

iSTART

EZ-BIST Quick Start Guide

v2.2

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1. EZ-BIST Tool Environment Setup

1.1. The Contents in the EZ-BIST Package

The released EZ-BIST tool package includes the following items:

- **Demo case:** [EZ-BIST_Demo.tar.gz](#)
The demo case folder contains an example case. Users can use this demo case to get familiar with the EZ-BIST tool.
- **DOC**
The DOC folder contains all the EZ-BIST-related documents for designers' reference.
- **License:**
It contains the iSTART tool license system. The file name is like [LM-CentOS-x.x-x86_64-xxxx.tar.gz](#). Before manipulating the EZ-BIST tool, users have to set up this license to their license servers. After setting up [iSTART_LICENSE_FILE](#) environment variables and invoking the license file, users can launch the EZ-BIST tool successfully.
- **EZ-BIST Tool:**
It contains the EZ-BIST tool, and the tool file name is like [EZ-BIST-CentOS-x.x-x86_64-develop-xxxx.tar.gz](#). Users can extract this tarball to the working server and setup alias. Then users can start to use EZ-BIST tools.

1.2. Untar Tarballs in the EZ-BIST Package

There are two tarballs in the EZ-BIST package. Users can refer to the following instructions to extract these tarballs and untar them in the Linux system.

- **EZ-BIST License Manager:**

The name of the EZ-BIST license manager is similar with [LM-CentOS-x.x-x86_64-xxxx.tar.gz](#). Users can create a folder in the license server to store this license tarball. Then, use the following command to extract.

```
$ tar xvf LM-CentOS-x.x-x86_64-xxxx.tar.gz
```

After decompressing correctly, users can find the following files:

- (1) [iSTART_lic_2023xxxxx.lic](#)
- (2) [lmgrd](#)
- (3) [lmutil](#)
- (4) [istart](#)

- **EZ-BIST tool:**

The name of the EZ-BIST tool is similar with [EZ-BIST-CentOS-x.x-x86_64-develop-xxxx.tar.gz](#). Users can create a folder in the workstation to store this tool tarball. Then, use the following command to extract.

```
$ tar -xvzf EZ-BIST-CentOS-x.x-x86_64-develop-xxxx.tar.gz
```

1.3. Set Up the EZ-BIST License

- Please put [istart](#) together with [lmgrd](#) in the same folder.
- Execute the following command under the folder [LM-CentOS-x.x-x86_64](#)

```
$ ./lmgrd -c iSTART_lic_2023xxxxx.lic
```
- The way to confirm EZ-BIST license launched:

```
$ ./lmutil lmstat -a
```

1.3.1 Kill Previous Registered License

iSTART tools have already adopted a new Flexnet license system. If users have the previous license system in their own license server, please refer to the following steps to terminate the existing license and `iSTART_LIC_FILE`.

1. `$ ps -ef | grep 'lmInvoke'`
2. `$ kill #license thread`
3. `$ unset iSTART_LIC_FILE`

1.4. Set Up the Environment

Set up the environment with `iSTART_LICENSE_FILE` to invoke the license server.

- **Bash Shell:**
`$ export iSTART_LICENSE_FILE=4141@hostname`
Or
`$ export iSTART_LICENSE_FILE=4141@IP`
- **C Shell (Tcsh):**
`$ setenv iSTART_LICENSE_FILE 4141@hostname`
Or
`$ setenv iSTART_LICENSE_FILE 4141@IP`

1.5. Set Up the Alias in EZ-BIST

Set the EZ-BIST tool alias names to easily invoke EZ-BIST at any working folder. The following shows the EZ-BIST alias settings in Bash shell & C shell.

- **Bash Shell:**
`$ alias ezBist=/usr/home/tools/EZ-BIST-CentOS-6.5-x86_64-xxxxx/bin/ezBist`
- **C Shell (Tcsh):**
`$ alias ezBist /usr/home/tools/EZ-BIST-CentOS-6.5-x86_64-xxxxx/bin/ezBist`

1.6. iSTART License Update

Once the license cannot be invoked successfully, please use `lmutil lmdown` to turn off the license server. After the iSTART license is off, please execute `lmgrd` with the new license again.

```
$ ./lmutil lmdown  
$ ./lmgrd -c iSTART_lic_2023xxxxx.lic
```

2. BFL Flow

Here is an example case for users to understand the BFL (BIST Feature List) flow for the first time executing EZ-BIST. Please note that this evaluation package, [NDAcase](#), is designed only for the design of the single clock domain.

