ML605 MIG Design Creation

October 2010

XTP047

Revision History

Date	Version	Description
10/05/10	12.3	Recompiled under 12.3. Added slides on measuring the Read Data Window with VIO
07/23/10	12.2	Recompiled under 12.2.

Overview

- Virtex-6 DDR3 Memory Interface
- ML605 Board
- ML605 Setup
- Generate MIG Example Design
- Modifications to Example Design
- Compile Example Design
- Run MIG Example Design
- Adjust Data Pattern using VIO Console
- Example Design VIO Consoles
- Measure Read Data Window with VIO
- References

Note: This presentation applies to the ML605

Virtex-6 DDR3 Memory Interface

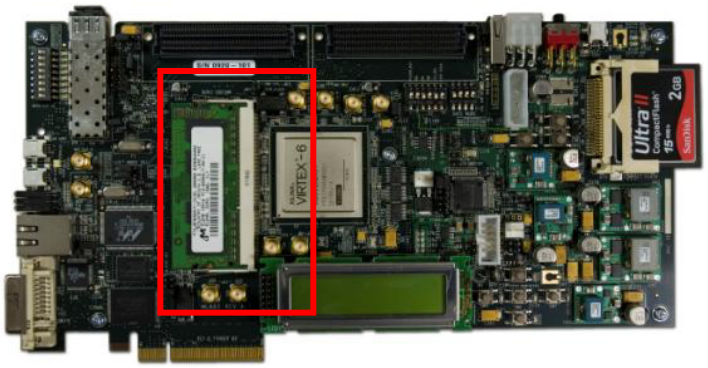
- **Pre-Engineered Controller and Physical Layer (PHY) memory interface**
- **300-533 MHz (600-1066 Mb/s) Performance**
  - Center Column Interfaces
  - 400 MHz in a -1 speed device
  - 533 MHz in -2, -3 devices
- **1 Gb density memory device support**
- **X4, x8, x16 device support**
- **Configurable data bus widths**
  - Multiples of 8 bits, up to 72 bits

Note: Presentation applies to the ML605

Virtex-6 Memory Controller and Interfaces

- **Improved performance**
  - Higher data rates
    - Faster circuitry (40 nm)
    - Enhanced I/O (50 ps IODELAY)
    - Dedicated clocking paths
    - Real-time calibration
  - Higher effective bandwidth
    - Reordering controller (DDR3/DDR2)
- **Improved functionality**
  - DDR3 DIMM write leveling
- **Easy to use**
  - MIG for ISE design flow
  - MPMC for EDK design flow

ML605 provides DDR3 SO-DIMM



Xilinx makes it easier and faster to design with Virtex-6

Note: Presentation applies to the ML605

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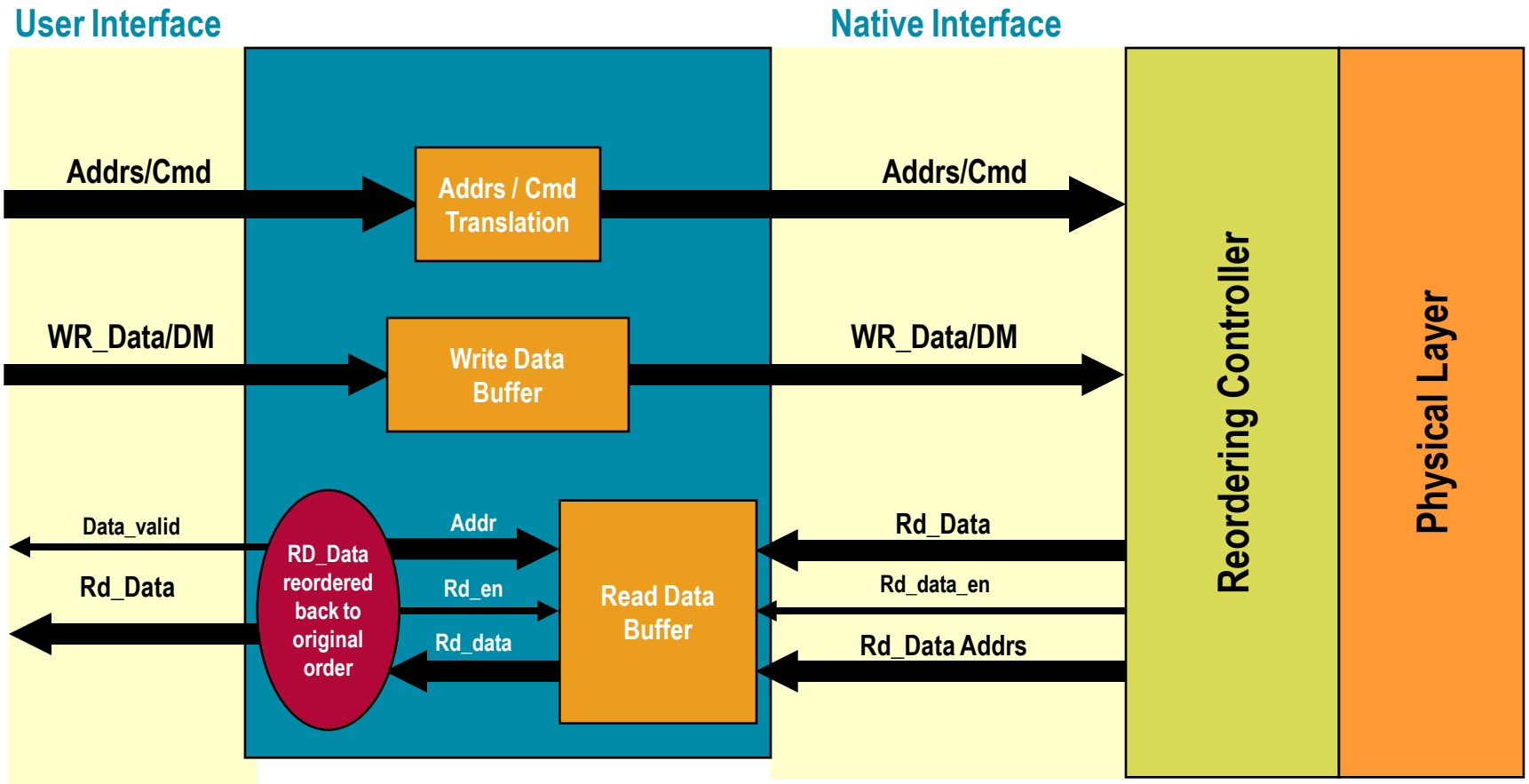
DDR3 User Interfaces

- **Virtex-6 FPGA user interface similar to Virtex-5 architecture**
  - Native interface option available for the advanced users to achieve lower latency



Note: Presentation applies to the ML605

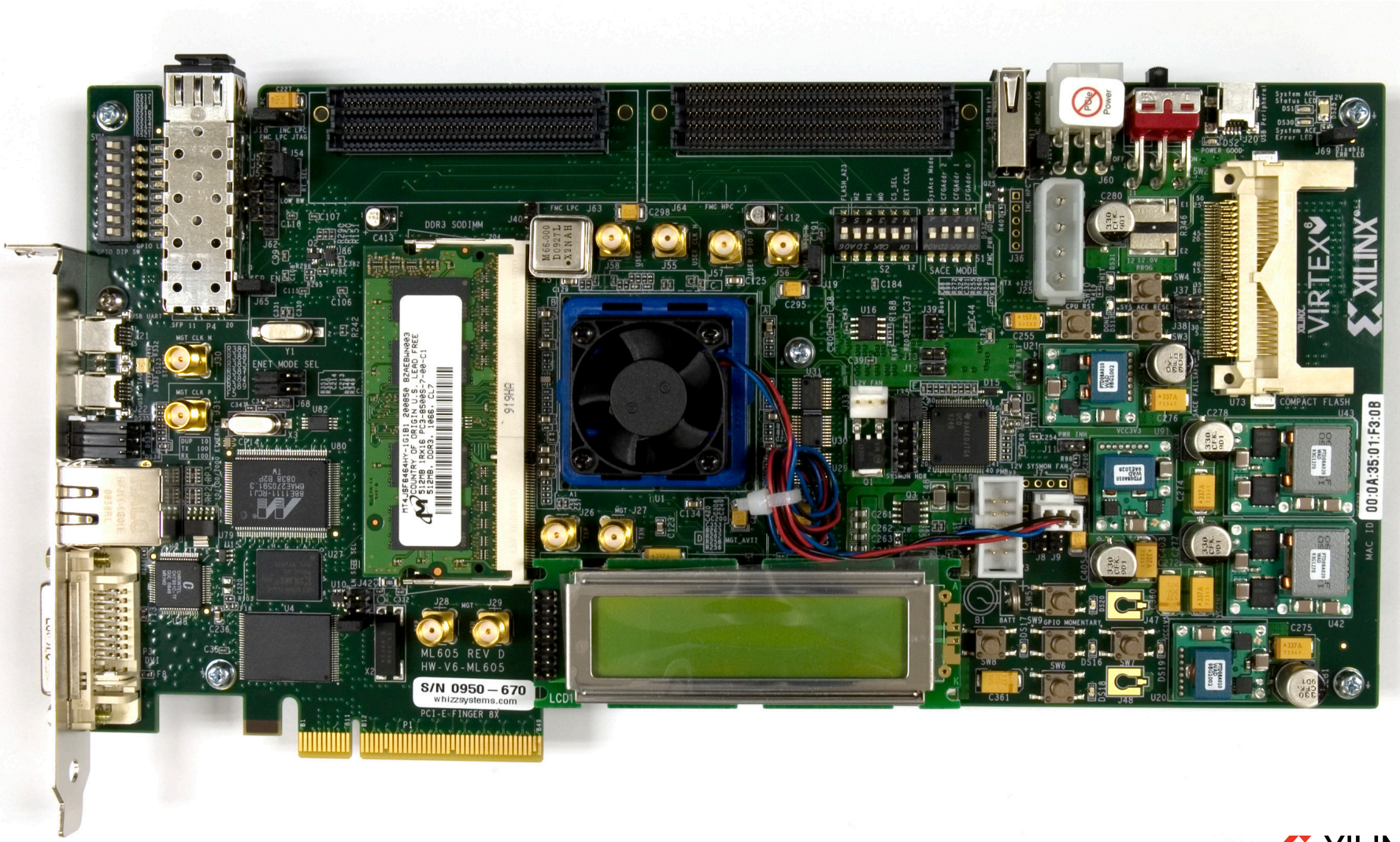
Reordering for Higher Effective Bandwidth

