MiniZed: Test Applications

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 2017.1
- FTDI FT2232H device driver

Hardware

The hardware setup used to test this reference design includes:

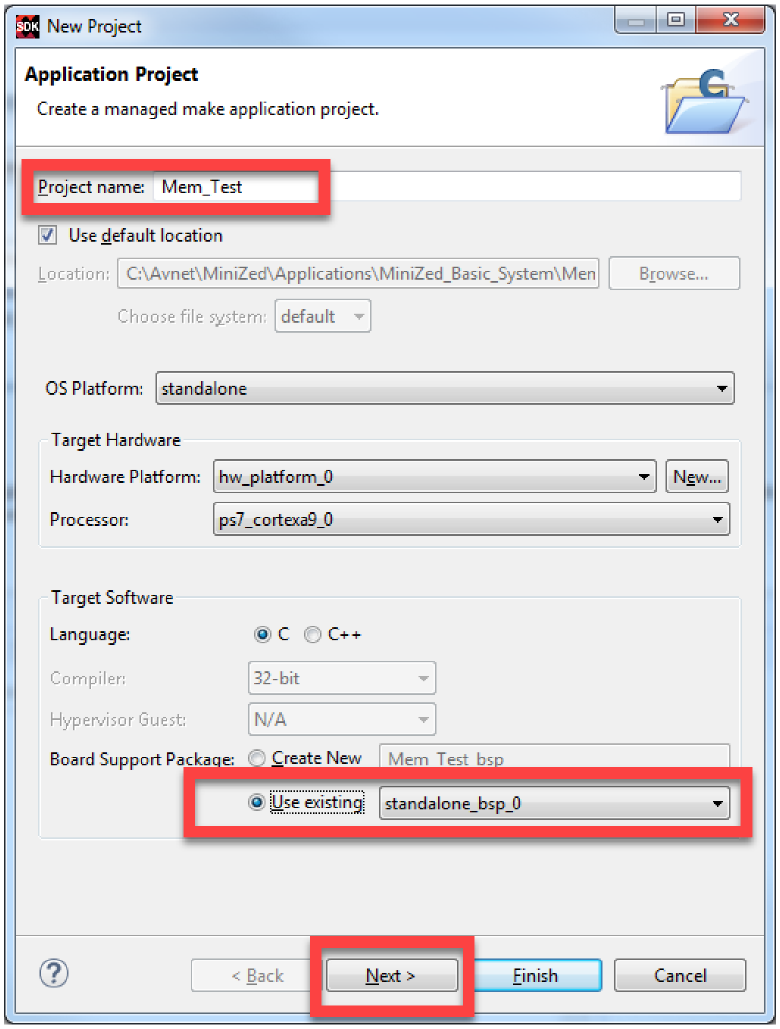
- Win-7 PC with the following recommended memory[1]:
    - 1.6 GB RAM available for the Xilinx tools to complete a XC7Z010 design
    - 2.3 GB RAM available for the Xilinx tools to complete a XC7Z015 design
    - 1.9 GB RAM available for the Xilinx tools to complete a XC7Z020 design
    - 2.7 GB RAM available for the Xilinx tools to complete a XC7Z030 design
- MiniZed
- USB cable (Type A to Micro-USB Type B)

[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 >**.


New Project

Application Project

Create a managed make application project.

Project name: Mem_Test

[✓] Use default location

Location: C:\Avnet\MiniZed\Applications\MiniZed_Basic_System\Men

Choose file system: default

OS Platform: standalone

Target Hardware

Hardware Platform: hw_platform_0

Processor: ps7_cortexa9_0

Target Software

Language: [✓ C] C++

Compiler: 32-bit

Hypervisor Guest: N/A

Board Support Package: Create New Mem_Test_bsp [✓ Use existing] standalone_bsp_0

Figure 1 - New Application Wizard

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

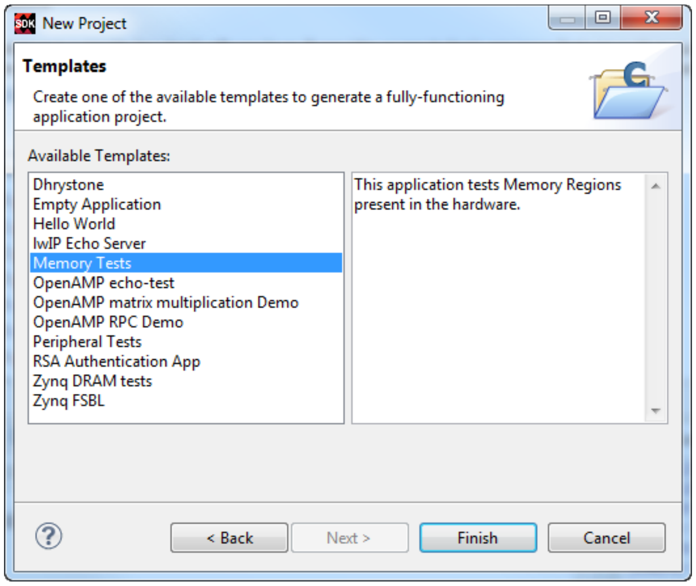


Figure 2 – New Application Project: Hello World

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.