2.1. Untar the Example Case

```
$ tar xvzf NDAcase.tgz
$ cd NDAcase
```

2.2. Check If the EZ-BIST Tool Workable

Use the following command under the execution folder.

```
$ ezBist --help
```

```
usage: ezBist [-h] [-bii INTEGRATE_FILE] [-bfl BFL_FILE]
             [-f RUN_FILE [RUN_FILE ...]]
             [-v VERILOG_FILE [VERILOG_FILE ...]] [-w DIR] [-top MODULE] [-I]
             [--genmeminfo] [-integ FILE [FILE ...]] [-u FILE [FILE ...]]
             [-pm Verilog type] [--integrator] [--faultfree]
             [--ug UDM_FILE config_FILE]
             [--rcfg Addr_length Data_width output_FILE] [--tempgen]
             [--memchecker] [--memlib2udm MEMLIB_FILE]
             [--bflconfig [BFL_FILE]] [--biiconfig [BII_FILE]]
             [--pathconv work_path] [--STILloopformat work_path]
             [--latchgo_hier latchgo_data meminfo] [--udmgui [UDMGUI]]
             [--meminfogui [MEMINFO]]

optional arguments:
-h, --help            show this help message and exit
-bii INTEGRATE_FILE  input BII file
-bfl BFL_FILE        input BFL file
-f RUN_FILE [RUN_FILE ...]
                    input run file(s)
-v VERILOG_FILE [VERILOG_FILE ...]
                    input verilog file(s)
-w DIR              specify working path
-top MODULE, -T MODULE
                    specify top module
-I, --insert         insert BIST to design
--genmeminfo        Generate meminfo file
-integ FILE [FILE ...]
                    input integ file(s)
-u FILE [FILE ...], -udm FILE [FILE ...]
                    Input User Defined Memory file(s)
-pm Verilog type, --parsingmode Verilog type
                    Specifies the Verilog input file types, RTL_only,
                    Netlist_only
--integrator        integrate multiple BIST
--faultfree        create file without faulty memory
--ug UDM_FILE config_FILE
                    User Defined Memory Generator
--rcfg Addr_length Data_width output_FILE
                    RCF Generator
--tempgen          EZBIST Defined Format Template generator
--memchecker       EZBIST auto memory identify (memory identify only)
--memlib2udm MEMLIB_FILE
                    Generate EZBIST udm file.(*.memlib -> *.udm, *.lvlib
                    -> *.udm)
--bflconfig [BFL_FILE]
                    GUI version of the BFL adjustment tool
--biiconfig [BII_FILE]
                    GUI version of the BII adjustment tool
--pathconv work_path
                    Path Conversion.(absolute path -> relative path)
--STILloopformat work_path
                    STIL file in loop format
--latchgo_hier latchgo_data meminfo
                    Latch_go data to memory hierarchy
--udmgui [UDMGUI]  GUI version of the udm tool
--meminfogui [MEMINFO]
                    GUI version of the meminfo tool
```

Figure 2-1 EZ-BIST Command Option

2.3. Create the FileList file (*.f)

The easiest way to execute EZ-BIST is to provide a completed design and FileList file (*.f). The FileList file format is the same as the NC-Verilog file which includes the following items.

- [Design.v](#) (RTL or Netlist)
- [Memory.v](#)
- [Standard_cell.v](#) (when the user's design is Netlist)
- Parameter, e.g., `+define+`, `+incdir+PATH/DIR`

Figure 2-2 shows an example of *.f file. To run *.f for this test case, [NDAcase](#), users should add the `-v` option in front of each memory Verilog file.

```
-v ./memory/rf_2p_24x28.v
-v ./memory/sram_sp_4096x64.v
-v ./memory/rom_6144_64.v
-v ./memory/rf_sp_128x22.v
-v ./memory/sram_dp_1024x64.v
-v ./memory/rf_2p_24x56.v
-v ./memory/sram_sp_2048x64.v
-v ./memory/sram_sp_640x32.v
-v ./memory/rf_2p_64x64.v
-v ./memory/rf_2p_72x14.v
-v ./memory/sram_sp_1024x32.v

./top.v
```

Figure 2-2 Example of *.f File

2.4. Memory Checking by EZ-BIST (Optional)

EZ-BIST assists to identify users' memory macros by executing the **memchecker** command. This command can check if users' memory models can be recognized by EZ-BIST. For details, please refer to [Appendix](#) in the end of the document.

If memory models cannot be recognized by EZ-BIST, users can edit **UDM** (User Defined Memory) and then add these UDM files into the BFL file. EZ-BIST also provides a `*.udm` file template, and users can modify it according to the memory models. For the details, please refer to Chapter 2 in [EZ-BIST User Manual](#).

2.5. Generate and Set the BFL File

```
$ cd NDAcase
$ ezBist --tempgen
```

Please choose item 1 as Figure 2-3 shows. MBIST Feature List (BFL) and the `ezbist_template.bfl` file will be generated to the working folder.

```
-- (c) Copyright 2009 - 2023 by iSTART-Technologies, Inc.
-- All rights reserved

EZ-BIST - Easy SRAM Built-in Testing Technology : ver. 1.1.02 build 2023.01
Build 230209

This computer program constitutes or contains trade secrets and confidential
information of iSTART-Technologies Inc. or its licensors. This computer program is
protected by copyright law and international treaties.

[18:17:08] EZ-BIST : ver. 1.1.02 build 2023.01 : (c) Copyright 2009- iSTART-Technologies. All rights reserved.
[EZ-BIST][TEMPLATE] EZ-BIST template generator :
    1. BIST Feature List (BFL)
    2. BIST Integration Information (BII)
    3. User defined memory
    4. Pattern Gen File (PGF)
    5. QUIT
[EZ-BIST][TEMPLATE] Select an option(Enter ':q' to quit): █
```