- **Half-frequency DDR2/DDR3 controller**
  - Control state machine runs at half the memory clock rate
- **Reorder READs to avoid precharge time penalty**
  - Example : Execute out-of-order READs to a different bank while performing precharge for the current bank
- **Regroup READs and WRITEs to minimize bus turnaround**
  - Example : Read A - Write B - Read C - Write D
  - Reordered to: Read A - Read C - Write B - Write D
- **Reordering controller looks ahead several commands**
  - Efficiency is dependent on applications (address / command patterns)

Reordering can more than double the throughput

Note: Presentation applies to the ML605

Xilinx ML605 Board



Note: Presentation applies to the ML605

ISE Software Requirements

- Xilinx ISE 12.3 software

Note: Presentation applies to the ML605

ChipScope Pro Software Requirement

- **Xilinx ChipScope Pro 12.3 software**

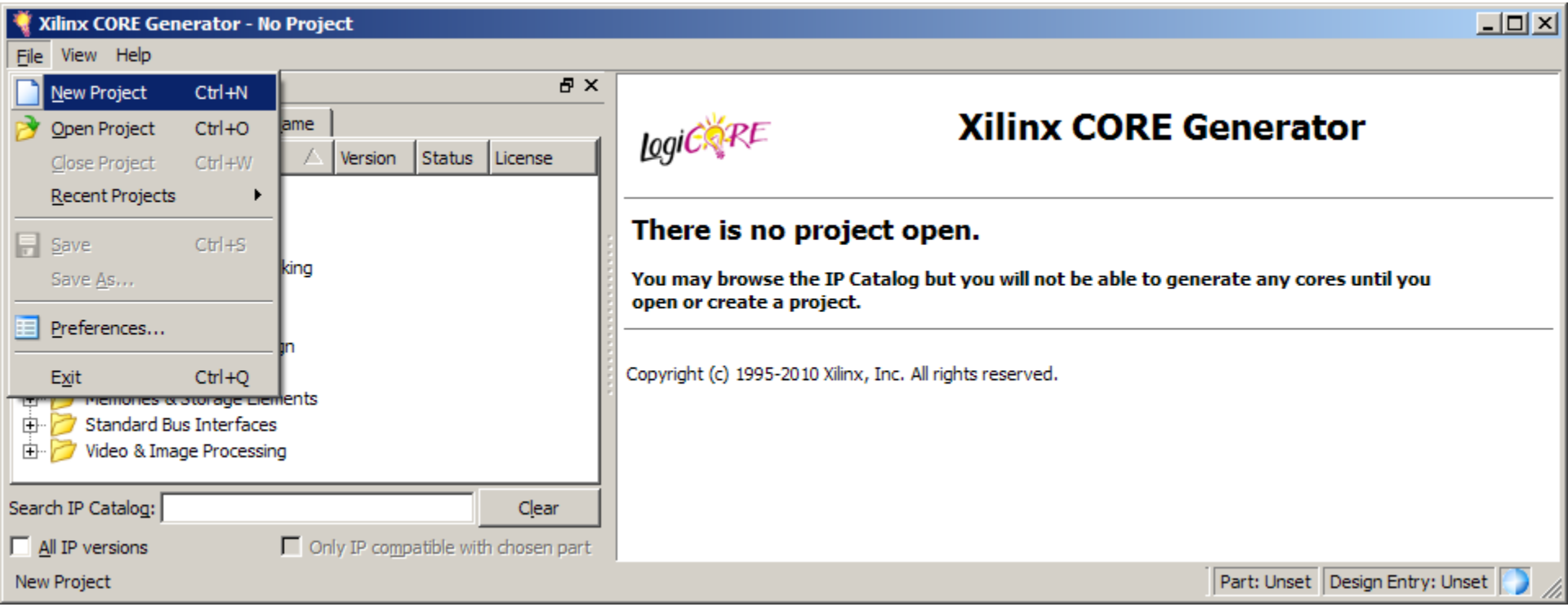
Note: Presentation applies to the ML605

Generate MIG Example Design

- **Open the CORE Generator**

  Start → All Programs → Xilinx ISE Design Suite 12.3 → ISE → Accessories → CORE Generator

- **Create a new project; select File → New Project**



Note: Presentation applies to the ML605

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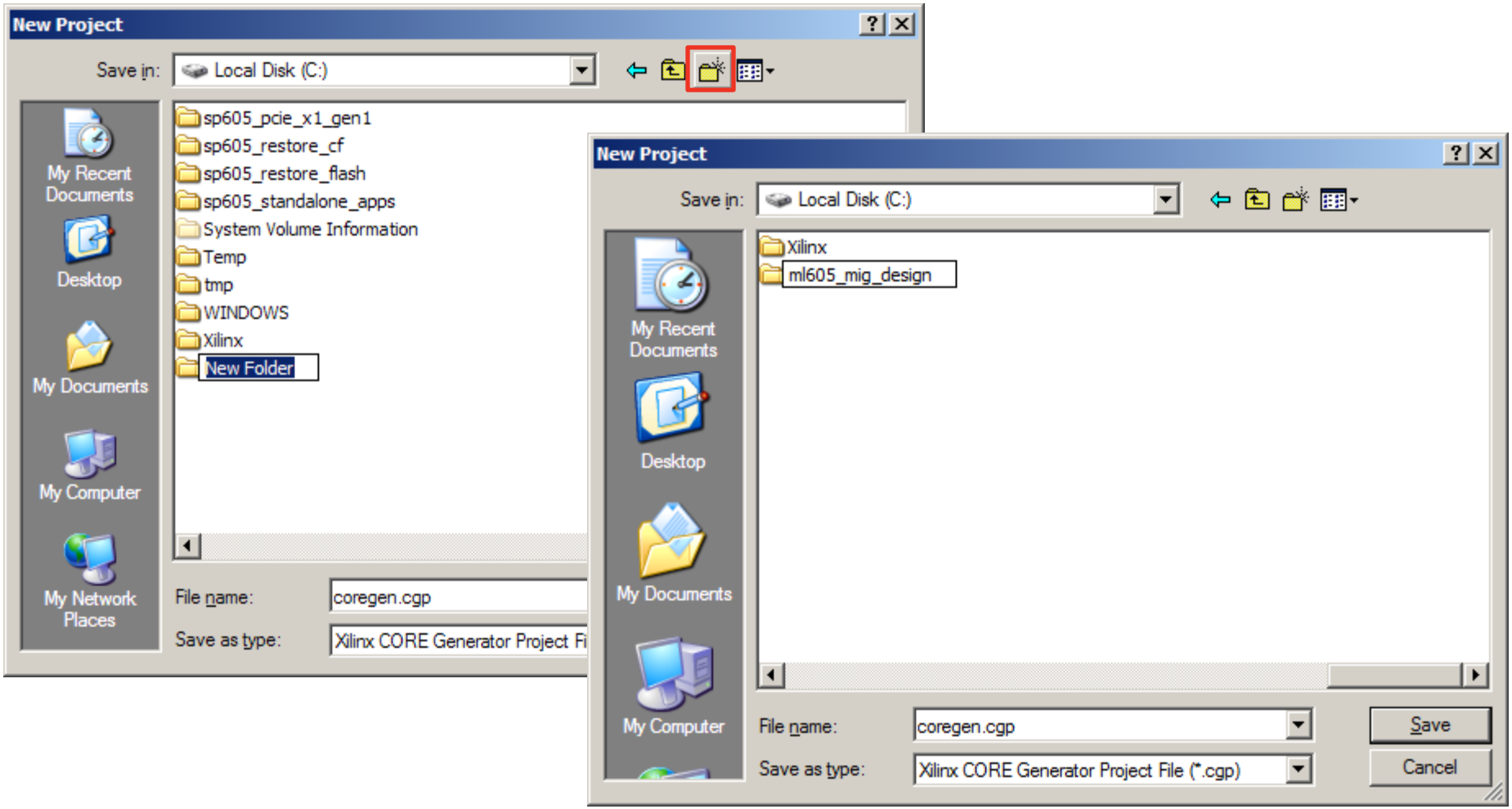
Generate MIG Example Design

