MicroZed/PicoZed: Test Applications

15 July 2015
Version 2015_2.01

Overview

With the Hello World application operational, we will now move on to more advanced test applications. Xilinx provides a Memory Test as well as a Peripherals Test in the built-in templates for example applications.

This Tutorial assumes that you have already completed the Hardware Platform and Hello World tutorials. Your starting point will be the SDK project after the Hello World tutorial is complete.

Objectives

When this tutorial is complete, you will be able to:

- Add the Memory Test application
- Add the Peripherals Test application
- Run both test applications
- Edit the memory test to increase the test range

Experiment Setup

Software

The software used to test this reference design is:

- Windows-7 64-bit
- Xilinx SDK 2015.2
- Silicon Labs CP201x USB-to-UART Bridge Driver
  - www.microzed.org → Support → Documentation → MicroZed Silicon Labs CP210x USB-to-UART Setup Guide
  - Note that MicroZed and the PicoZed FMC Carrier both use the same Silicon Labs CP2104 device, so the setup is the same.

Hardware

The hardware setup used to test this reference design includes:

- Win-7 PC with the following recommended memory[1]:
  - 1.6 GB RAM available for the Xilinx tools to complete a XC7Z010 design
  - 1.9 GB RAM available for the Xilinx tools to complete a XC7Z020 design
  - 2.7 GB RAM available for the Xilinx tools to complete a XC7Z030 design
- One of the following:
  - Avnet MicroZed 7010 or 7020
  - Avnet PicoZed 7010, 7015, 7020, or 7030 with the PicoZed FMC Carrier
- USB cable (Type A to Micro-USB Type B) – *one included in kit*
- JTAG Programming Cable (Platform Cable, Digilent HS1, HS2, or HS3 cable)
  - If you don't already have a JTAG Cable, Avnet recommends the Digilent HS3 Cable
  - http://www.em.avnet.com/jtaghs3

[1] Refer to www.xilinx.com/design-tools/vivado/memory.htm

Experiment 1: Create Memory and Peripherals Test Applications

Similar to Hello World, use templates to create two very useful test applications.

1. Launch SDK and open the workspace from the Hello World project.
2. In SDK, select **File → New → Application Project**.
3. In the **Project Name** field type in `Mem_Test`. Change the **BSP** to the existing StandAlone BSP. Click **Next >**.