Figure 2-3 Generated BFL File

A BFL file includes the related requirements of MBIST circuit specifications. Users can modify it based on the project requirements. Figure 2 4 and Figure 2 5 show examples of BFL setting for this test case. Users also can refer to the [ref](#) folder in the test case package to find an BFL file example.

```

define{OPTION}
  set verilog_path      = ./run.f          # /absolute path/design.f
  set user_define_memory = ./run.f        # /absolute path/memory.udm
  set top_module_name   = top             # design top
  set top_hierarchy     = top             # BIST top
  set clock_trace       = no              # yes, no (User group instances will all be un-group when setting yes)
  set auto_group        = yes             # yes, no
  set insertion         = yes             # yes, no
  set integrator_mode   = no              # yes, no
  set work_path         = ./mbist         # ./work
  set fault_free        = no              # yes, no
  set parsing_mode      = RTL_only        # RTL_only, Netlist_only
  set repair_prefix     = RP              # prefix for repair module

  define{CLOCK}
    set sdc_file          =                # /absolute path/design.sdc
    define{100MHz}
      set clock_cycle     = 10            # integer
      set clock_source_list = top CLK1    # top design1 CLK
    end_define{100MHz}
    define{10MHz}
      set clock_cycle     = 100           #integer
      set clock_source_list = top CLK2    # top design2 CLK
    end_define{10MHz}
  end_define{CLOCK}

  define{GROUP}
    set sequencer_limit = 60              # integer
    set group_limit     = 30              # integer smaller than sequencer limit
    set memory_list     = #./test.meminfo # /absolute path/design.meminfo
    set time_hierarchy  = 1               # 0(time) < value <1(hierarchy)
    set lib_path        =                # /absolute path/lib (Accept file dictionary)
    set power_limit     = 1.0            # mW (float bigger than 0)
    set hierarchy_limit = 0               # integer (default: 0)

    define{PHYSICAL}
      set enable_physical = no            # yes, no
      set physical_location_file =        # /absolute path/design.def
      set distance_limit  = 1
      set physical_logical = 0.5
    end_define{PHYSICAL}
  end_define{GROUP}
end_define{OPTION}

```

Figure 2-4 BFL File Example (1)

```

define{BIST}
  set STIL_test_bench      = no          # yes, no
  set asynchronous_reset   = yes         # yes, no
  set bist_interface       = ieee1500   # minibist, basic, ieee1149.1, ieee1500
  set address_fast_y       = no          # yes, no
  set program_algorithm    = no          # yes, no
  set algorithm_selection  = no          # no, outside, scan
  set background_style     = SOLID       # SOLID, WORD, 5A
  set background_bit_inverse = no        # yes, no
  set background_col_inverse = no        # yes, no
  set bypass_support       = no          # no, wire, reg
  set bypass_clock         = no          # yes, no
  set bypass_include_bist_pin = no       # yes, no
  set bypass_reg_sharing   = 1           # 1 ~ 1024
  set clock_function_hookup = no         # yes, no
  set clock_switch_of_memory = yes       # yes, no
  set clock_source_gated   = no          # yes, no
  set clock_source_switch  = no          # yes, no
  set clock_within_pll     = no          # yes, no
  set diagnosis_support    = no          # yes, no
  set diagnosis_data_sharing = no        # yes, no
  set diagnosis_memory_info = no         # yes, no
  set diagnosis_time_info  = no          # yes, no
  set diagnosis_faulty_items = algorithm, operation, element, seq_id, grp_id, address, ram_data,
  set parallel_on          = no          # yes, no
  set reduce_address_simulation = no     # yes, no
  set rom_half_access      = no          # yes, no
  set rom_result_shiftout  = no          # yes, no
  set specify_clock_mux    = no          # yes, no
  set specify_dt_port_value = no        # yes, no
  set Q_pipeline           = no          # yes, no
  set repair_mode          = yes         # yes, no. Repair mode with redundancy memory model.
  set soft_repair          = no          # yes, no. yes = soft repair, no = hard repair

```

Figure 2-5 BFL File Example (2)

2.6. Execute EZ-BIST with the BFL File

The command to execute EZ-BIST with the BFL file is:

```
$ ezBist -bfl ezbist_template.bfl
```

Please note that if the location of files defined in the BFL file is a relative path instead of an absolute path, the relative path is based on the location of the BFL file.

After executing the commands above, users can see messages like Figure 2-6 and Figure 2-7 show. All the generated files will be output to the `mbist` folder. Users can find the `EZ-BIST_memory_spec.meminfo` file in the `mbist` folder, which represents a grouping architecture.

```
[16:36:33] [CHECK][GROUPING] top_default: seq 1, grp 1, 8 members
[16:36:33] [CHECK][GROUPING] top_default: seq 2, grp 1, 1 members
[16:36:33] [CHECK][GROUPING] top_default: seq 3, grp 1, 2 members
[16:36:33] [CHECK][GROUPING] top_default: seq 4, grp 1, 1 members
```

