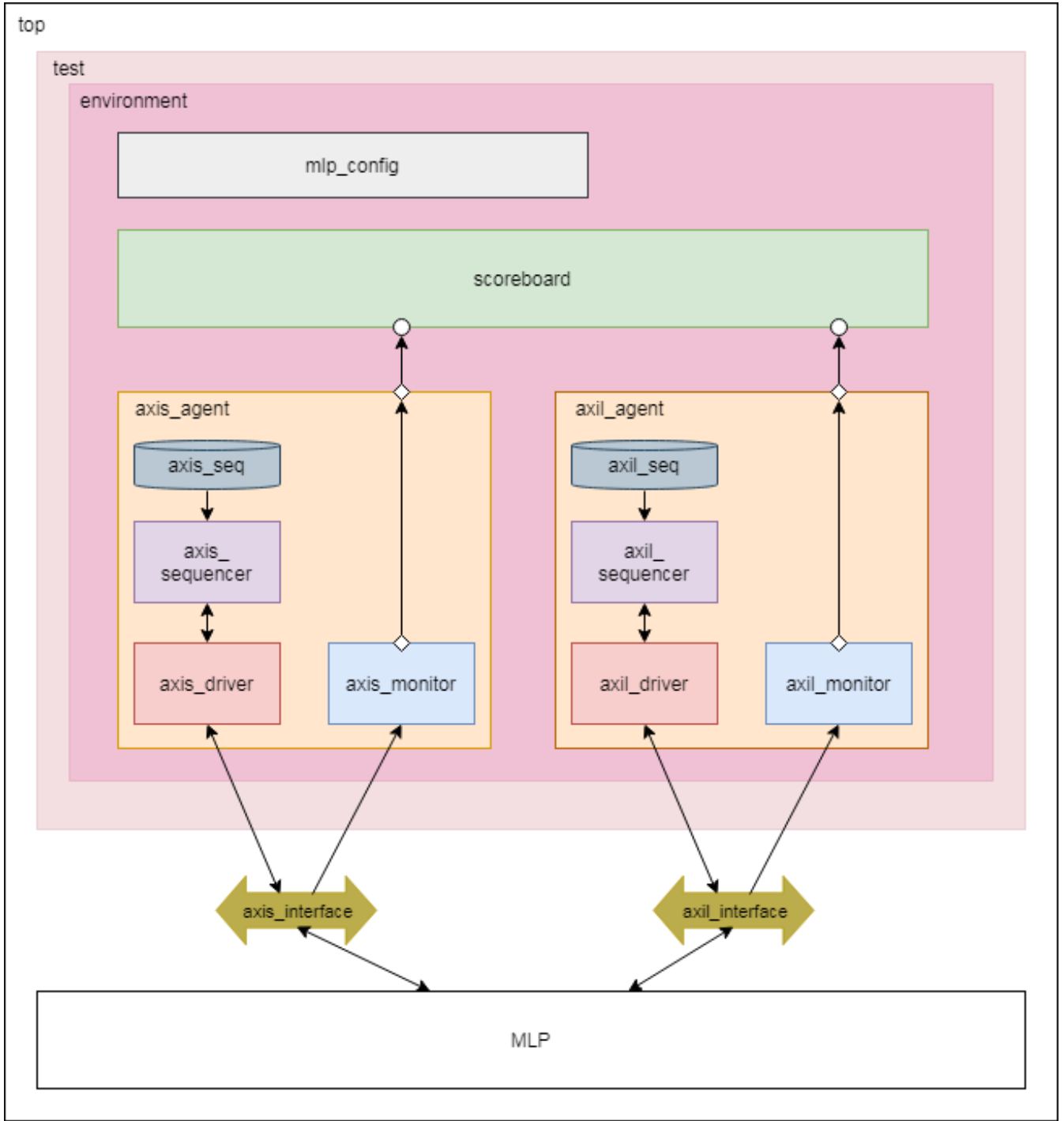
naziv registra	adresa pristupa AXI *Lite* interfejsom
start	0
ready	4
toggle	8
cl_num	12

Verifikacioni plan

1. Funkcionalnost reseta sistema
2. Funkcionalnost AXI Lite interfejsa
3. Ispravnost klasfikacije

- QuestaSim - Mentor Graphics
- coverage-driven constraint random-based functional verification (UVM)