- Create a project directory: ml605_mig_design



Note: Presentation applies to the ML605

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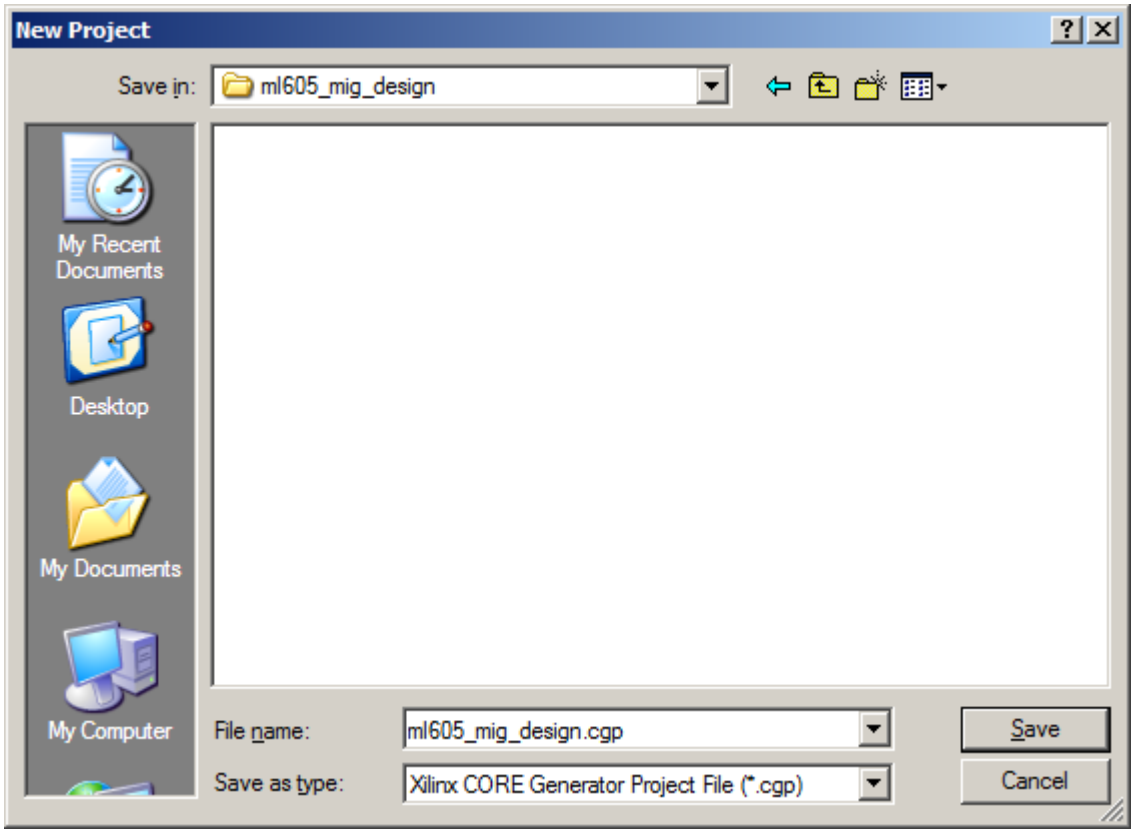
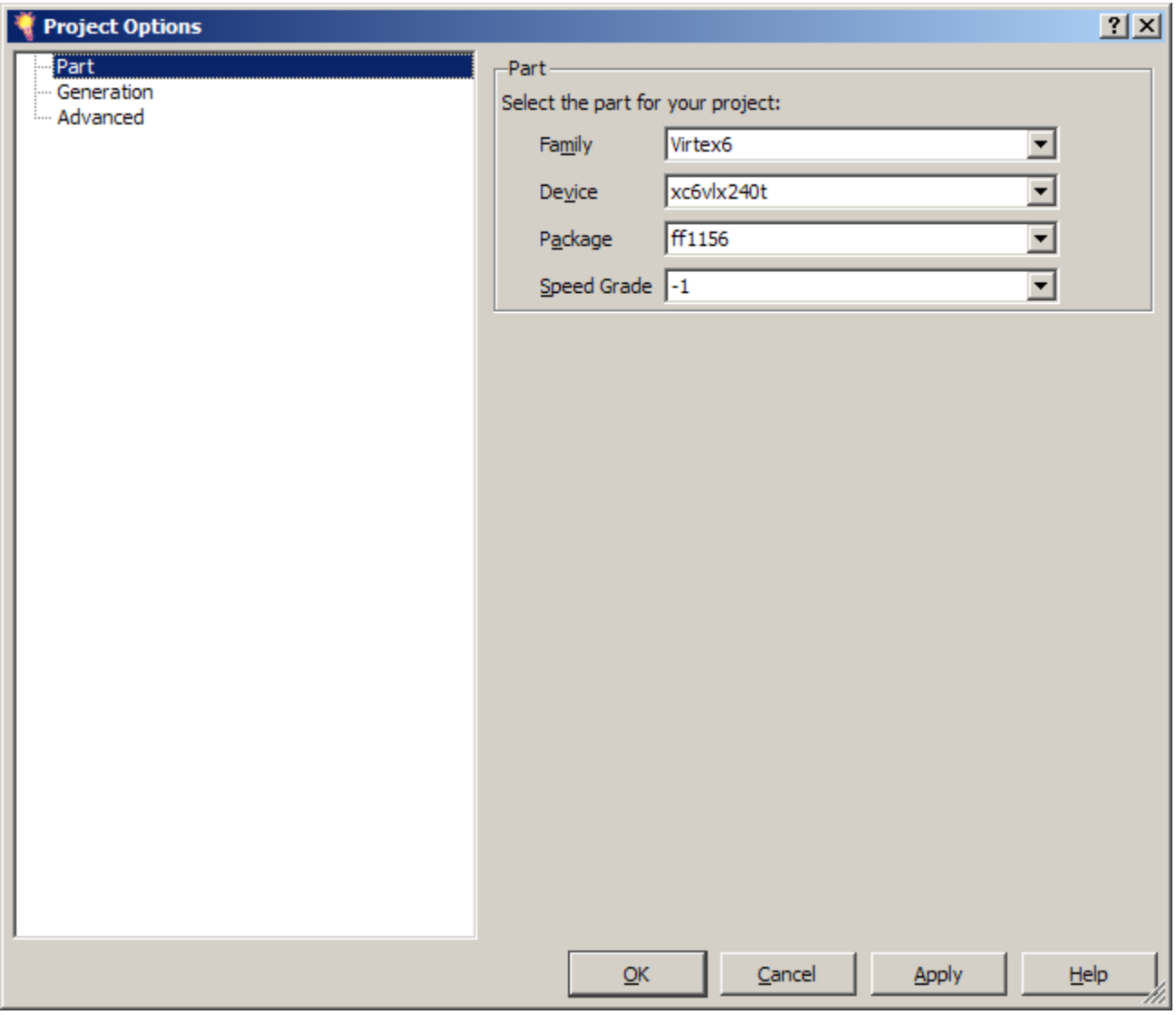
Generate MIG Example Design