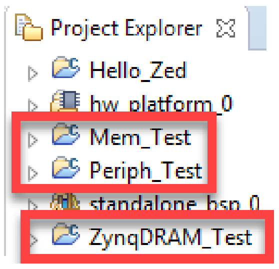


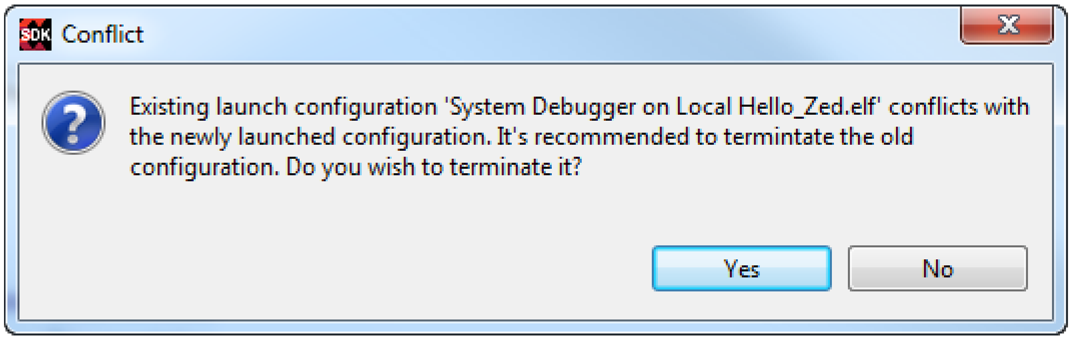
Figure 3 – Project Explorer with New Apps Highlighted

Experiment 2: Run the Applications

1. Follow the instructions in the Hello World tutorial to configure the MiniZed for Cascaded JTAG and plug in the USB-JTAG-UART cable. 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.

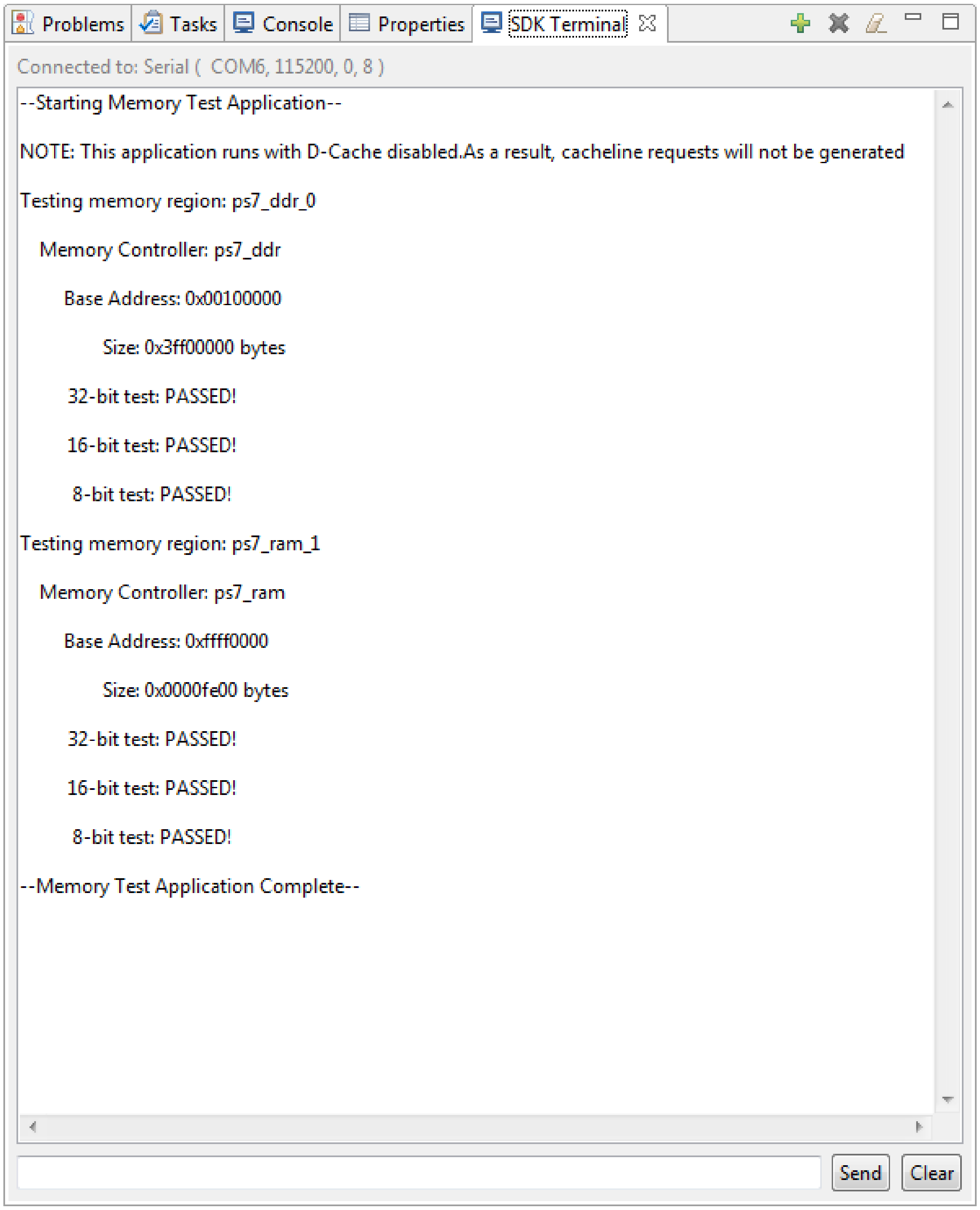
3. When asked to terminate the old configuration, select **Yes**.



Existing launch configuration 'System Debugger on Local Hello_Zed.elf' conflicts with the newly launched configuration. It's recommended to termintate the old configuration. Do you wish to terminate it?