Figure 2-6 Grouping Information

```
[16:36:34] [INSERT]
[16:36:34] [INSERT] #===== BIST Insert Path =====#
[16:36:34] [INSERT] #
[16:36:34] [INSERT] #      ----- Controller -----      #
[16:36:34] [INSERT] #
[16:36:34] [INSERT] # CTR(top_default) : top                #
[16:36:34] [INSERT] #
[16:36:34] [INSERT] #      ----- Sequencer -----      #
[16:36:34] [INSERT] #
[16:36:34] [INSERT] # SEQ 1 : top.u_t1                      #
[16:36:34] [INSERT] # SEQ 2 : top.u_t1                      #
[16:36:34] [INSERT] # SEQ 3 : top.u_t1                      #
[16:36:34] [INSERT] # SEQ 4 : top.u_t1                      #
[16:36:34] [INSERT] #
[16:36:34] [INSERT] #      ----- TPG -----            #
[16:36:34] [INSERT] #
[16:36:34] [INSERT] # TPG top_default_t_1_1_1 : top.u_t1    [sram_sp_1024x32] (ram_1) #
[16:36:34] [INSERT] # TPG top_default_t_1_1_2 : top.u_t1    [sram_sp_1024x32] (ram_2) #
[16:36:34] [INSERT] # TPG top_default_t_1_1_3 : top.u_t1    [sram_sp_1024x32] (ram_3) #
[16:36:34] [INSERT] # TPG top_default_t_1_1_4 : top.u_t1    [sram_sp_1024x32] (ram_4) #
[16:36:34] [INSERT] # TPG top_default_t_1_1_5 : top.u_t1    [sram_sp_1024x32] (ram_e) #
[16:36:34] [INSERT] # TPG top_default_t_1_1_6 : top.u_t1    [sram_sp_1024x32] (ram_w) #
[16:36:34] [INSERT] # TPG top_default_t_1_1_7 : top.u_t1    [sram_sp_1024x32] (ram_x) #
[16:36:34] [INSERT] # TPG top_default_t_1_1_8 : top.u_t1    [sram_sp_1024x32] (ram_y) #
[16:36:34] [INSERT] # TPG top_default_t_2_1_1 : top.u_t1    [rf_2p_24x28] (u_2p)   #
[16:36:34] [INSERT] # TPG top_default_t_3_1_1 : top.u_t1    [sram_dp_1024x64] (u_dp) #
[16:36:34] [INSERT] # TPG top_default_t_3_1_2 : top.u_t1    [sram_dp_1024x64] (u_dp2) #
[16:36:34] [INSERT] # TPG top_default_t_4_1_1 : top.u_t1    [rom_6144_64] (u_rom)  #
[16:36:34] [INSERT] #
[16:36:34] [INSERT] #      ----- END -----            #
[16:36:34] [INSERT] #
[16:36:34] [INSERT] #=====#
[16:36:34] [INSERT]
[16:36:34] [INSERT] Perform auto insertion ... done (0.11 sec)
[16:36:34] [INSERT] Create synthesis interpretation TGL script: /home/lsyram/TempCase/MPAApp/...
```

Figure 2-7 Auto-Insertion Information

2.7. Setting the Memory Info File (Optional)

After executing EZ-BIST, the memory info file will be output to the `mbist` folder. The memory info file represents a grouping architecture. If users want to adjust memory grouping according to their design requirements, modify the memory info file directly.

The memory info file includes the following items. For the detailed information, please refer to Chapter 7 in [Application Notes](#).

Clock Domain:	Memory clock domain and testing clock cycle
Memory Module:	The memory module name and memory hierarchy
Bypass/Diagnosis:	Setting the values of the bypass function and diagnosis function
q_pipeline:	Setting the value of the q_pipeline option
Group Architecture:	Grouping architecture information (including a controller and sequencer)

Figure 2-8 shows the content of `EZ-BIST_memory_spec.meminfo`.

```
[DOMAIN=top_default, cycle=100.0ns]
[CTR] # Hier: top
[SEQ] # No.= 1, InstanceNo= 8, SEQ_max_addr_size= 1024, Hier: top u_t1
  [GROUP] # No.=1_1
    [SP=1_1_1, byp=no, diag=no, q_pipe=no]sram_sp_1024x32          top u_t1 ram_1
    [SP=1_1_2, byp=no, diag=no, q_pipe=no]sram_sp_1024x32          top u_t1 ram_2
    [SP=1_1_3, byp=no, diag=no, q_pipe=no]sram_sp_1024x32          top u_t1 ram_3
    [SP=1_1_4, byp=no, diag=no, q_pipe=no]sram_sp_1024x32          top u_t1 ram_4
    [SP=1_1_5, byp=no, diag=no, q_pipe=no]sram_sp_1024x32          top u_t1 ram_e
    [SP=1_1_6, byp=no, diag=no, q_pipe=no]sram_sp_1024x32          top u_t1 ram_w
    [SP=1_1_7, byp=no, diag=no, q_pipe=no]sram_sp_1024x32          top u_t1 ram_x
    [SP=1_1_8, byp=no, diag=no, q_pipe=no]sram_sp_1024x32          top u_t1 ram_y
  [SEQ] # No.= 2, InstanceNo= 1, SEQ_max_addr_size= 24, Hier: top u_t1
    [GROUP] # No.=2_1
      [2P=2_1_1, byp=no, diag=no, q_pipe=no]rf_2p_24x28            top u_t1 u_2p
  [SEQ] # No.= 3, InstanceNo= 2, SEQ_max_addr_size= 1024, Hier: top u_t1
    [GROUP] # No.=3_1
      [DP=3_1_1, byp=no, diag=no, q_pipe=no]sram_dp_1024x64        top u_t1 u_dp
      [DP=3_1_2, byp=no, diag=no, q_pipe=no]sram_dp_1024x64        top u_t1 u_dp2
  [SEQ] # No.= 4, InstanceNo= 1, SEQ_max_addr_size= 6144, Hier: top u_t1
    [GROUP] # No.=4_1
      [ROM=4_1_1, byp=no, diag=no, q_pipe=no]rom_6144_64          top u_t1 u_rom
```

Figure 2-8 Memory Info Setting Information

2.8. Using the Memory Info File as Default Memory Grouping

If users use a memory info file, `EZ-BIST_memory_spec.meminfo`, as the memory grouping setting, they should turn off the `auto_group` option and specify the `memory_list` option to the path of `EZ-BIST_memory_spec.meminfo` in the BFL configuration file as Figure 2-9 shows.

After executing the EZ-BIST BFL flow with the memory info file, EZ-BIST can automatically modify the naming and operating frequency of the BIST controller. It also assists users to do grouping-related settings according to their requirements. There is a memory info file example in the `ref` folder of NDAcase. Execute EZ-BIST with the modified BFL file which includes the modified memory info file and commands as Figure 2-9. The prompt will appear as Figure 2-10 and Figure 2-11.