- **Name the project: ml605_mig_design.cgp**



Note: Presentation applies to the ML605

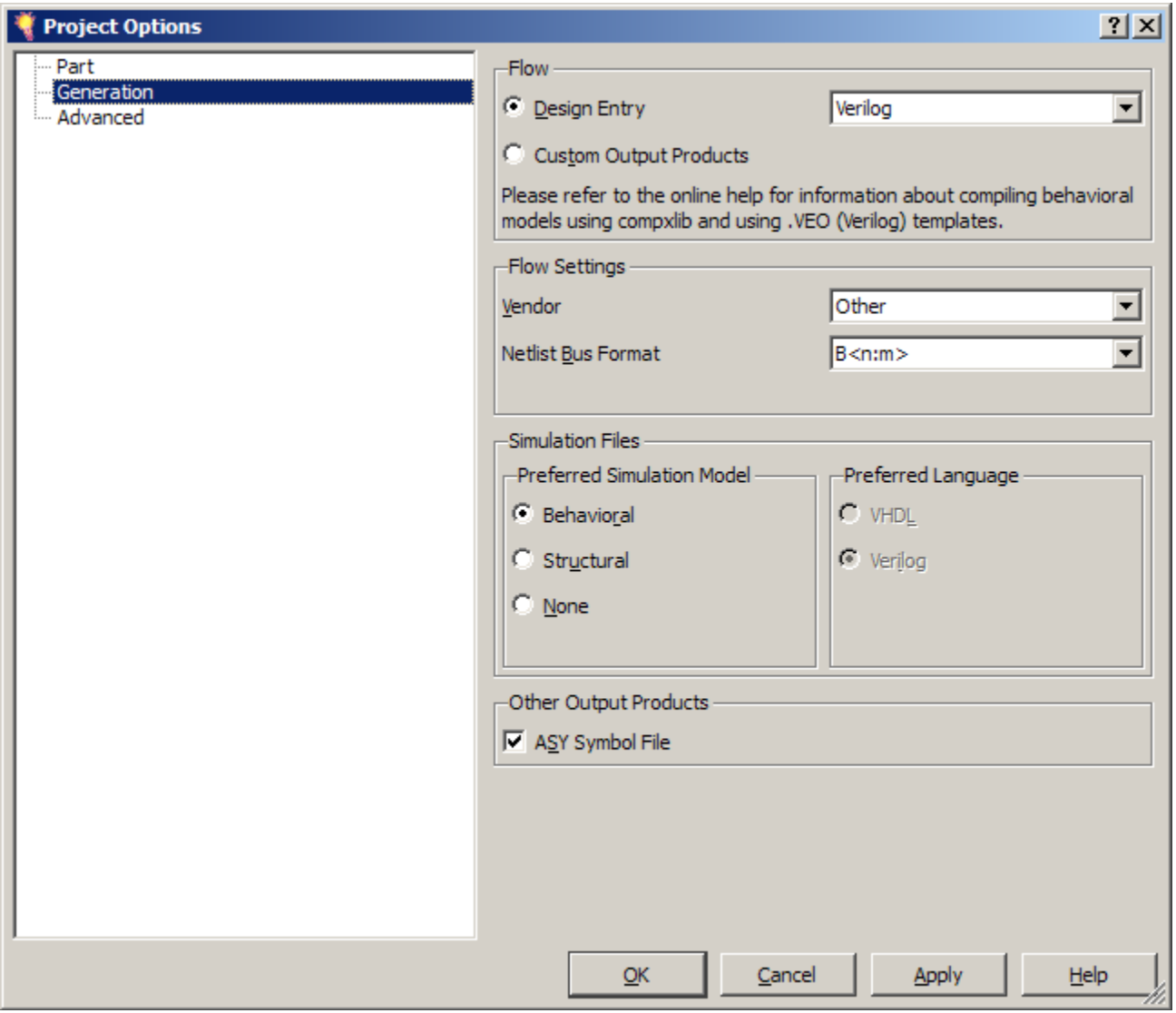
Generate MIG Example Design



- **Select Part**
- **Set the Part (as shipped on the ML605):**
  - Family: Virtex6
  - Device: xc6vlx240t
  - Package: ff1156
  - Speed Grade: -1
- **Select Generation**