Verifikaciono okruženje

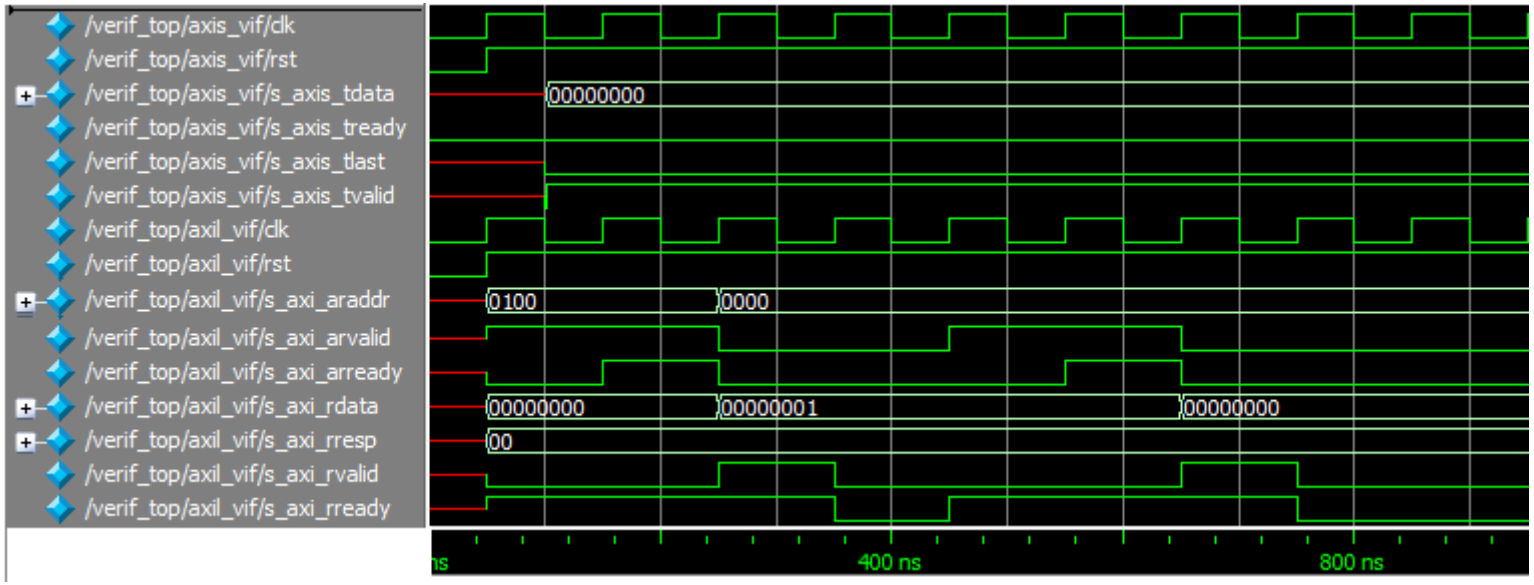


Pokrivenost

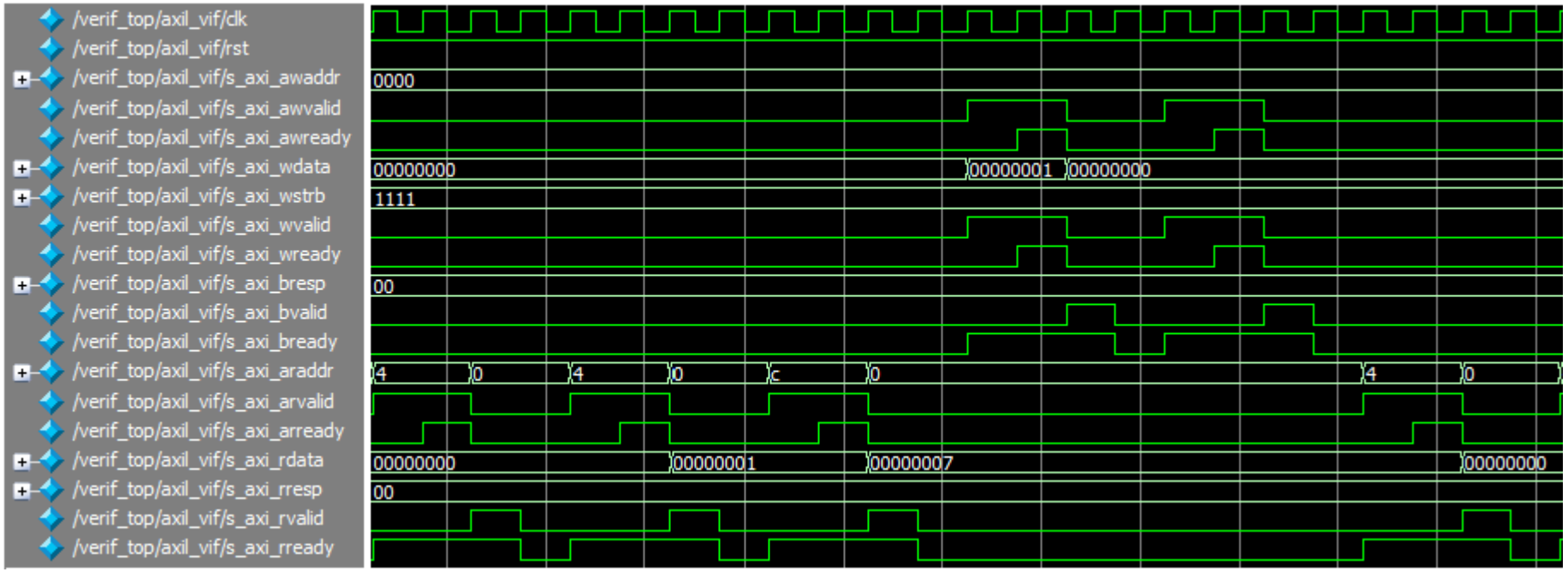
Listing 13: Kôd za prikupljanje pokrivenosti

```
1  covergroup write_address;
2        option.per_instance = 1;
3        write_address: coverpoint address{
4            bins write_address_bin = {0};
5        }
6        data_write: coverpoint vif.s_axi_wdata {
7            bins start_0 = {0};
8            bins start_1 = {1};
9        }
10   endgroup
11
12   covergroup read_address;
13       option.per_instance = 1;
14       read_address: coverpoint address{
15           bins start_address_bin = {0};
16           bins ready_address_bin = {4};
17       }
18       data_read: coverpoint vif.s_axi_rdata{
19           bins data_bin_ready = {1};
20           bins data_bin_not_ready = {0};
21       }
22       cp_cross: cross read_address, data_read;
23   endgroup
```