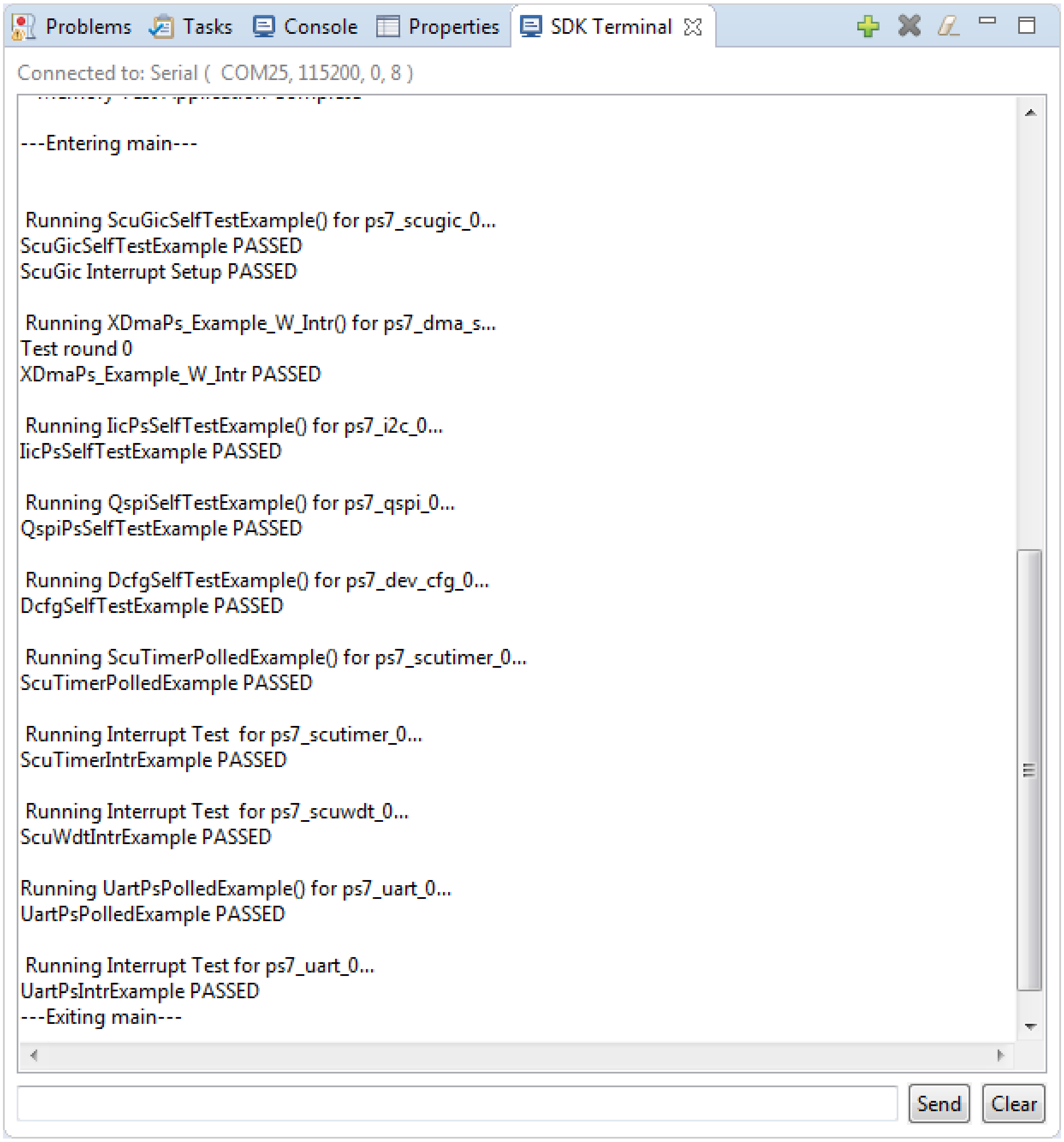
Figure 4 – Terminate Old Configuration

When done you should see these terminal messages.



```
Connected to: Serial ( COM6, 115200, 0, 8 )
--Starting Memory Test Application--

NOTE: This application runs with D-Cache disabled.As a result, cacheline requests will not be generated

Testing memory region: ps7_ddr_0

   Memory Controller: ps7_ddr

       Base Address: 0x00100000

             Size: 0x3ff00000 bytes

        32-bit test: PASSED!

        16-bit test: PASSED!

         8-bit test: PASSED!

Testing memory region: ps7_ram_1

   Memory Controller: ps7_ram

       Base Address: 0xffff0000

             Size: 0x0000fe00 bytes

        32-bit test: PASSED!

        16-bit test: PASSED!

         8-bit test: PASSED!

--Memory Test Application Complete--
```

Figure 5 - Memory Test Console



Connected to: Serial (COM25, 115200, 0, 8)