In this example case, there is one extra group for sequencer 1, and the name of the BIST controller is changed to `testcase`.

```
$ ezBist -bfl ez-bist_template.bfl
```

```
define{GROUP}
  set sequencer_limit = 60           # integer
  set group_limit     = 30           # integer smaller than sequencer limit
  set memory_list     = ./test.meminfo # /absolute path/design.meminfo
  set time_hierarchy  = 1            # 0(time) < value <1(hierarchy)
  set lib_path        =              # /absolute path/lib (Accept file dictionary)
  set power_limit     = 1.0          # mW (float bigger than 0)
  set hierarchy_limit = 0            # integer (default: 0)
```

Figure 2-9 memory_list Option

```
[17:39:24] [CHECK][GROUPING] testcase: seq 1, grp 1, 5 members
[17:39:24] [CHECK][GROUPING] testcase: seq 1, grp 2, 3 members
[17:39:24] [CHECK][GROUPING] testcase: seq 2, grp 1, 1 members
[17:39:24] [CHECK][GROUPING] testcase: seq 3, grp 1, 2 members
[17:39:24] [CHECK][GROUPING] testcase: seq 4, grp 1, 1 members
```

Figure 2-10 Grouping Information with Memory Info File

```

[17:39:25] [INSERT]
[17:39:25] [INSERT] #===== BIST Insert Path =====#
[17:39:25] [INSERT] # #
[17:39:25] [INSERT] # ----- Controller ----- #
[17:39:25] [INSERT] # #
[17:39:25] [INSERT] # CTR(testcase) : top #
[17:39:25] [INSERT] # #
[17:39:25] [INSERT] # ----- Sequencer ----- #
[17:39:25] [INSERT] # #
[17:39:25] [INSERT] # SEQ 1 : top.u_t1 #
[17:39:25] [INSERT] # SEQ 2 : top.u_t1 #
[17:39:25] [INSERT] # SEQ 3 : top.u_t1 #
[17:39:25] [INSERT] # SEQ 4 : top.u_t1 #
[17:39:25] [INSERT] # #
[17:39:25] [INSERT] # ----- TPG ----- #
[17:39:25] [INSERT] # #
[17:39:25] [INSERT] # TPG testcase_t_1_1_1 : top.u_t1 [sram_sp_1024x32] (ram_1) #
[17:39:25] [INSERT] # TPG testcase_t_1_1_2 : top.u_t1 [sram_sp_1024x32] (ram_2) #
[17:39:25] [INSERT] # TPG testcase_t_1_1_3 : top.u_t1 [sram_sp_1024x32] (ram_3) #
[17:39:25] [INSERT] # TPG testcase_t_1_1_4 : top.u_t1 [sram_sp_1024x32] (ram_4) #
[17:39:25] [INSERT] # TPG testcase_t_1_1_5 : top.u_t1 [sram_sp_1024x32] (ram_e) #
[17:39:25] [INSERT] # TPG testcase_t_1_2_1 : top.u_t1 [sram_sp_1024x32] (ram_w) #
[17:39:25] [INSERT] # TPG testcase_t_1_2_2 : top.u_t1 [sram_sp_1024x32] (ram_x) #
[17:39:25] [INSERT] # TPG testcase_t_1_2_3 : top.u_t1 [sram_sp_1024x32] (ram_y) #
[17:39:25] [INSERT] # TPG testcase_t_2_1_1 : top.u_t1 [rf_2p_24x28] (u_2p) #
[17:39:25] [INSERT] # TPG testcase_t_3_1_1 : top.u_t1 [sram_dp_1024x64] (u_dp) #
[17:39:25] [INSERT] # TPG testcase_t_3_1_2 : top.u_t1 [sram_dp_1024x64] (u_dp2) #
[17:39:25] [INSERT] # TPG testcase_t_4_1_1 : top.u_t1 [rom_6144_64] (u_rom) #
[17:39:25] [INSERT] # #
[17:39:25] [INSERT] # ----- END ----- #
[17:39:25] [INSERT] # #
[17:39:25] [INSERT] #=====#
[17:39:25] [INSERT]
[17:39:25] [INSERT] Perform auto insertion ... done (0.08 sec)

```

Figure 2-11 Auto-Insertion Information with Memory Info File

3. Simulation

3.1. Self-Simulation

Figure 3-1 shows the architecture of the testbench for self-simulation. This self-simulation is used to verify the function correctness of the BIST circuit only. This system design is not included in self-simulation. The simulation environment is built by the `make` language. Users can refer to the `Makefile.top_default` file. This file defines commands and parameters for executing simulation.

If users want to debug with the waveform file, turn on the related dump parameters in the `top_default.f` file.