Note: Presentation applies to the ML605

Generate MIG Example Design

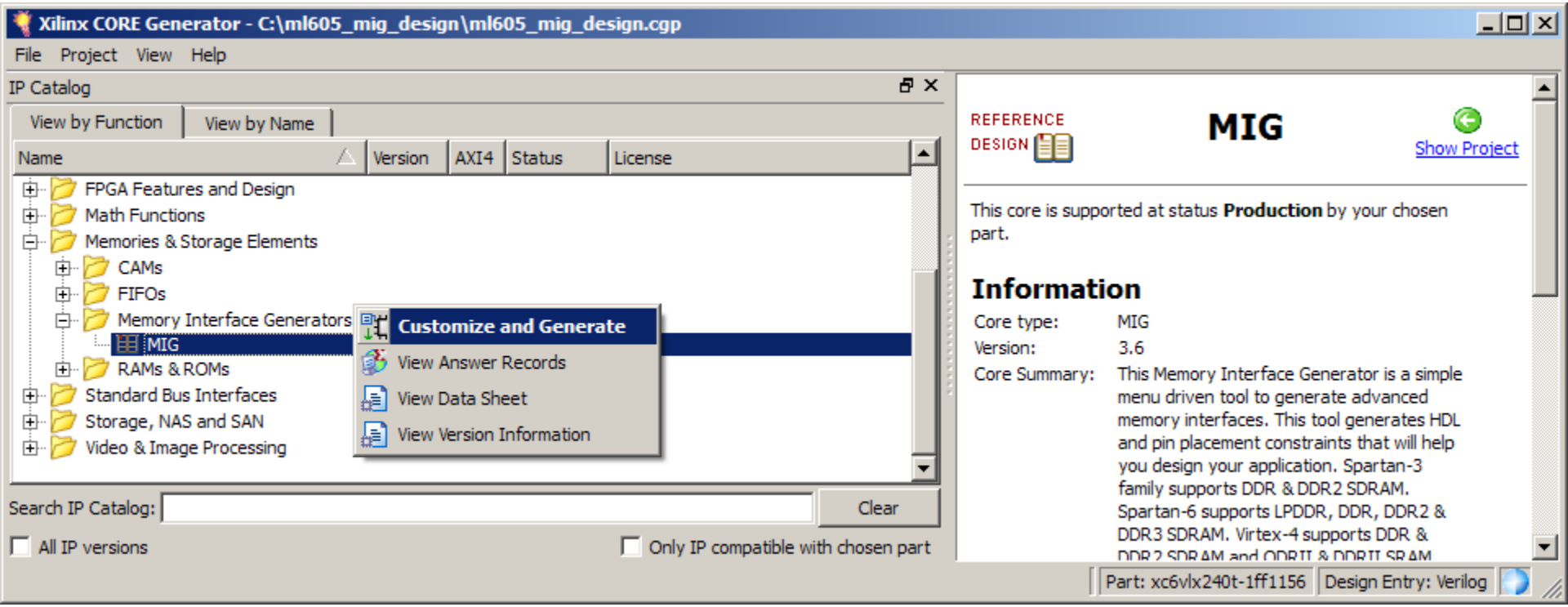


- **Under Generation**
  - Set the Design Entry to Verilog
- **Click OK**

Note: Presentation applies to the ML605

Generate MIG Example Design

- **Right click on MIG Version 3.6**
  - Select **Customize and Generate**



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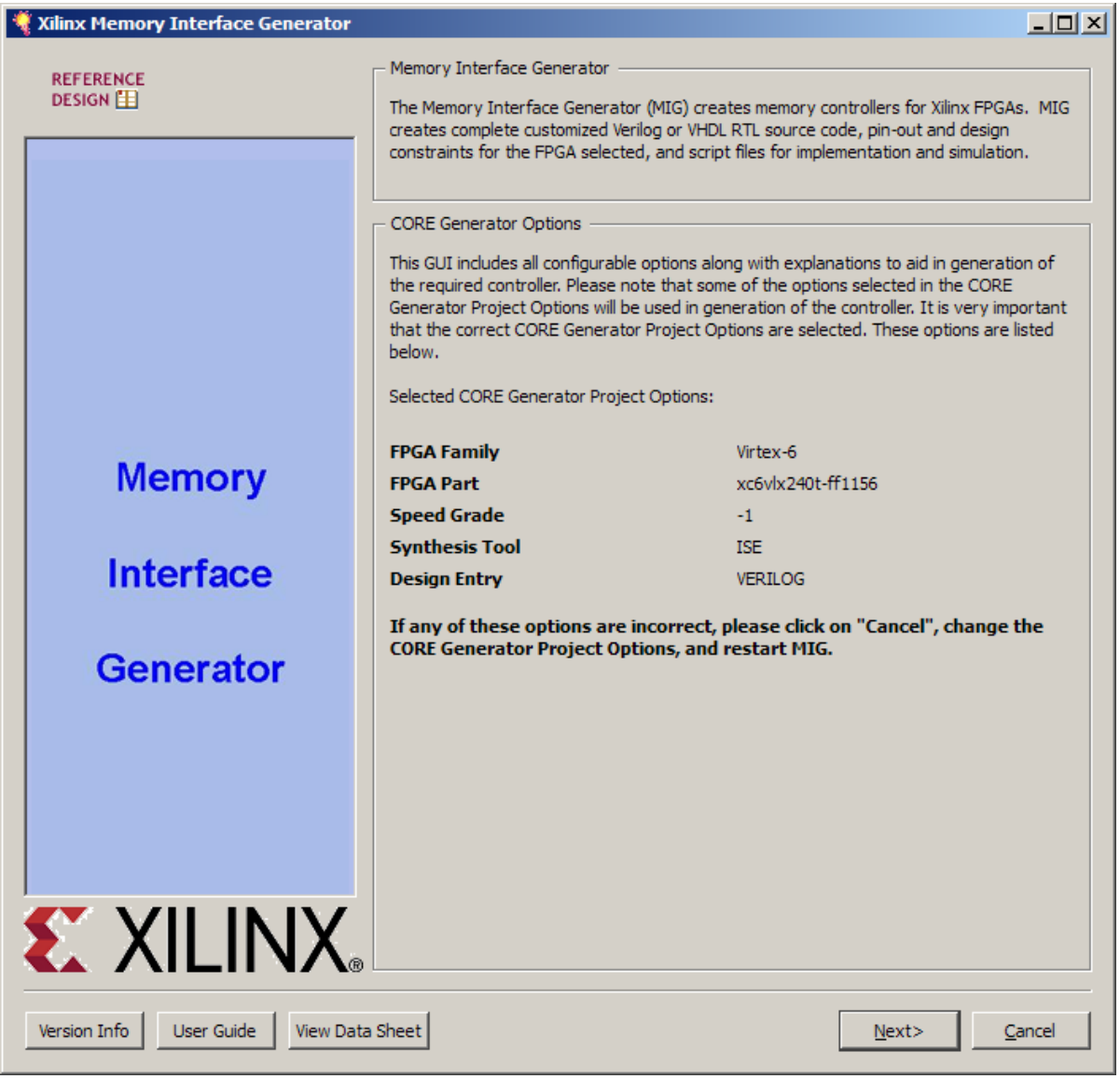
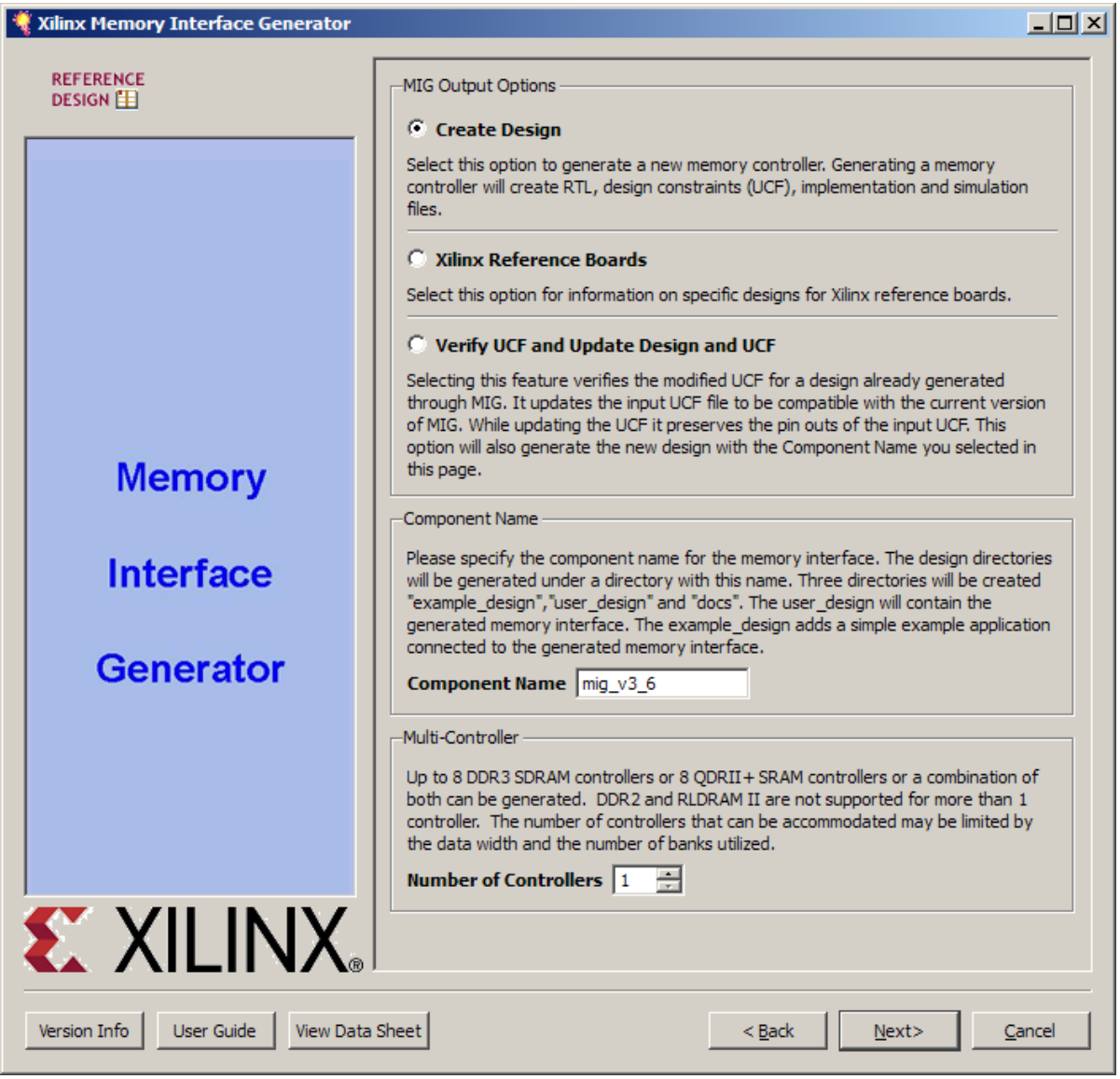
Generate MIG Example Design



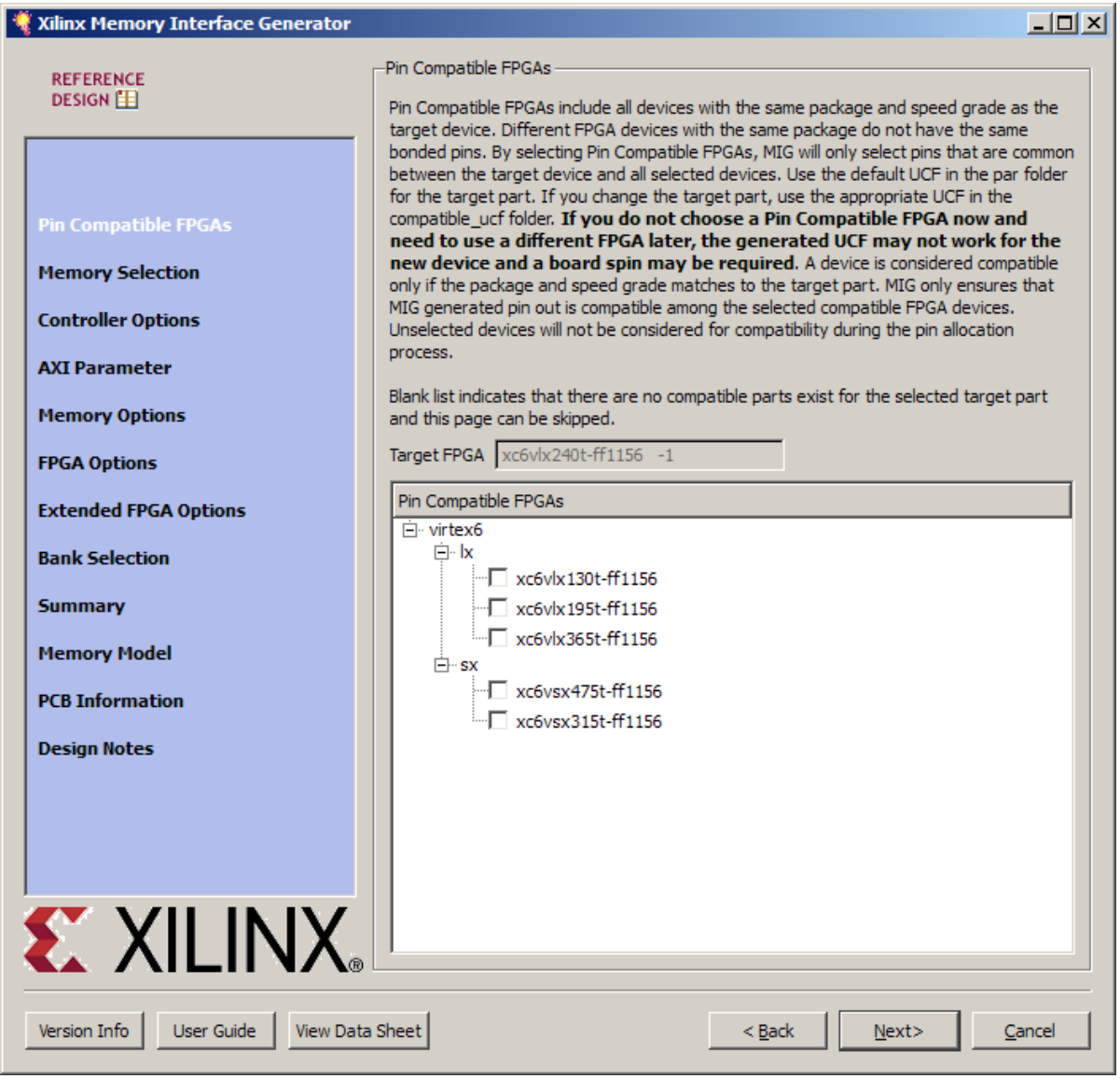
- **Leave this page as is**
  - Click Next