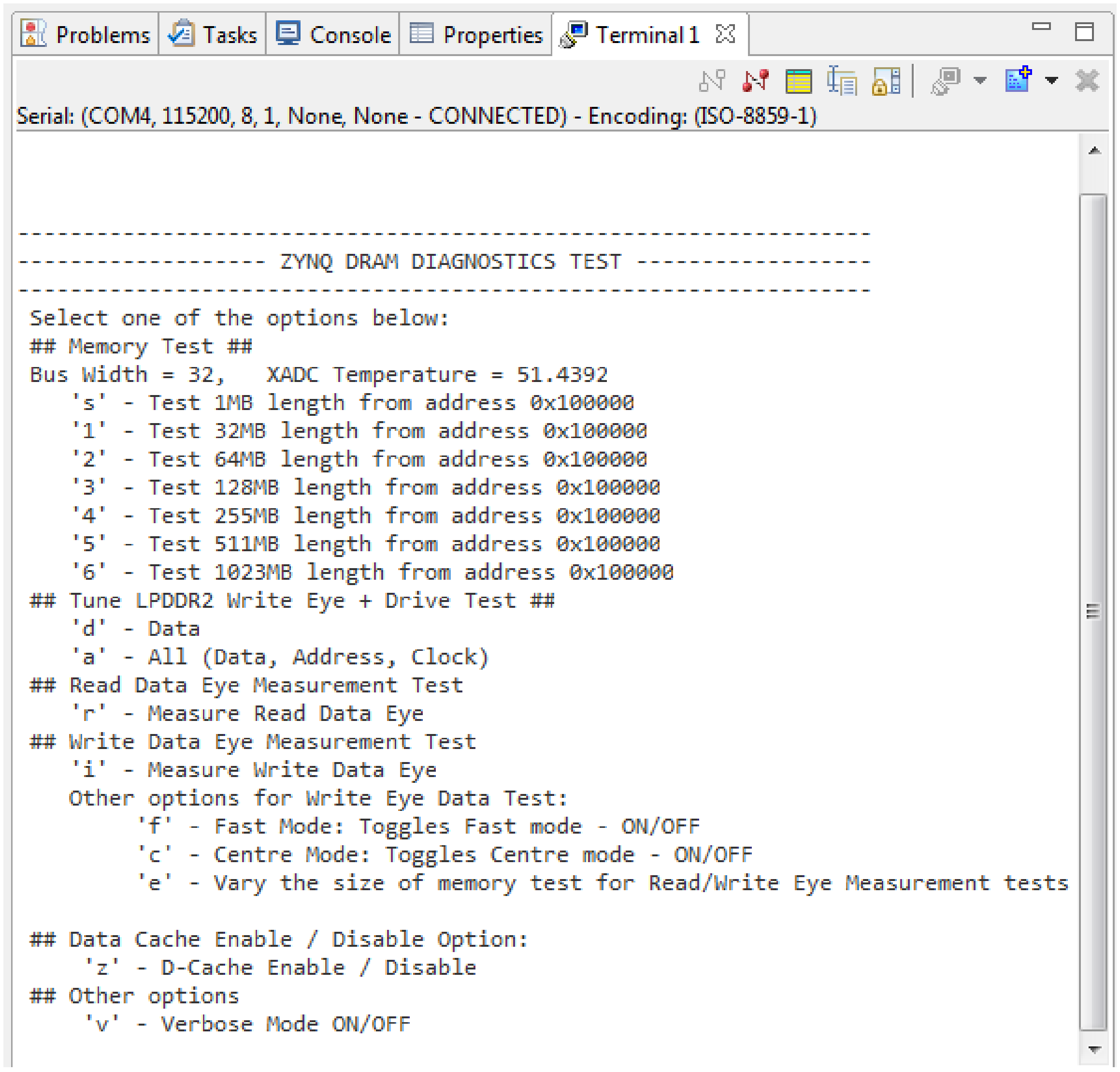
```
---Entering main---


 Running ScuGicSelfTestExample() for ps7_scugic_0...
ScuGicSelfTestExample PASSED
ScuGic Interrupt Setup PASSED

 Running XDmaPs_Example_W_Intr() for ps7_dma_s...
Test round 0
XDmaPs_Example_W_Intr PASSED

 Running IicPsSelfTestExample() for ps7_i2c_0...
IicPsSelfTestExample PASSED

 Running QspiSelfTestExample() for ps7_qspi_0...
QspiPsSelfTestExample PASSED

 Running DcfgSelfTestExample() for ps7_dev_cfg_0...
DcfgSelfTestExample PASSED

 Running ScuTimerPolledExample() for ps7_scutimer_0...
ScuTimerPolledExample PASSED

 Running Interrupt Test  for ps7_scutimer_0...
ScuTimerIntrExample PASSED

 Running Interrupt Test  for ps7_scuwdt_0...
ScuWdtIntrExample PASSED

Running UartPsPolledExample() for ps7_uart_0...
UartPsPolledExample PASSED

 Running Interrupt Test for ps7_uart_0...
UartPsIntrExample PASSED
---Exiting main---
```

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\MiniZed\Applications\MiniZed_Basic_System\ZynqDRAM_Test\src`

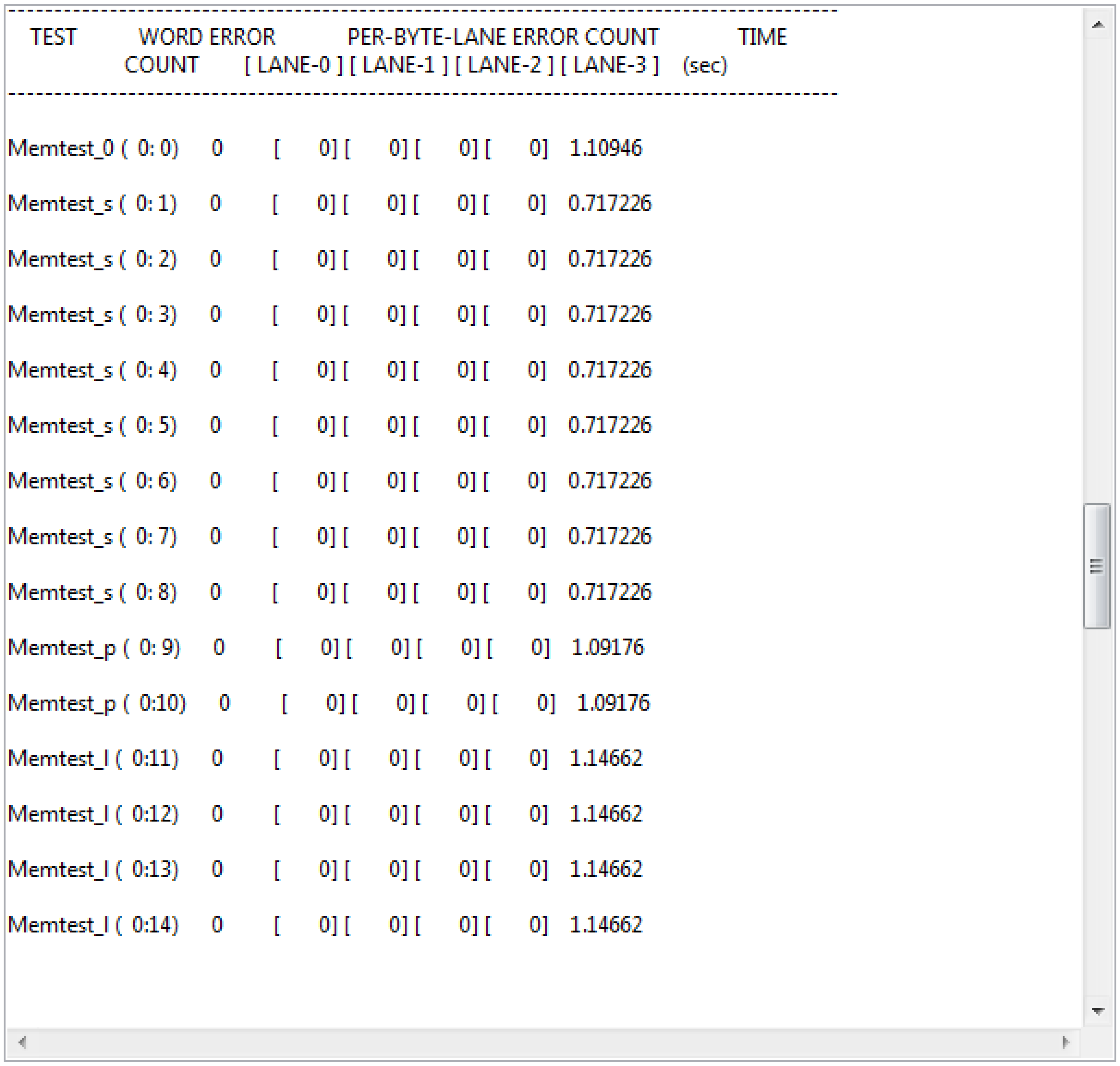
A couple of the test outputs are shown below for a MiniZed.