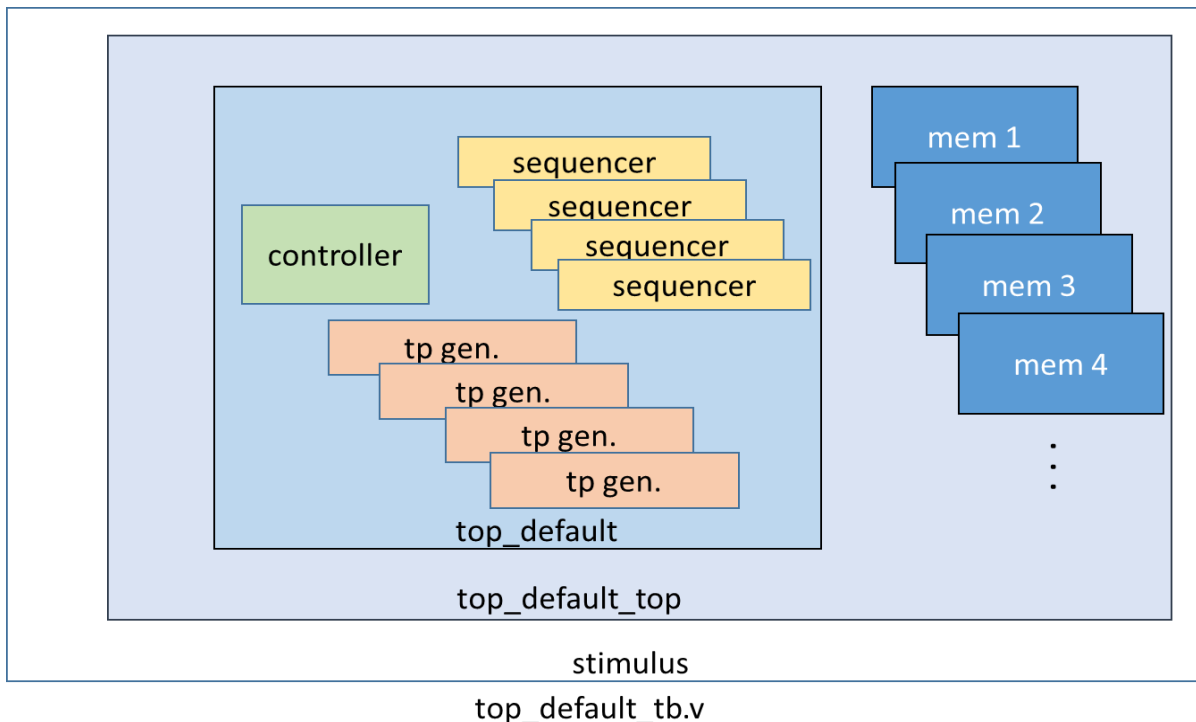


Figure 3-1 Testbench Architecture of Self-Simulation

If users adjust the clock domain, they can check the difference of the output file in the `mbist` folder. In a test case, the controller's name of the default clock domain is `top_default`.

The command for self-simulation is:

```
$ mak top_default FUNC=tb
```

If the timeout message, "Simulation time-out!", appears during self-simulation, users can modify the delay parameter of the block "`ifndef FAULT`" in the `top_default_tb.v` file as Figure 3-2 shows. This delay parameter is generated by EZ-BIST and is designed to prevent an infinite loop. Figure 3-3 shows the simulation results of self-simulation.

Note: If the user's design includes an ROM memory inside, please check the path setting of the ROM code file before executing simulation.

```

1 `ifndef FAULT
2   initial begin
3     #(cyc*414611);
4
5     $display("\nSimulation time-out!\n");
6     $finish;
7   end
8 `endif

```

Figure 3-2 Delay Parameter Setting

```

Writing initial simulation snapshot: worklib.stimulus.v
Loading snapshot worklib.stimulus.v ..... Done
*Verdi3* Loading libsscore_ius142.so
*Verdi3* : Enable Parallel Dumping.
ncsim> source /usr/cad/cadence/IUS/cur/tools/inca/files/ncsimrc
ncsim> run

Test Result: Pass!

Simulation complete via $finish(1) at time 39383600 NS + 0
./top_default_tb.v:154 $finish;
ncsim> exit
make[1]: Leaving directory `/home/jeremy/TestCase/NDACase/mbist'

```

Figure 3-3 Self-Simulation Result

3.2. Inserted Simulation

Figure 3-4 shows the architecture of the testbench for the inserted simulation. This inserted simulation is to verify the function correctness of the inserted design which combines EZ-BIST circuits and the user's system design. The simulation environment is built by the `make` language. Users can refer to the `Makefile.top_default` file. This file defines commands and parameters for executing simulation.

If users want to debug with a waveform file, please turn on the related dump parameters in the `top_default_INS_FAULT.f` file. It is the same as self-simulation. If there are several clock domains, each clock domain should be passed when doing the inserted simulation.

The command of the inserted simulation is:

```
$ make top_default FUNC=tb_INS
```