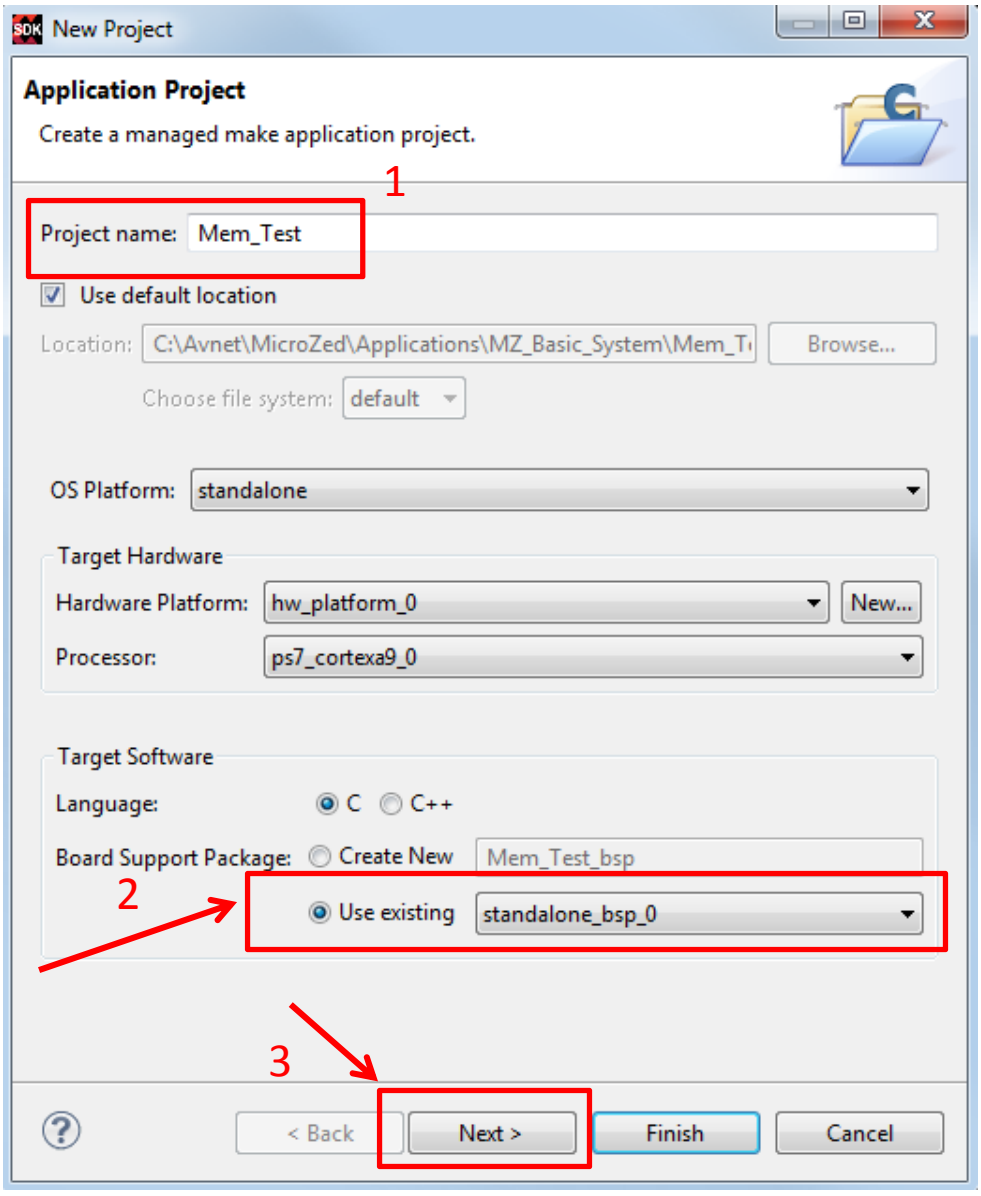

Figure 1 - New Application Wizard

4. Select **Memory Tests** from the *Available Templates* field. Click **Finish**.

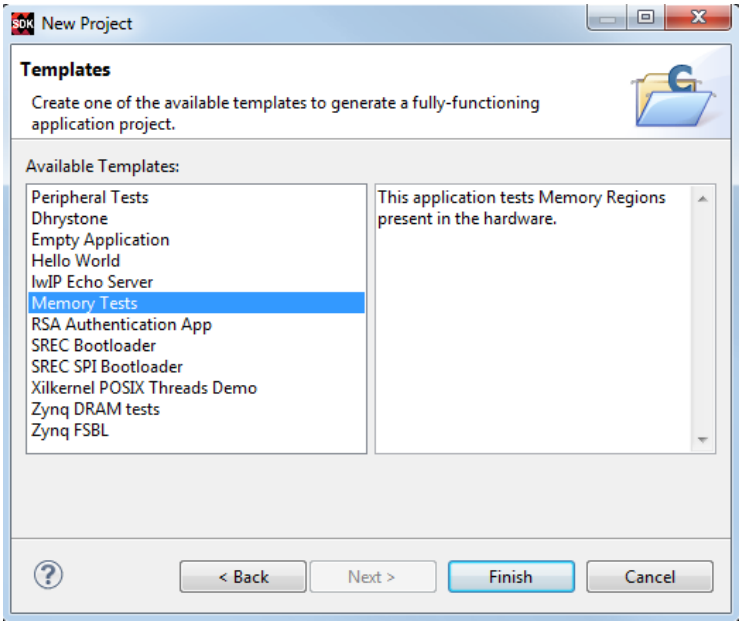

Figure 2 – New Application Project: Hello World

5. Repeat steps 2 through 4 with the following options:
   a. Project Name = **Periph_Test**
   b. BSP = **standalone_bsp_0**
   c. Template = **Peripheral Tests**

6. Repeat steps 2 through 4 with the following options:
   a. Project Name = **ZynqDRAM_Test**
   b. BSP = **standalone_bsp_0**
   c. Template = **Zynq DRAM tests**

When complete, *Project Explorer* should look similar to below.

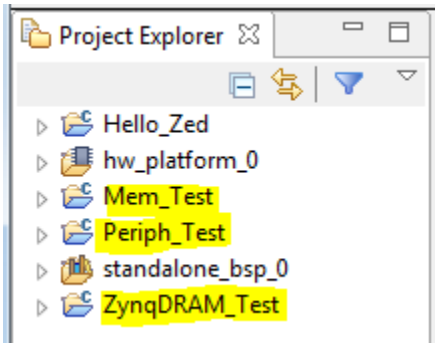

Figure 3 – Project Explorer with New Apps Highlighted

Experiment 2: Run the Applications

1. Follow the instructions in the Hello World tutorial to configure and plug in the MicroZed or PicoZed hardware for Cascaded JTAG with JTAG and USB-UART plugged in. Make sure to also program the bitstream so that the Blue DONE LED is lit.