Serial: (COM4, 115200, 8, 1, None, None - CONNECTED) - Encoding: (ISO-8859-1)

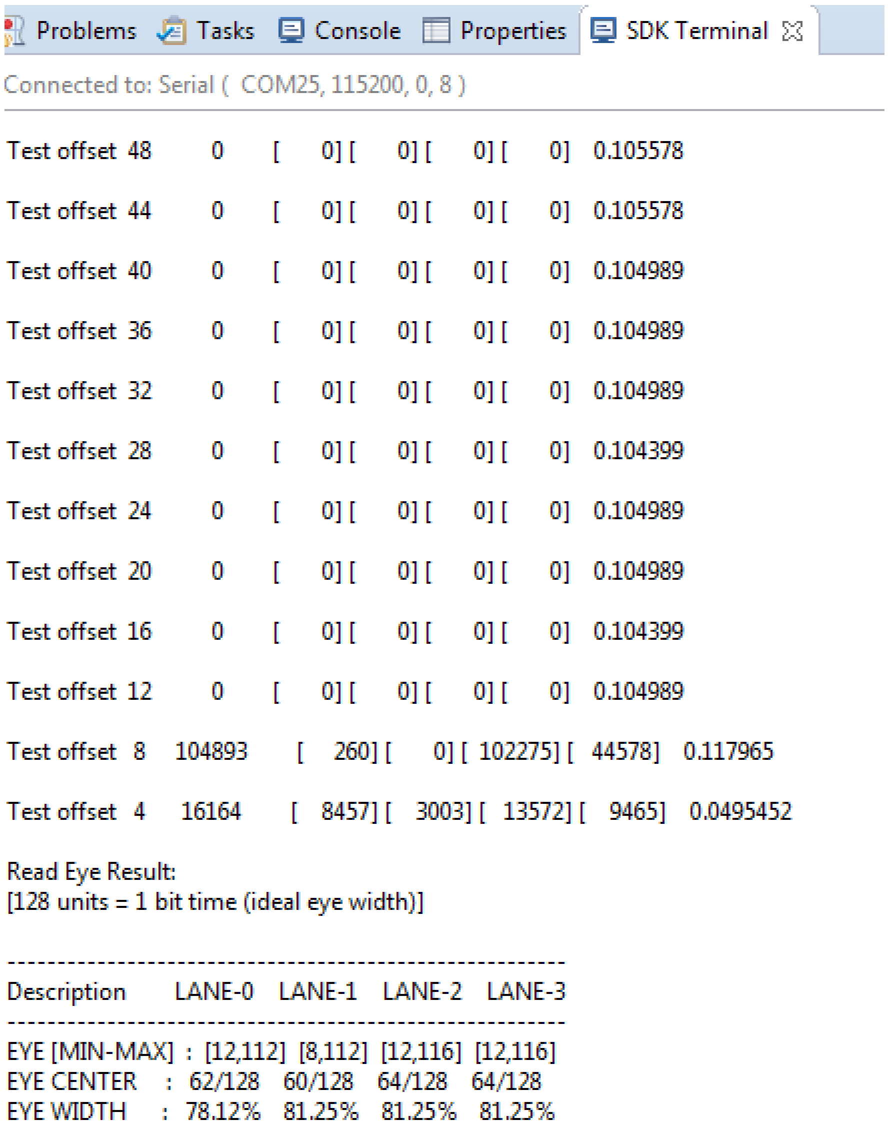
```
-----------------------------------------------------------------
------------------- ZYNQ DRAM DIAGNOSTICS TEST ------------------
-----------------------------------------------------------------
 Select one of the options below:
 ## Memory Test ##
 Bus Width = 32,   XADC Temperature = 51.4392
    's' - Test 1MB length from address 0x100000
    '1' - Test 32MB length from address 0x100000
    '2' - Test 64MB length from address 0x100000
    '3' - Test 128MB length from address 0x100000
    '4' - Test 255MB length from address 0x100000
    '5' - Test 511MB length from address 0x100000
    '6' - Test 1023MB length from address 0x100000
 ## Tune LPDDR2 Write Eye + Drive Test ##
    'd' - Data
    'a' - All (Data, Address, Clock)
 ## Read Data Eye Measurement Test
    'r' - Measure Read Data Eye
 ## Write Data Eye Measurement Test
    'i' - Measure Write Data Eye
    Other options for Write Eye Data Test:
         'f' - Fast Mode: Toggles Fast mode - ON/OFF
         'c' - Centre Mode: Toggles Centre mode - ON/OFF
         'e' - Vary the size of memory test for Read/Write Eye Measurement tests

 ## Data Cache Enable / Disable Option:
     'z' - D-Cache Enable / Disable
 ## Other options
     'v' - Verbose Mode ON/OFF
```