Generate MIG Example Design



- **Leave this page as is**
  - Click Next

Generate MIG Example Design

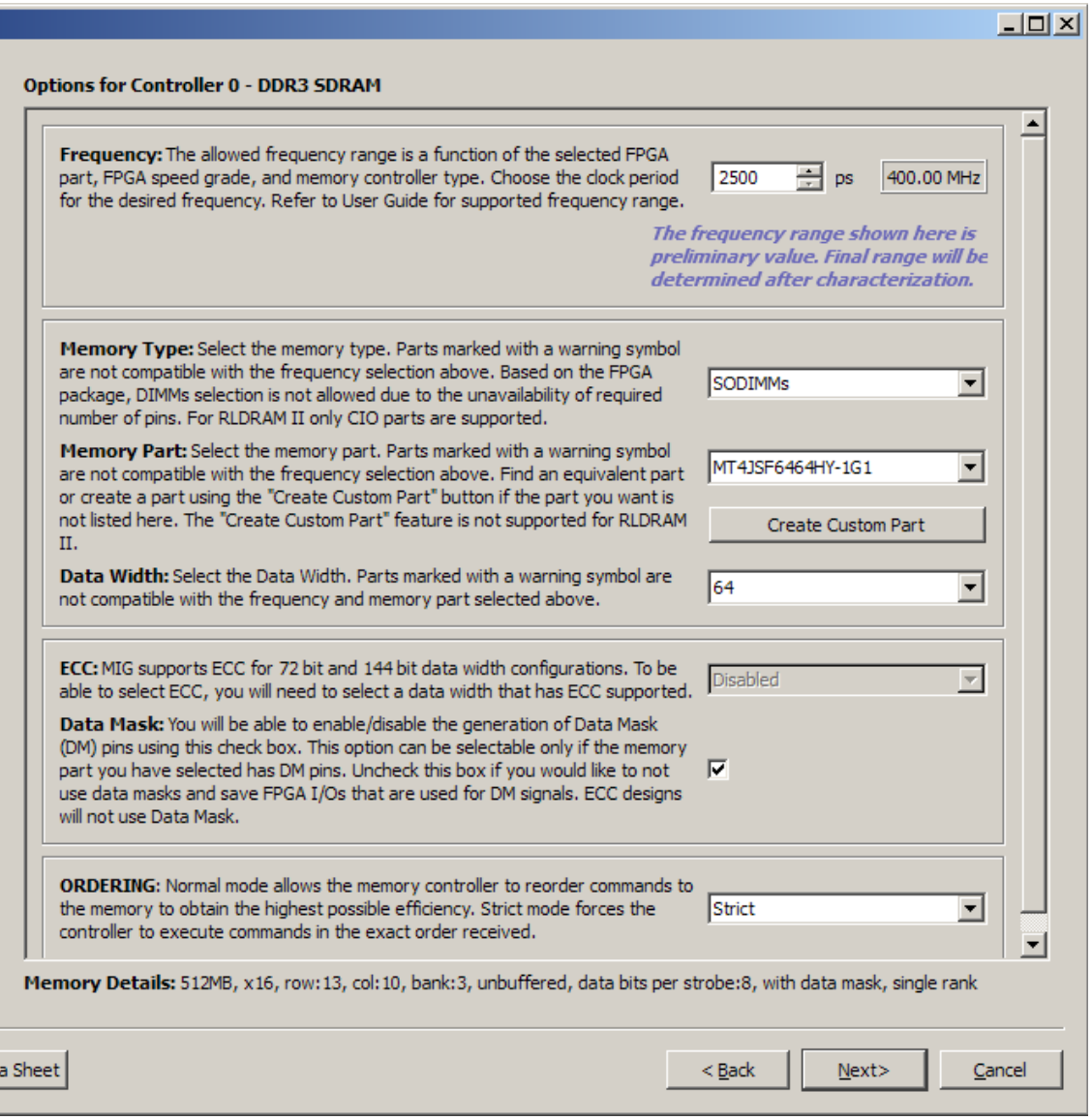


- **Leave this page as is**
  - Click Next

Generate MIG Example Design

- **Select Memory Type**
  - DDR3 SDRAM
  - Click Next

Generate MIG Example Design



- **Select**
  - Type: SODIMMs
  - Part: MT4JSF6464HY-1G1
  - Ordering: Strict

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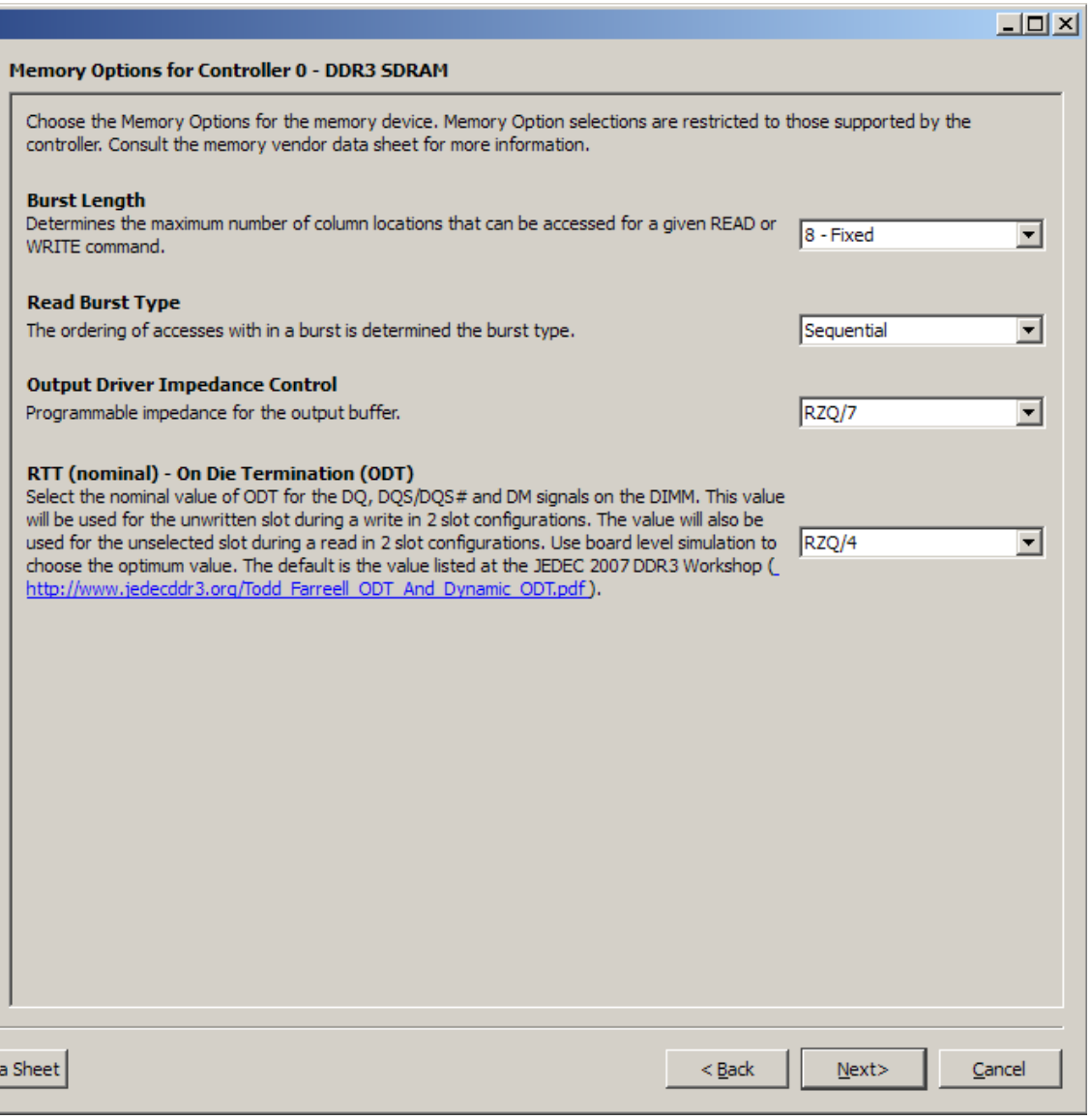
Generate MIG Example Design