2. Continue by right-clicking on the Mem_Test and Periph_Test applications selecting **Run As**…, as previously shown in the Hello World tutorial.

3. When asked to terminate the old configuration, select **Yes**.

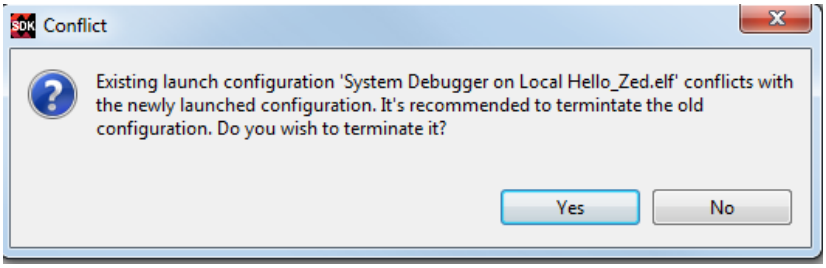

Figure 4 – Terminate Old Configuration

When done you should see these terminal messages.

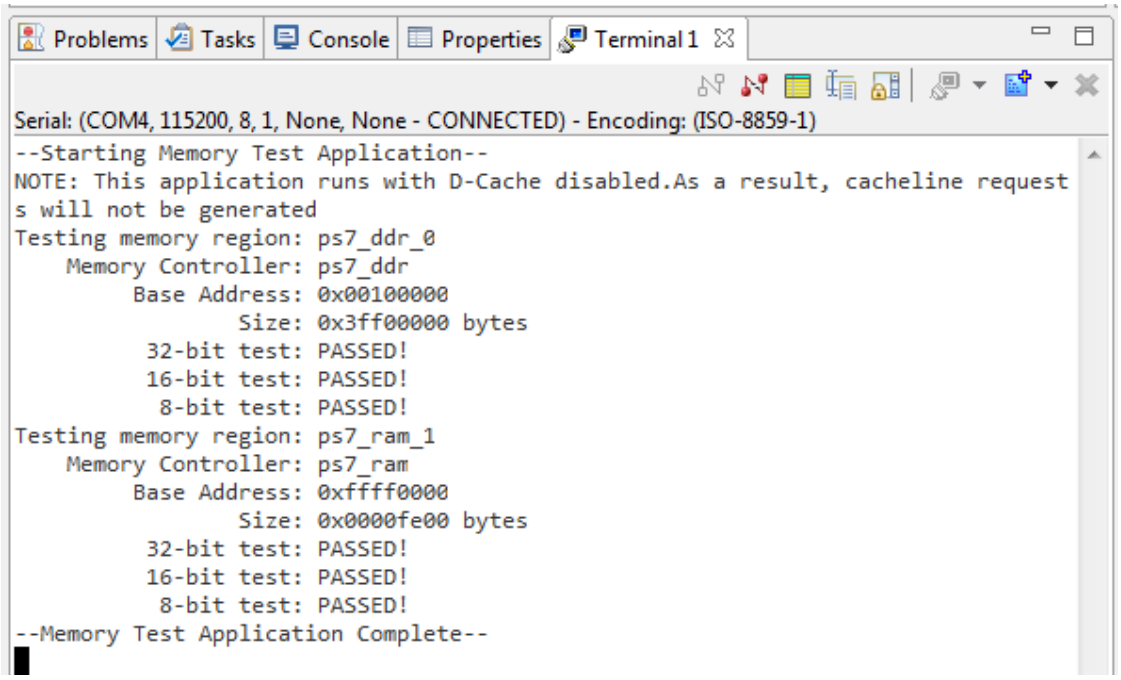