Figure 7 – Zynq DRAM Diagnostics Test Menu



```
--------------------------------------------------------------------------------------------
  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]   0.717226

Memtest_s (  0: 2)     0      [      0] [      0] [      0] [      0]   0.717226

Memtest_s (  0: 3)     0      [      0] [      0] [      0] [      0]   0.717226

Memtest_s (  0: 4)     0      [      0] [      0] [      0] [      0]   0.717226

Memtest_s (  0: 5)     0      [      0] [      0] [      0] [      0]   0.717226

Memtest_s (  0: 6)     0      [      0] [      0] [      0] [      0]   0.717226

Memtest_s (  0: 7)     0      [      0] [      0] [      0] [      0]   0.717226

Memtest_s (  0: 8)     0      [      0] [      0] [      0] [      0]   0.717226

Memtest_p (  0: 9)     0      [      0] [      0] [      0] [      0]   1.09176

Memtest_p (  0:10)     0      [      0] [      0] [      0] [      0]   1.09176

Memtest_l (  0:11)     0      [      0] [      0] [      0] [      0]   1.14662

Memtest_l (  0:12)     0      [      0] [      0] [      0] [      0]   1.14662

Memtest_l (  0:13)     0      [      0] [      0] [      0] [      0]   1.14662

Memtest_l (  0:14)     0      [      0] [      0] [      0] [      0]   1.14662
```

Figure 8 – Test #1, 32MB test



```
Connected to: Serial ( COM25, 115200, 0, 8 )

Test offset 48      0     [     0] [     0] [     0] [     0]   0.105578

Test offset 44      0     [     0] [     0] [     0] [     0]   0.105578

Test offset 40      0     [     0] [     0] [     0] [     0]   0.104989

Test offset 36      0     [     0] [     0] [     0] [     0]   0.104989

Test offset 32      0     [     0] [     0] [     0] [     0]   0.104989

Test offset 28      0     [     0] [     0] [     0] [     0]   0.104399

Test offset 24      0     [     0] [     0] [     0] [     0]   0.104989

Test offset 20      0     [     0] [     0] [     0] [     0]   0.104989

Test offset 16      0     [     0] [     0] [     0] [     0]   0.104399

Test offset 12      0     [     0] [     0] [     0] [     0]   0.104989

Test offset  8  104893    [   260] [     0] [ 102275] [  44578]   0.117965

Test offset  4   16164    [  8457] [  3003] [  13572] [   9465]   0.0495452

Read Eye Result:
[128 units = 1 bit time (ideal eye width)]

-------------------------------------------------------
Description      LANE-0    LANE-1    LANE-2    LANE-3
-------------------------------------------------------
EYE [MIN-MAX] :  [12,112]  [8,112]  [12,116]  [12,116]
EYE CENTER    :   62/128    60/128    64/128    64/128
EYE WIDTH     :   78.12%    81.25%    81.25%    81.25%
```