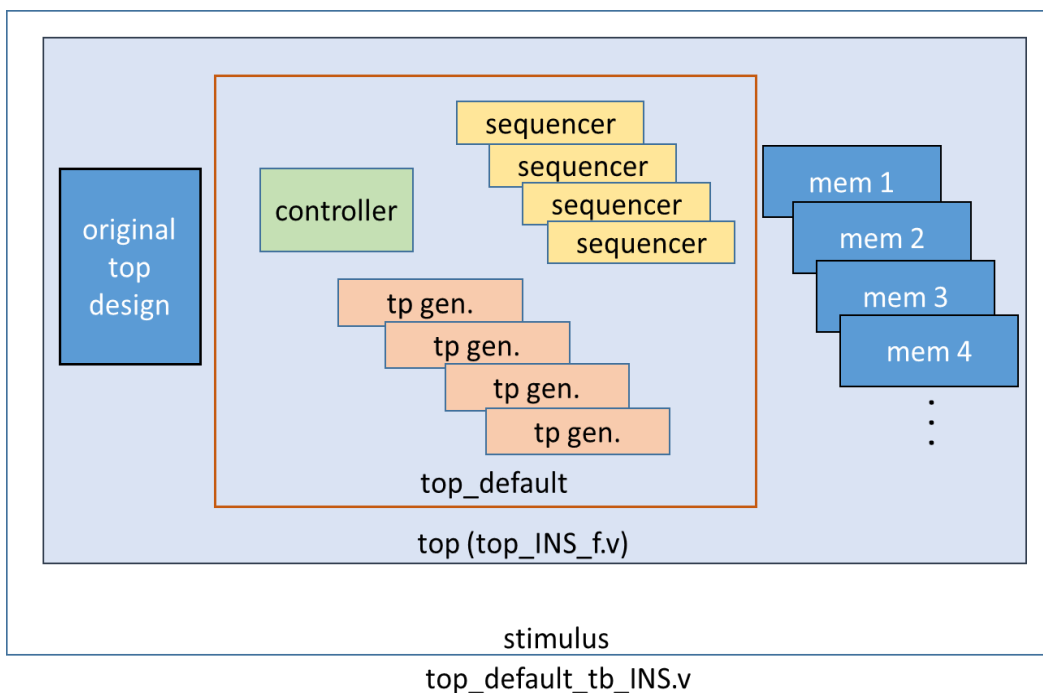


Figure 3-4 Testbench Architecture of Inserted Simulation

If the timeout message, “[Simulation time-out!](#)”, appears during the period of executing simulation, users can modify the delay parameter of the block “[ifndef FAULT](#)” in [top_default_tb_INS.v](#). Figure 3-5 shows the prompt of the inserted simulation.

```
Loading snapshot worklib.stimulus:v ..... Done
*Verdi3* Loading libsscore_ius142.so
*Verdi3* : Enable Parallel Dumping.
ncsim> source /usr/cad/cadence/IUS/cur/tools/inca/files/ncsimrc
ncsim> run

Test Result: Pass!

Simulation complete via $finish(1) at time 39383600 NS + 0
./top_default_tb_INS.v:188 $finish;
ncsim> exit
make[1]: Leaving directory `/home/jeremy/TestCase/NDACase/mbist'
```

Figure 3-5 Inserted Simulation Result

3.3. Simulation with Fault Memory Models

EZ-BIST can automatically generate fault memory models to verify the functional correctness of BIST circuits. These models can be found in the [FAULT_MEMORY](#) directory. Use the commands below to execute simulation with these models.

These operations will use [fault_memory.f](#) in the [FAULT_MEMORY](#) folder.

For self-simulation:

```
$ make top_default FUNC=tb_f
```

For inserted simulation:

```
$ make top_default FUNC=tb_INS_f
```

When executing this type of simulation, it will show a **failed prompt**. This is caused by the pre-defined error bits in fault memory models. The simulation waveform can be viewed for users to understand the behaviors of EZ-BIST designs and fault memory models. Figure 3-6 shows an example of running simulation with fault memory models. In this case, users can find the access sequence of the memories in **group 1 (1_1_8, sram_sp_640x32 memory model)**.

- (1) Write the access with data `32'hffff_fff` to address `10'h350`
- (2) Read the access from address `10'h350`
- (3) Read data `32'hfffd_fff`

The data of reading does not equal to the data of writing in “A” in Figure 3-6 and this wrong behavior will cause the simulation to fail.

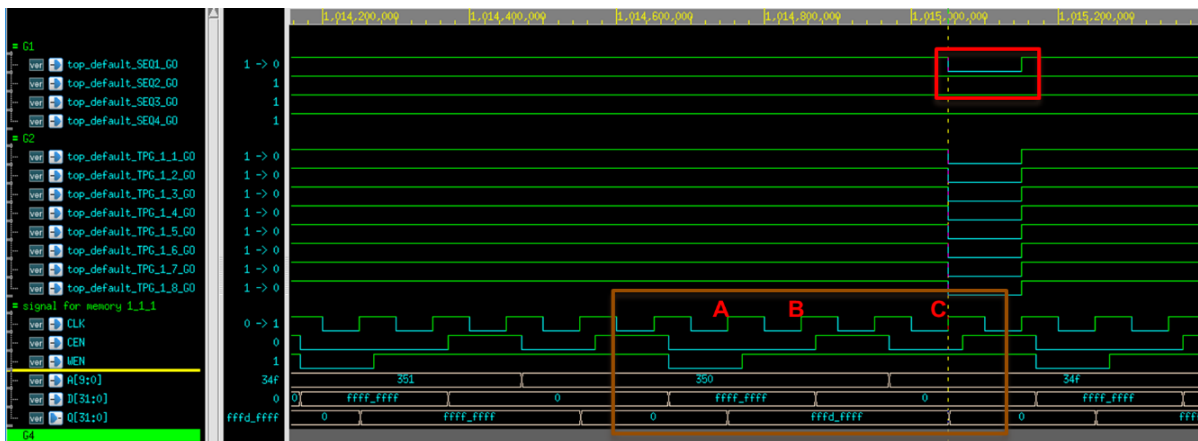


Figure 3-6 Simulation Waveform of Fault Memory Models

Users can find pre-defined error bits in fault memory models. Figure 3-7 is an example of a `sram_sp_1024x32` memory model in the `FAULT_MEMORY` directory.

```

module sram_sp_1024x32_f(
    Q,
    CLK,
    CEN,
    WEN,
    A,
    D,
    EMA,
    RETN
);
    integer _addr;
    parameter _BITS = 32;
    parameter _sa_fault = 1'b0; // sa0
    parameter _faulty_bit = 17;
    parameter _faulty_addr = 10'h350;
endmodule

```

Figure 3-7 Example of Error Bit Definitions

4. Synthesis

EZ-BIST also provides a synthesis script for BIST circuits. Users can find it in the output directory, named `[design_name].tcl`. Before executing synthesis, the related settings including the library path, standard cell type and path of the memory library file should be completed. If there are different clock domains, each clock domain should undergo synthesis.