Figure 5 - Memory Test Console

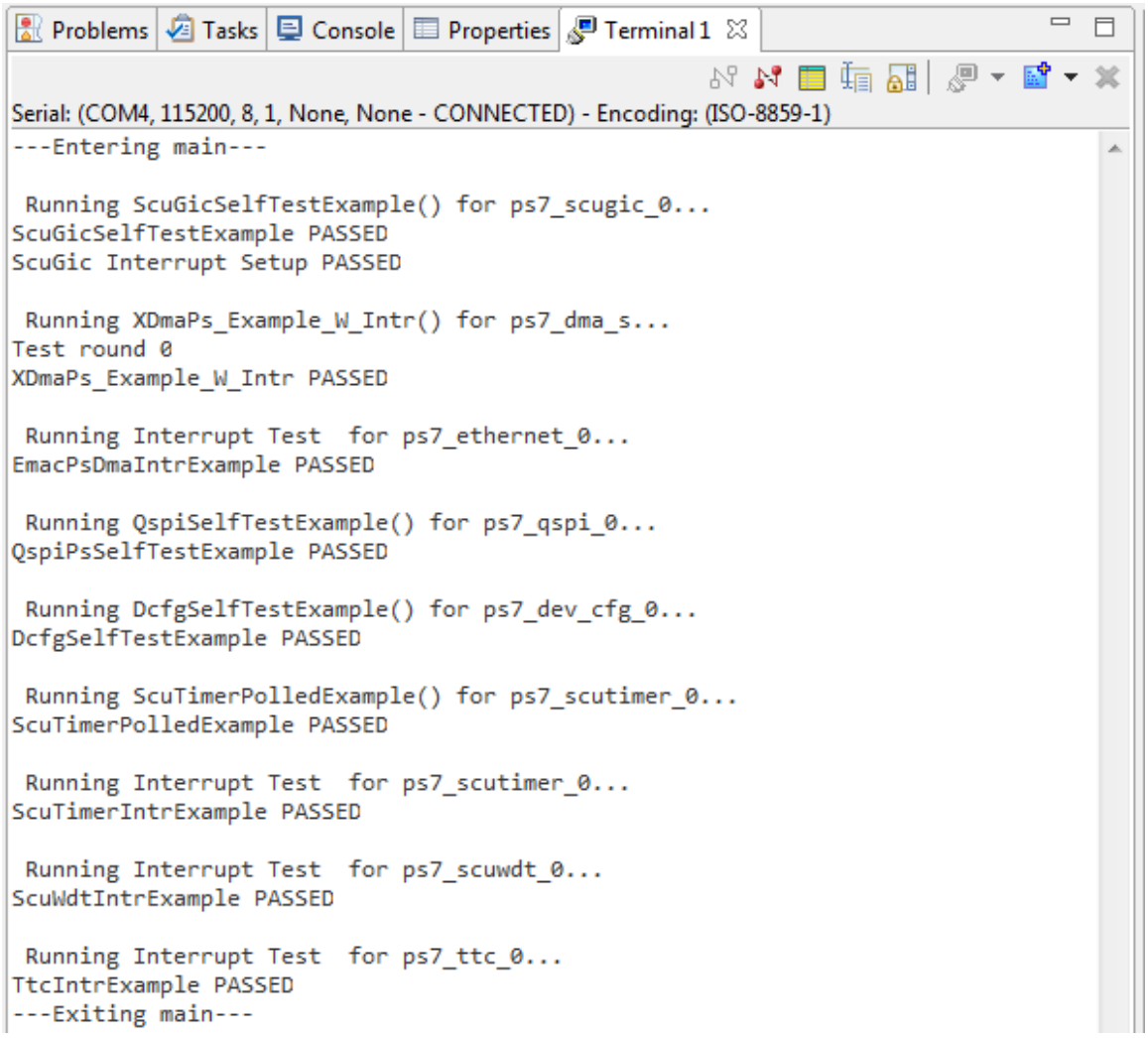

Figure 6 - Peripheral Test Console

The Zynq DRAM Test is a bit more complex. It is explained in detail in the **ZYNQ_DRAM_DIAGNOSTICS_TEST.docx** document that is included in the following directory:

`C:\Avnet\MicroZed\Applications\MZ_Basic_System\ZynqDRAM_Test\src`

A couple of the test outputs are shown below for a MicroZed 7010 Rev F01.