Tok verifikacije



Tok verifikacije



Tok verifikacije

```
# UVM_INFO ../sv/sequences/axis_seq.sv(13) @ 0: uvm_test_top.mlp_env.mlp_axis_agent.axis_seqr@@mlp_axis_seq [axis_seq] Sequence starting...
# UVM_INFO ../sv/sequences/axis_seq.sv(16) @ 0: uvm_test_top.mlp_env.mlp_axis_agent.axis_seqr@@mlp_axis_seq [axis_seq] Sending image number           0.
# UVM_INFO ../sv/sequences/axil_seq.sv(17) @ 0: uvm_test_top.mlp_env.mlp_axil_agent.axil_seqr@@mlp_axil_seq [axil_seq]           7 images are being classified
# UVM_INFO ../sv/sequences/axil_seq.sv(26) @ 1950: uvm_test_top.mlp_env.mlp_axil_agent.axil_seqr@@mlp_axil_seq [axil_seq] image           0 is being classified
# UVM_INFO ../sv/sequences/axis_seq.sv(27) @ 79650: uvm_test_top.mlp_env.mlp_axis_agent.axis_seqr@@mlp_axis_seq [axis_seq] Layer number           1 calculating
# UVM_INFO ../sv/sequences/axis_seq.sv(27) @ 4789750: uvm_test_top.mlp_env.mlp_axis_agent.axis_seqr@@mlp_axis_seq [axis_seq] Layer number           2 calculating
# UVM_INFO ../sv/scoreboard.sv(76) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Finished classifying img
# UVM_INFO ../sv/scoreboard.sv(170) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Res for neuron 0 is: 3fff9
# UVM_INFO ../sv/scoreboard.sv(173) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Res for neuron           1 is: 3fff4
# UVM_INFO ../sv/scoreboard.sv(173) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Res for neuron           2 is: 3fff9
# UVM_INFO ../sv/scoreboard.sv(173) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Res for neuron           3 is: 3fffc
# UVM_INFO ../sv/scoreboard.sv(173) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Res for neuron           4 is: 3ffee
# UVM_INFO ../sv/scoreboard.sv(173) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Res for neuron           5 is: 3fffe
# UVM_INFO ../sv/scoreboard.sv(173) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Res for neuron           6 is: 3fff2
# UVM_INFO ../sv/scoreboard.sv(173) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Res for neuron           7 is: 03cc1
# UVM_INFO ../sv/scoreboard.sv(173) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Res for neuron           8 is: 3fff4
# UVM_INFO ../sv/scoreboard.sv(173) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Res for neuron           9 is: 3fffb
# UVM_INFO ../sv/scoreboard.sv(180) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] New cl_num:  7
# UVM_INFO ../sv/scoreboard.sv(78) @ 4851950: uvm_test_top.mlp_env.scbd [scoreboard] Classified number is:  7
```

Rezultati prikupljanja pokrivenosti

CVP write_address	100.0%	100	100.0%	
CVP data_write	100.0%	100	100.0%	
CVP read_address	100.0%	100	100.0%	
CVP data_read	100.0%	100	100.0%	
CROSS cp_cross	100.0%	100	100.0%	

Q&A