EZ-BIST provides a referenced synthesis script in the `mbist` folder. The command of synthesis is:

```
$ make top_default FUNC=dc
```

Figure 4-1 shows the prompt during the execution of the synthesis command. After synthesis is completed, users can find synthesis results including area and timing reports in the `REPORT` folder.

```
write_sdc ${WORK_PATH}/output/${TOP}_netlist.sdc
1
#***** worst case timing report *****/
redirect ${WORK_PATH}/REPORT/${TOP}_maxtiming.rpt { report_timing -nets -delay max -max_paths 5 -
transition_time -nosplit }
redirect ${WORK_PATH}/REPORT/${TOP}_mintiming.rpt { report_timing -nets -delay min -max_paths 5 -
transition_time -nosplit }
redirect ${WORK_PATH}/REPORT/${TOP}_looptim.rpt { report_timing -loops -max_paths 5 }
#***** area report *****/
redirect ${WORK_PATH}/REPORT/${TOP}_area.rpt { report_area -hier }
redirect -append ${WORK_PATH}/REPORT/${TOP}_area.rpt { report_reference }
redirect ${WORK_PATH}/REPORT/${TOP}_power.rpt {report_power}
redirect ${WORK_PATH}/REPORT/${TOP}_qor.rpt {report_qor}
#***** write_script *****/
write_script -output ${WORK_PATH}/REPORT/${TOP}_scrip.rpt
1
#***** all violation *****/
redirect ${WORK_PATH}/REPORT/${TOP}_constraint.rpt { report_constraint -all_violators -verbose -nosplit }
exit
```

```
Memory usage for main task 65 Mbytes.  
Memory usage for this session 65 Mbytes.  
CPU usage for this session 2 seconds ( 0.00 hours ).  
  
Thank you...  
make[1]: Leaving directory `/home/tina.lin/workspace/project/UDS/NDACase_bottomup_230105/integ'
```

Figure 4-1 Synthesis Output of top_default Controller

5. Appendix: Memchecker Usage

The appendix introduces how to do memory checking with the EZ-BIST `memchecker` option. This can make sure if users' memory models can be recognized by the EZ-BIST tool.

EZ-BIST assists to identify memory macros in users' designs by executing the `memchecker` command. Here is an example to identify memories and output results into the `memck` folder.

```
$ cd NDAcase
$ ezBist --memchecker -N -W memck -v run.f
```

Users can also identify memories in the `memory` folder directly.

```
$ cd NDAcase/memory
$ ezBist --memchecker -N -W memck -v *.v
```

Figure 5-1 shows the output message of the `memchecker` command.

```
Input file(s):
[1] /home/jeremy/LAB_e/NDAcase/memory/rom_6144_64.v
[2] /home/jeremy/LAB_e/NDAcase/memory/sram_sp_4096x64.v
[3] /home/jeremy/LAB_e/NDAcase/memory/sram_sp_640x32.v
[4] /home/jeremy/LAB_e/NDAcase/memory/rf_sp_128x22.v
[5] /home/jeremy/LAB_e/NDAcase/memory/rf_2p_72x14.v
[6] /home/jeremy/LAB_e/NDAcase/top.v
[7] /home/jeremy/LAB_e/NDAcase/memory/sram_sp_2048x64.v
[8] /home/jeremy/LAB_e/NDAcase/memory/rf_2p_64x64.v
[9] /home/jeremy/LAB_e/NDAcase/memory/sram_dp_1024x64.v
[10] /home/jeremy/LAB_e/NDAcase/memory/rf_2p_24x28.v
[11] /home/jeremy/LAB_e/NDAcase/memory/rf_2p_24x56.v
[12] /home/jeremy/LAB_e/NDAcase/memory/sram_sp_1024x32.v

Valid file(s):
[1] /home/jeremy/LAB_e/NDAcase/memory/rom_6144_64.v
[2] /home/jeremy/LAB_e/NDAcase/memory/sram_sp_4096x64.v
[3] /home/jeremy/LAB_e/NDAcase/memory/sram_sp_640x32.v
[4] /home/jeremy/LAB_e/NDAcase/memory/rf_sp_128x22.v
[5] /home/jeremy/LAB_e/NDAcase/memory/rf_2p_72x14.v
[6] /home/jeremy/LAB_e/NDAcase/memory/sram_sp_2048x64.v
[7] /home/jeremy/LAB_e/NDAcase/memory/rf_2p_64x64.v
[8] /home/jeremy/LAB_e/NDAcase/memory/sram_dp_1024x64.v
[9] /home/jeremy/LAB_e/NDAcase/memory/rf_2p_24x28.v
[10] /home/jeremy/LAB_e/NDAcase/memory/rf_2p_24x56.v
[11] /home/jeremy/LAB_e/NDAcase/memory/sram_sp_1024x32.v

Unrecognized file(s):
[1] /home/jeremy/LAB_e/NDAcase/top.v
```

Figure 5-1 Memchecker Information

Contact Information

If there are any questions or comments, please contact iSTART-TEK at support@istart-tek.com. The following information might be included in the mail.

- ★ Document title
- ★ Document version
- ★ Page number
- ★ Simple and clear descriptions of the problem

Any suggestions for improvements are welcome.