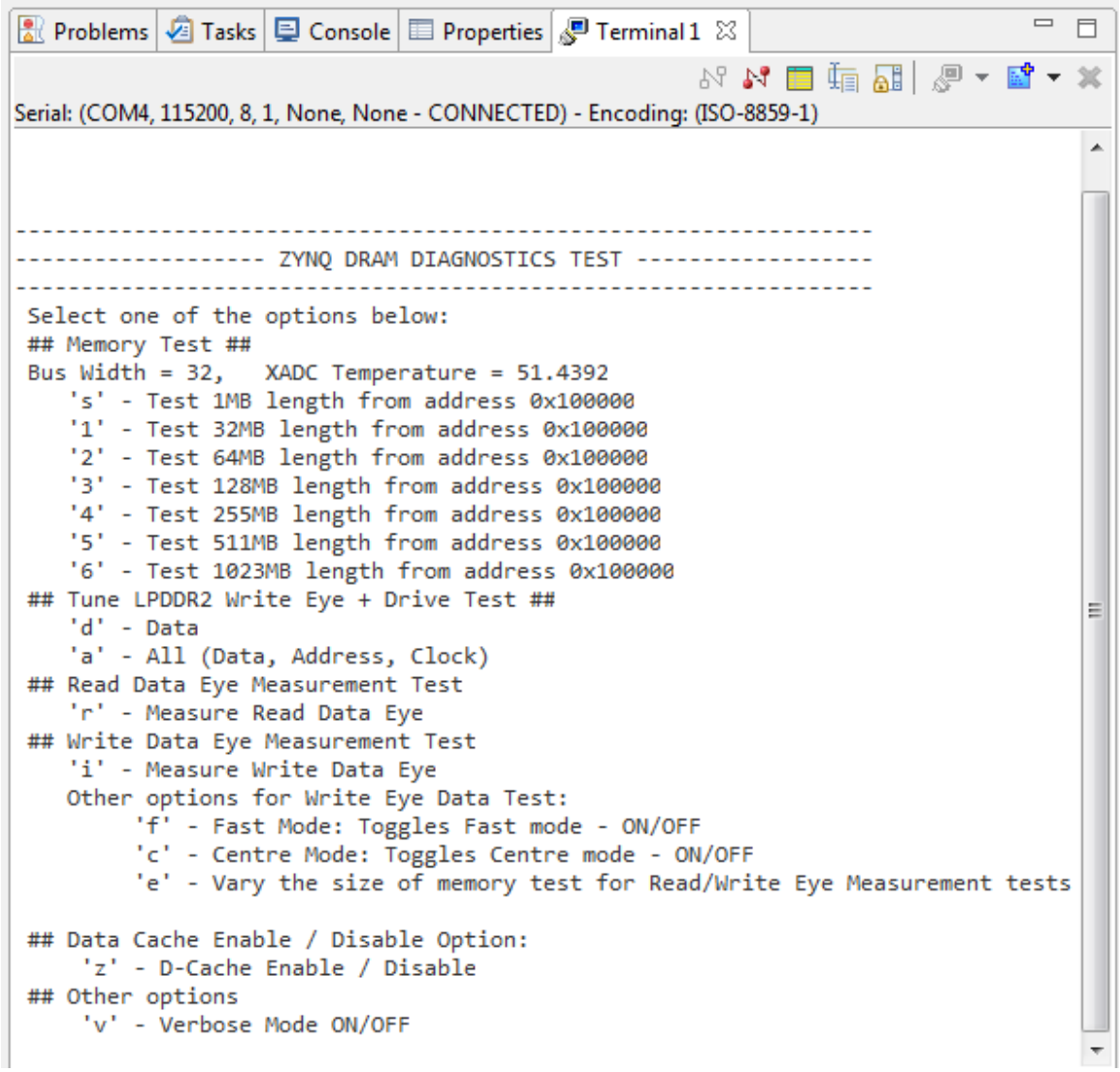

Figure 7 – Zynq DRAM Diagnostics Test Menu

```
Option Selected : 1


Starting Memory Test '1' - Testing 32MB length from address 0x100000...
-------------------------------------------------------------------------------------------
    TEST            WORD ERROR              PER-BYTE-LANE ERROR COUNT                TIME
                      COUNT         [ LANE-0 ] [ LANE-1 ] [ LANE-2 ] [ LANE-3 ]    (sec)
-------------------------------------------------------------------------------------------
Memtest_0 (  0: 0)      0           [       0] [       0] [       0] [       0]    1.10946
Memtest_s (  0: 1)      0           [       0] [       0] [       0] [       0]    0.731382
Memtest_s (  0: 2)      0           [       0] [       0] [       0] [       0]    0.731382
Memtest_s (  0: 3)      0           [       0] [       0] [       0] [       0]    0.731382
Memtest_s (  0: 4)      0           [       0] [       0] [       0] [       0]    0.731382
Memtest_s (  0: 5)      0           [       0] [       0] [       0] [       0]    0.731382
Memtest_s (  0: 6)      0           [       0] [       0] [       0] [       0]    0.731382
Memtest_s (  0: 7)      0           [       0] [       0] [       0] [       0]    0.731382
Memtest_s (  0: 8)      0           [       0] [       0] [       0] [       0]    0.731382
Memtest_p (  0: 9)      0           [       0] [       0] [       0] [       0]    1.10592
Memtest_p (  0:10)      0           [       0] [       0] [       0] [       0]    1.10238
Memtest_l (  0:11)      0           [       0] [       0] [       0] [       0]    1.07761
Memtest_l (  0:12)      0           [       0] [       0] [       0] [       0]    1.07761
Memtest_l (  0:13)      0           [       0] [       0] [       0] [       0]    1.07761
Memtest_l (  0:14)      0           [       0] [       0] [       0] [       0]    1.07761
```