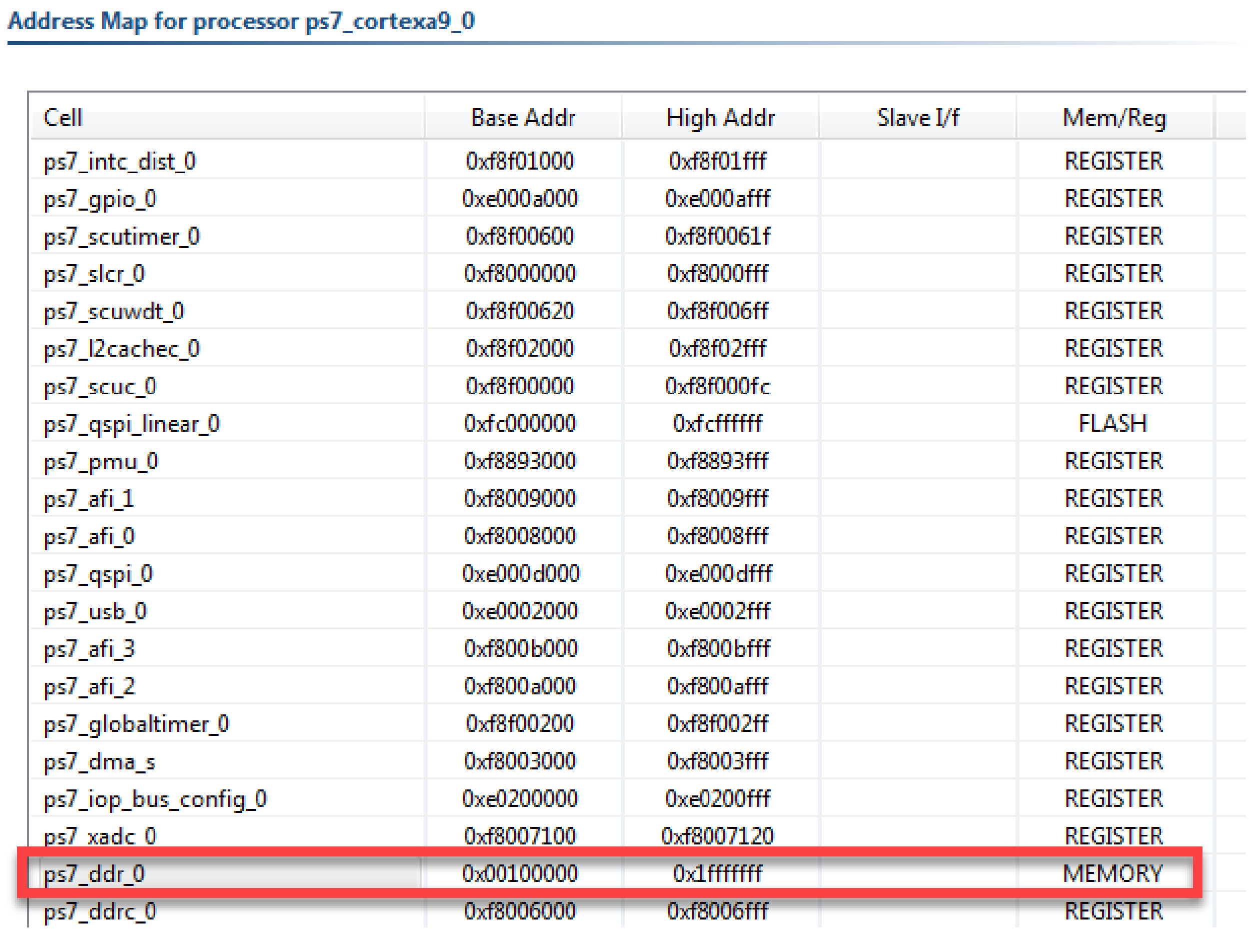
Figure 9 – Measure Read Data Eye

4. When finished with the Zynq DRAM Test, click ✖ to disconnect the terminal. Switch to the *Console* tab.

Experiment 3: Edit Memory Test to Expand the Range

MiniZed contain 512 MBytest of DDR3 RAM. 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.



Address Map for processor ps7_cortexa9_0

Cell	Base Addr	High Addr	Slave I/f	Mem/Reg
ps7_intc_dist_0	0xf8f01000	0xf8f01fff		REGISTER
ps7_gpio_0	0xe000a000	0xe000afff		REGISTER
ps7_scutimer_0	0xf8f00600	0xf8f0061f		REGISTER
ps7_slcr_0	0xf8000000	0xf8000fff		REGISTER
ps7_scuwdt_0	0xf8f00620	0xf8f006ff		REGISTER
ps7_l2cachec_0	0xf8f02000	0xf8f02fff		REGISTER
ps7_scuc_0	0xf8f00000	0xf8f000fc		REGISTER
ps7_qspi_linear_0	0xfc000000	0xfcffffff		FLASH
ps7_pmu_0	0xf8893000	0xf8893fff		REGISTER
ps7_afi_1	0xf8009000	0xf8009fff		REGISTER
ps7_afi_0	0xf8008000	0xf8008fff		REGISTER
ps7_qspi_0	0xe000d000	0xe000dfff		REGISTER
ps7_usb_0	0xe0002000	0xe0002fff		REGISTER
ps7_afi_3	0xf800b000	0xf800bfff		REGISTER
ps7_afi_2	0xf800a000	0xf800afff		REGISTER
ps7_globaltimer_0	0xf8f00200	0xf8f002ff		REGISTER
ps7_dma_s	0xf8003000	0xf8003fff		REGISTER
ps7_iop_bus_config_0	0xe0200000	0xe0200fff		REGISTER
ps7_xadc_0	0xf8007100	0xf8007120		REGISTER
ps7_ddr_0	0x00100000	0x1fffffff		MEMORY
ps7_ddrc_0	0xf8006000	0xf8006fff		REGISTER

Figure 10 – DDR3 Memory Map

Notice that the address range is 0x00100000 to 0x1fffffff, which is 0x1FF00000 or 535,822,336 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