- **Leave this page as is**
  - Click Next

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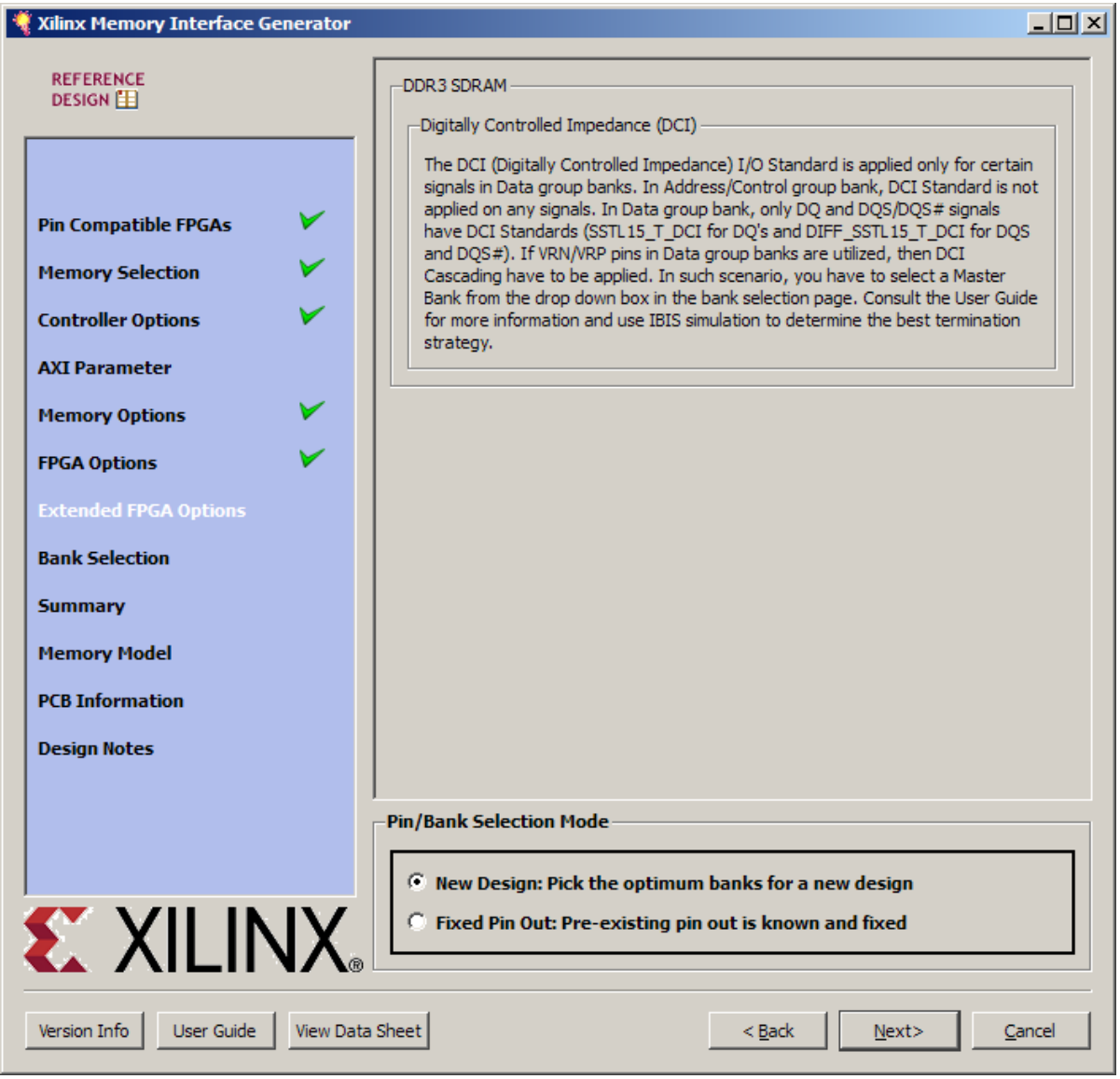
Generate MIG Example Design

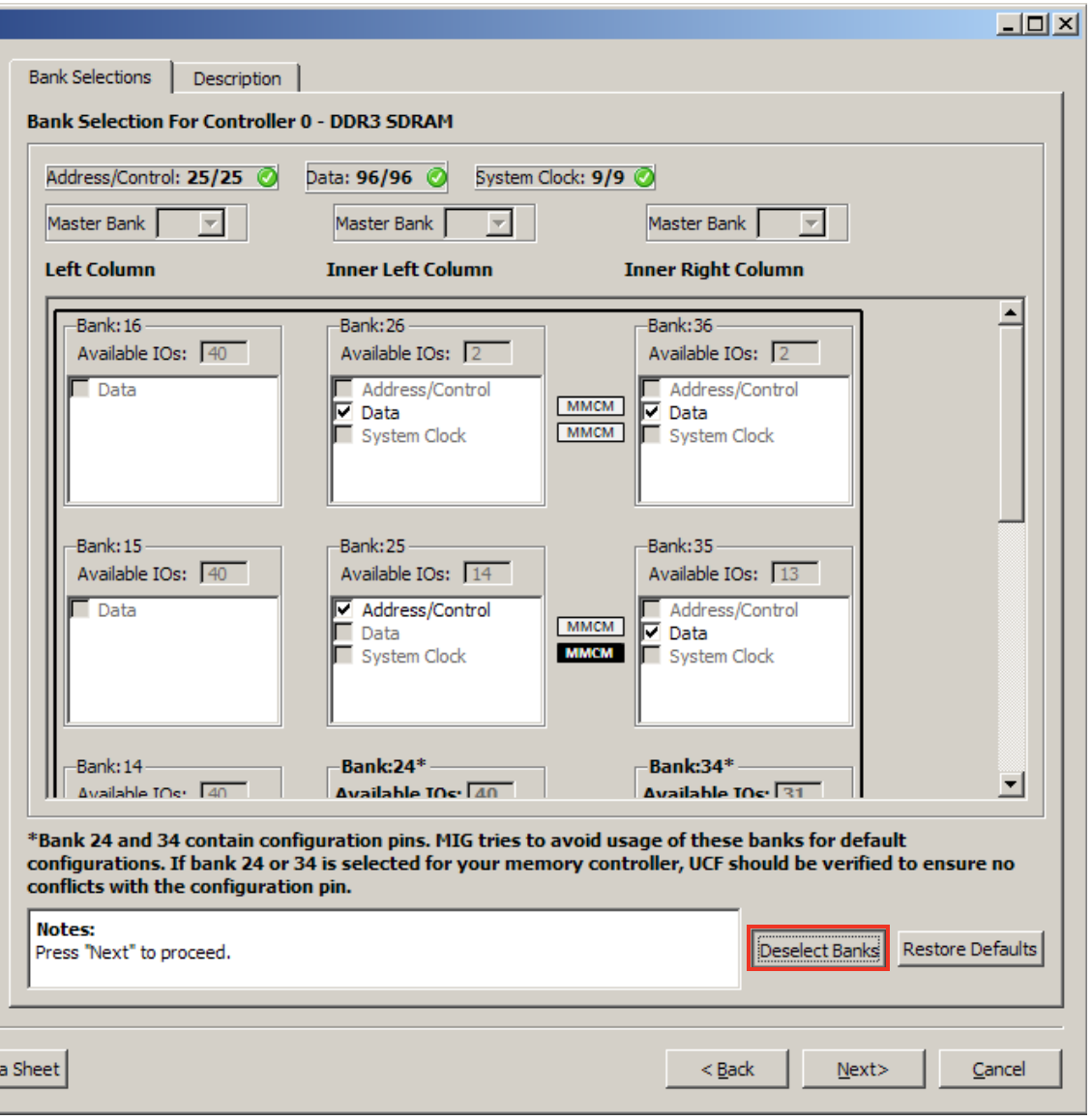
- **Select**
  - Debug: ON

Generate MIG Example Design



- **Select New Design**
  - Click Next

Generate MIG Example Design



- On this screen select the banks as used on the ML605 SODIMM interface
- Click Deselect Banks

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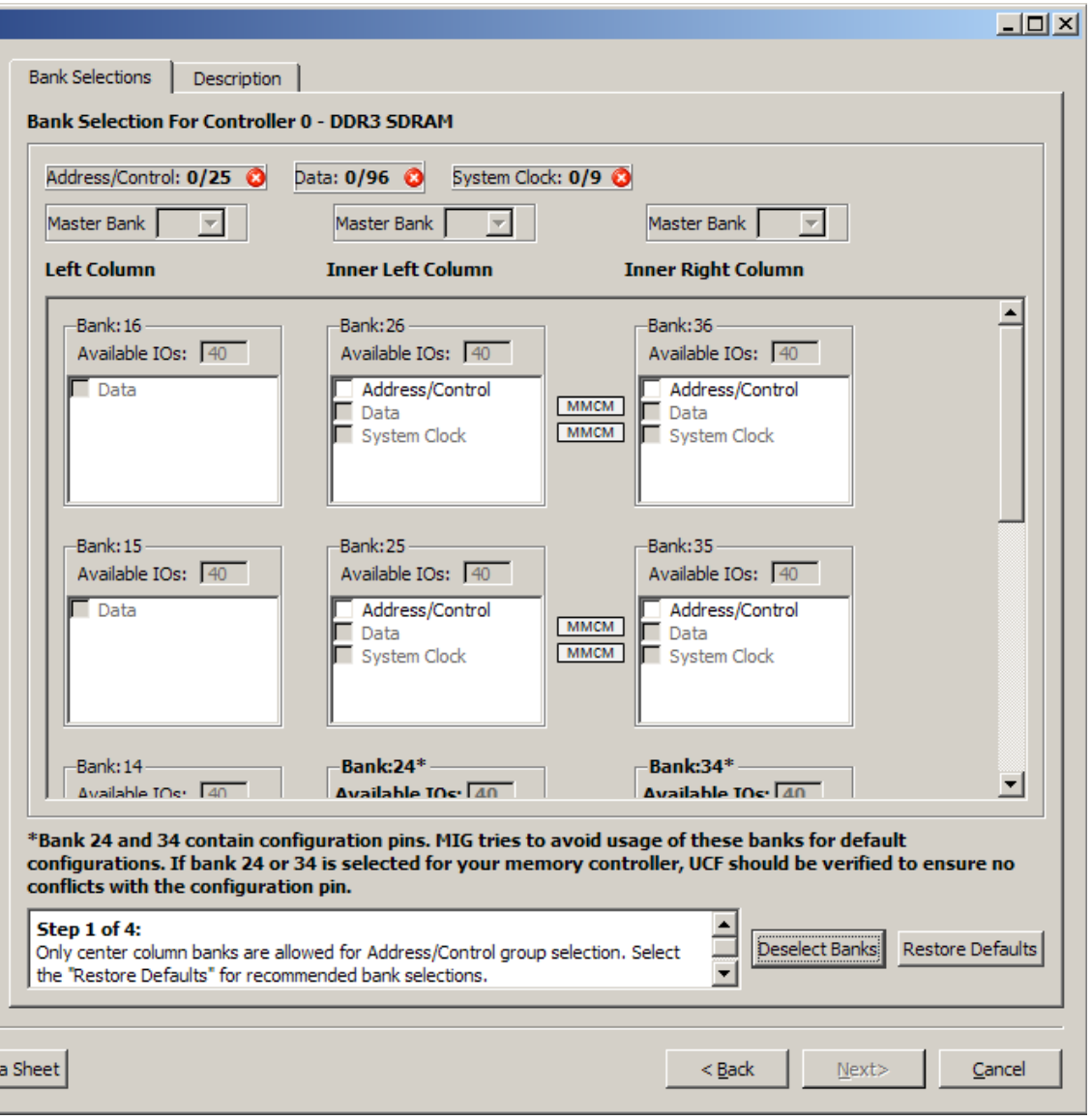
Generate MIG Example Design