Figure 8 – Test #1, 32MB test

```
Option Selected : r


Running Read Eye Measurement now ...
-------------------------------------------------------------------------------------------
    TEST           WORD ERROR              PER-BYTE-LANE ERROR COUNT              TIME
                     COUNT         [ LANE-0 ] [ LANE-1 ] [ LANE-2 ] [ LANE-3 ]    (sec)
-------------------------------------------------------------------------------------------
Test offset  64          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  68          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  72          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  76          0         [       0] [       0] [       0] [       0]    0.102629
Test offset  80          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  84          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  88          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  92          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  96       6629         [       0] [       0] [       0] [    6629]    0.103809
Test offset 100      21945         [       0] [       0] [       0] [   21945]    0.105578
Test offset 104     167779         [    3700] [   28103] [       0] [  154158]    0.122094
Test offset 108     354211         [   28556] [  116049] [    1185] [  332086]    0.143327
Test offset  60          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  56          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  52          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  48          0         [       0] [       0] [       0] [       0]    0.102629
Test offset  44          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  40          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  36          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  32          0         [       0] [       0] [       0] [       0]    0.102629
Test offset  28          0         [       0] [       0] [       0] [       0]    0.102629
Test offset  24          0         [       0] [       0] [       0] [       0]    0.102629
Test offset  20          0         [       0] [       0] [       0] [       0]    0.102629
Test offset  16          0         [       0] [       0] [       0] [       0]    0.102629
Test offset  12     115873         [  101190] [       0] [     171] [   86632]    0.116195
Test offset   8     143934         [  132762] [     183] [   53348] [  115630]    0.120324

Read Eye Result:
[128 units = 1 bit time (ideal eye width)]
-----------------------------------------------------
Description        LANE-0    LANE-1    LANE-2    LANE-3
-----------------------------------------------------
EYE [MIN-MAX]  :  [16,100]  [12,100]  [16,104]  [16, 92]
EYE CENTER     :   58/128    56/128    60/128    54/128
EYE WIDTH      :   65.62%    68.75%    68.75%    59.38%
```

Figure 9 – Measure Read Data Eye

```
Option Selected : i


Running Write Eye Measurement now ...
    ** read all ddrc regs
    ** read all ddriob regs
-------------------------------------------------------------------------------------------
    TEST           WORD ERROR              PER-BYTE-LANE ERROR COUNT              TIME
                     COUNT         [ LANE-0 ] [ LANE-1 ] [ LANE-2 ] [ LANE-3 ]    (sec)
-------------------------------------------------------------------------------------------
Test offset  64          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  68          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  72          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  76          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  80          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  84          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  88          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  92          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  96          0         [       0] [       0] [       0] [       0]    0.103219
Test offset 100          0         [       0] [       0] [       0] [       0]    0.103219
Test offset 104       2220         [       7] [       0] [       0] [    2220]    0.103219
Test offset 108      36880         [   11730] [       1] [    1683] [   35041]    0.108528
Test offset  60          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  56          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  52          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  48          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  44          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  40          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  36          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  32          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  28          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  24          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  20          0         [       0] [       0] [       0] [       0]    0.103219
Test offset  16       1276         [       0] [       0] [       0] [    1276]    0.103219
Test offset  12      88858         [   14295] [   12951] [    1001] [   82967]    0.106758

Write Eye Result:
[128 units = 1 bit time (ideal eye width)]
-----------------------------------------------------------
Description        LANE-0    LANE-1    LANE-2    LANE-3
-----------------------------------------------------------
EYE [MIN-MAX]   :  [16,100]  [16,104]  [16,104]  [20,100]
EYE CENTER      :   58/128    60/128    60/128    60/128
EYE WIDTH       :   65.62%    68.75%    68.75%    62.50%
EYE ADJUSTED    :      0         0         0         0
```

Figure 10 – Measure Write Data Eye

4. When finished with the Zynq DRAM Test, click  to disconnect the terminal. Switch to the *Console* tab. Click the  icon to stop the processor.