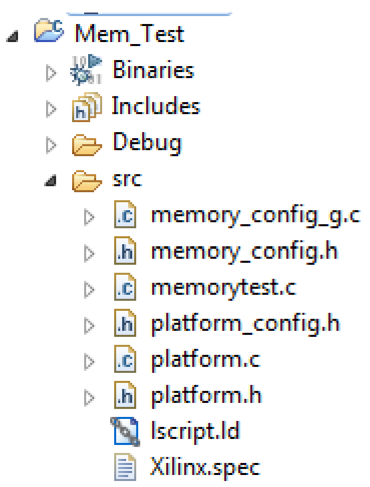


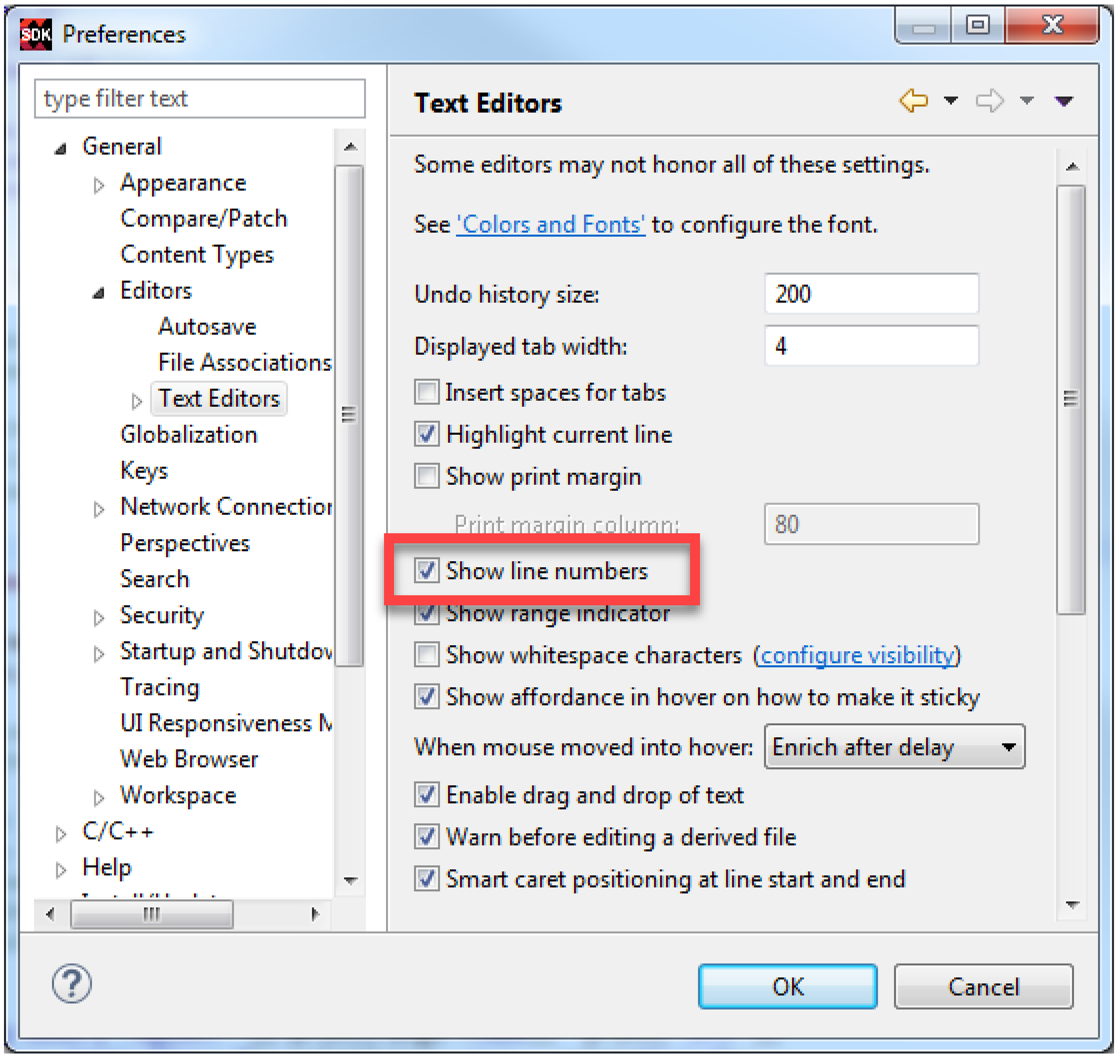
Figure 11 – Memory Test C Sources

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**.



Preferences

type filter text

- General
  - Appearance
  - Compare/Patch
  - Content Types
  - Editors
    - Autosave
    - File Associations
    - Text Editors
  - Globalization
  - Keys
  - Network Connectior
  - Perspectives
  - Search
  - Security
  - Startup and Shutdov
  - Tracing
  - UI Responsiveness M
  - Web Browser
  - Workspace
- C/C++
- Help

Text Editors

Some editors may not honor all of these settings.

See 'Colors and Fonts' to configure the font.

Undo history size: 200

Displayed tab width: 4

- [ ] Insert spaces for tabs
- [x] Highlight current line
- [ ] Show print margin

Print margin column: 80

- [x] Show line numbers
- [x] Show range indicator
- [ ] Show whitespace characters (configure visibility)
- [x] Show affordance in hover on how to make it sticky

When mouse moved into hover: Enrich after delay

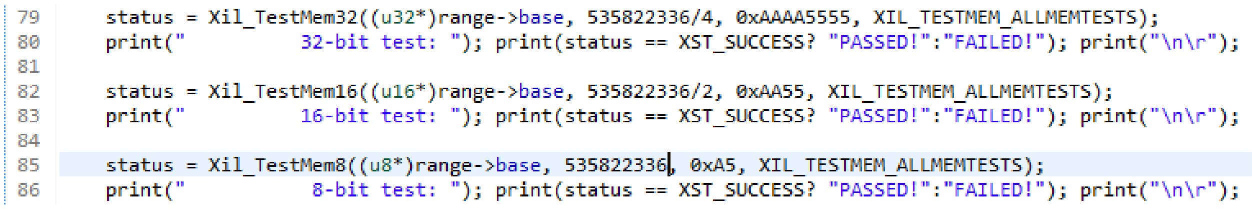
- [x] Enable drag and drop of text
- [x] Warn before editing a derived file
- [x] Smart caret positioning at line start and end

Figure 12 – Show Line Numbers

5. Find lines 79, 82, and 85. 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.

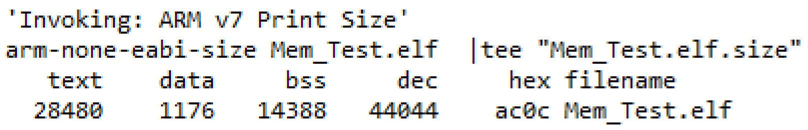
6. Open memory_config_g.c, which defines the memory_range_s structure.
7. Comment out lines 12 through 17. This can easily be done by selecting the range with your mouse then using Ctrl / on your keyboard.
8. Change the n_memory_ranges to 1.
9. Return to memorytest.c. Make the following edits:
    - Line 79: replace 1024 with 535822336/4
    - Line 82: replace 2048 with 535822336/2
    - Line 85: replace 4096 with 535822336



```
79      status = Xil_TestMem32((u32*)range->base, 535822336/4, 0xAAAA5555, XIL_TESTMEM_ALLMEMTESTS);
80      print("           32-bit test: "); print(status == XST_SUCCESS? "PASSED!":"FAILED!"); print("\n\r");
81
82      status = Xil_TestMem16((u16*)range->base, 535822336/2, 0xAA55, XIL_TESTMEM_ALLMEMTESTS);
83      print("           16-bit test: "); print(status == XST_SUCCESS? "PASSED!":"FAILED!"); print("\n\r");
84
85      status = Xil_TestMem8((u8*)range->base, 535822336, 0xA5, XIL_TESTMEM_ALLMEMTESTS);
86      print("            8-bit test: "); print(status == XST_SUCCESS? "PASSED!":"FAILED!"); print("\n\r");
```

Figure 13 – 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 ~44KB. Since cpu0 OCM has 196K useable bytes, we are well within the limits.



```
'Invoking: ARM v7 Print Size'
arm-none-eabi-size Mem_Test.elf  |tee "Mem_Test.elf.size"
   text    data     bss     dec     hex filename
  28480    1176   14388   44044    ac0c Mem_Test.elf
```

Figure 14 – 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: ~1:00
    - 16-bit test: ~1:45
    - 8-bit test: ~3:15

Total elapsed time will be about 6 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
06 Apr 2016	2015_4.01	Update to 2015.4. Add support for PZCC-FMC-V2.
01 Jun 2016	2015_4.02	Update to 2015.4. Clarified terminal disconnect function.
15 Sept 2016	2016_2.01	Updated to 2016.2
20 Jan 2017	2016_4.01	Updated to 2016.4
07 Jun 2017	2017_1.01	Updated to 2017.1 for MiniZed