Experiment 3: Edit Memory Test to Expand the Range

MicroZed and PicoZed contain 1 GB of DDR3 RAM, configured as 256M x 32-bits. You may have noticed that the Memory Test application actually runs three different memory tests – 32-bit, 16-bit, and 8-bit. These tests completed very quickly, which should be an indication that the entire memory range was not tested.

1. Open the system.hdf in the hw_platform_0 to investigate the memory map for the DDR.

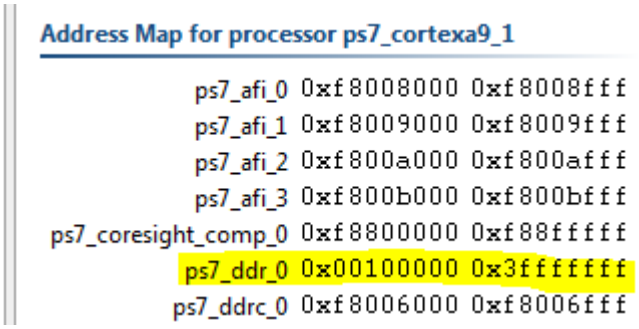

Figure 11 – DDR3 Memory Map

Notice that the address range is 0x00100000 to 0x3fffffff, which is 0x3FF00000 or 1,072,693,248 bytes. (For an explanation on where the lowest 1 MB of DDR3 went, see the Zynq TRM, *On-Chip Memory (OCM)*.)

2. Browse to the C source code for the Memory Test application in the *Project Explorer* at Mem_Test → src

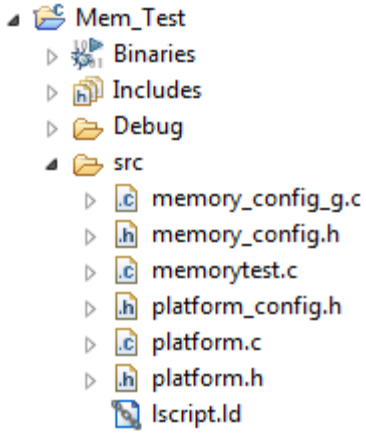

Figure 12 – Memory Test C Sources

3. The main() function is located in memorytest.c. Open that source by double-clicking it.

In main(), a for loop iterates on a variable n_memory_ranges to run function test_memory_range. The n_memory_ranges will allow this application to test both the on-chip-memory (OCM) for cpu1 as well as the DDR3. The cpu0 OCM is not tested as that is the memory used to store and execute the application (as shown in source lscript.ld).

Looking up further in the file, you will notice the test_memory_range() function. To make it easier to reference code, we'll turn on line numbers now.

4. Turn on line numbers by right-clicking in the left-hand column, or use the **Window → Preferences** dialog. Go to **General → Editors → Text Editors** and then check the box for *Show line numbers*. Click **OK**.

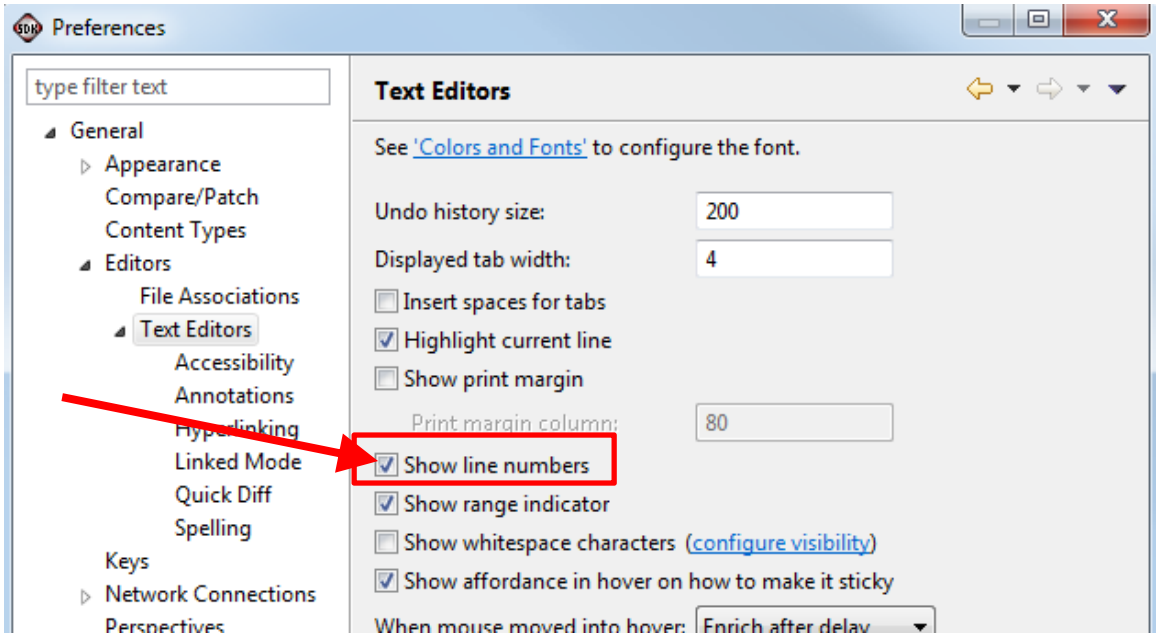

Figure 13 – Show Line Numbers

5. Find lines 74, 77, and 80. You will see that the default function only tests the first 4K bytes:
   - 1024 locations in the 32-bit (4-bytes) test
   - 2048 locations in the 16-bit (2-bytes) test
   - 4096 locations in the 8-bit (1 byte) test

Since the cpu0 OCM is used to execute the code, there is no consequence to testing the entire range other than it will take much, much longer. We will change this to test the full DDR3. However, remember that this function is universally used to test 4KB on both cpu1 OCM and DDR3. Since cpu1 OCM doesn't have 1 GB, if we just change the range in the test function, it will cause the OCM to fail. Therefore, we will change the test to test only DDR3, and we will extend the range.

6. Open memory_config_g.c, which defines the memory_range_s structure.
7. Comment out lines 12 through 17. This can easily be done by selecting the range with your mouse then using Ctrl / on your keyboard.
8. Change the n_memory_ranges to 1.
9. Return to memorytest.c. Make the following edits:
    - Line 74: replace 1024 with 1072693248/4
    - Line 77: replace 2048 with 1072693248/2
    - Line 80: replace 4096 with 1072693248

```
74    status = Xil_TestMem32((u32*)range->base, 1072693248/4, 0xAAAA5555, XIL_TESTMEM_ALLMEMTESTS);
75    print("          32-bit test: "); print(status == XST_SUCCESS? "PASSED!":"FAILED!"); print("\n\r");
76
77    status = Xil_TestMem16((u16*)range->base, 1072693248/2, 0xAA55, XIL_TESTMEM_ALLMEMTESTS);
78    print("          16-bit test: "); print(status == XST_SUCCESS? "PASSED!":"FAILED!"); print("\n\r");
79
80    status = Xil_TestMem8((u8*)range->base, 1072693248, 0xA5, XIL_TESTMEM_ALLMEMTESTS);
81    print("           8-bit test: "); print(status == XST_SUCCESS? "PASSED!":"FAILED!"); print("\n\r");
```

Figure 14 – Modified Memory Test

10. Save all files using the  icon, which will cause a re-build.
11. In the Console, notice the size of the application is ~42KB. Since cpu0 OCM has 196K useable bytes, we are well within the limits.

```
'Invoking: ARM Print Size'
arm-xilinx-eabi-size Mem_Test.elf  |tee "Mem_Test.elf.size"
   text    data     bss     dec     hex filename
  26284    1168   14388   41840    a370 Mem_Test.elf
```

Figure 15 – Mem_Test Built

12. Reconnect the terminal and re-run this edited and newly built Mem_Test. Be patient as the test times are significantly longer.
    - 32-bit test: ~1:45
    - 16-bit test: ~3:20
    - 8-bit test: ~6:20

Total elapsed time will be about 11.5 minutes.

Revision History

Date	Version	Revision
23 Aug 2013	2013_2.01	Initial Avnet release for Vivado 2013.2
09 Jun 2014	2014_1.01	Update for Vivado 2014.1
11 Jun 2014	2014_2.01	Update for Vivado 2014.2
29 Jun 2015	2015_1.01	Update for Vivado 2015.1. Added support for PicoZed.
15 Jul 2015	2015_2.01	Update for Vivado 2015.2