- All Banks Deselected

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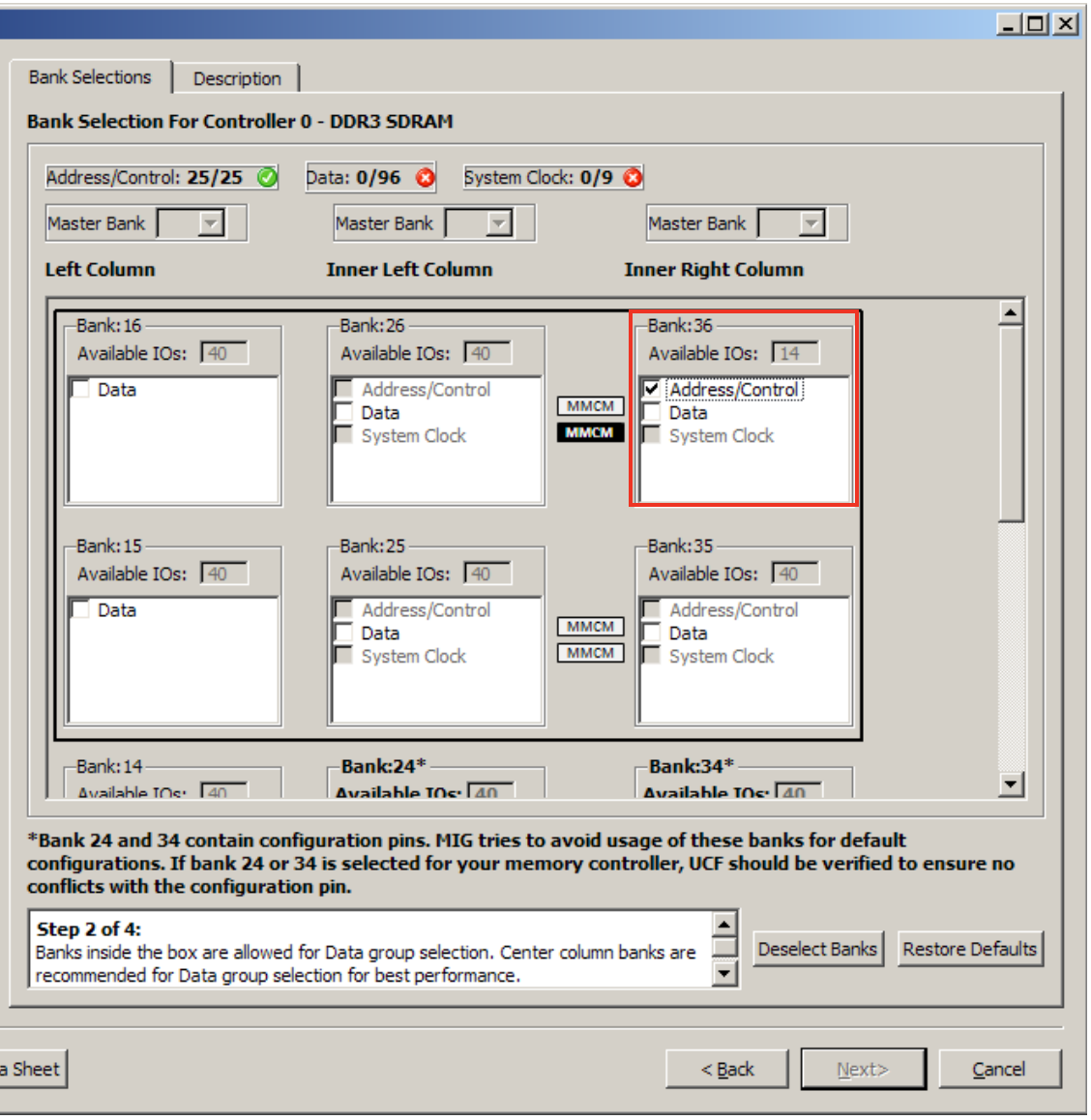
Generate MIG Example Design



- **Select**
  - Bank 36: Address/Control

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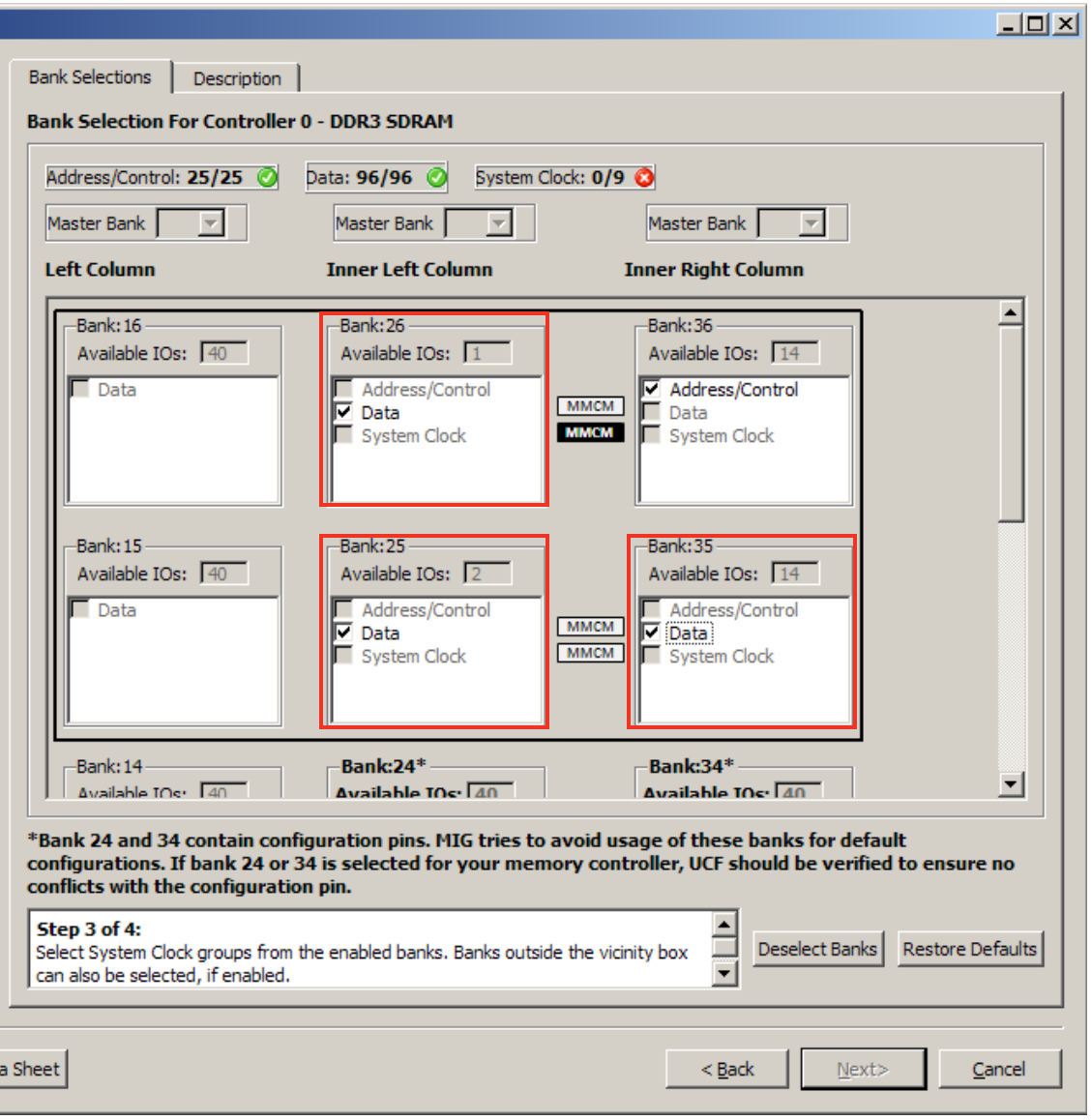
Generate MIG Example Design



- **Select**
  - Bank 26: Data
  - Bank 25: Data
  - Bank 35: Data

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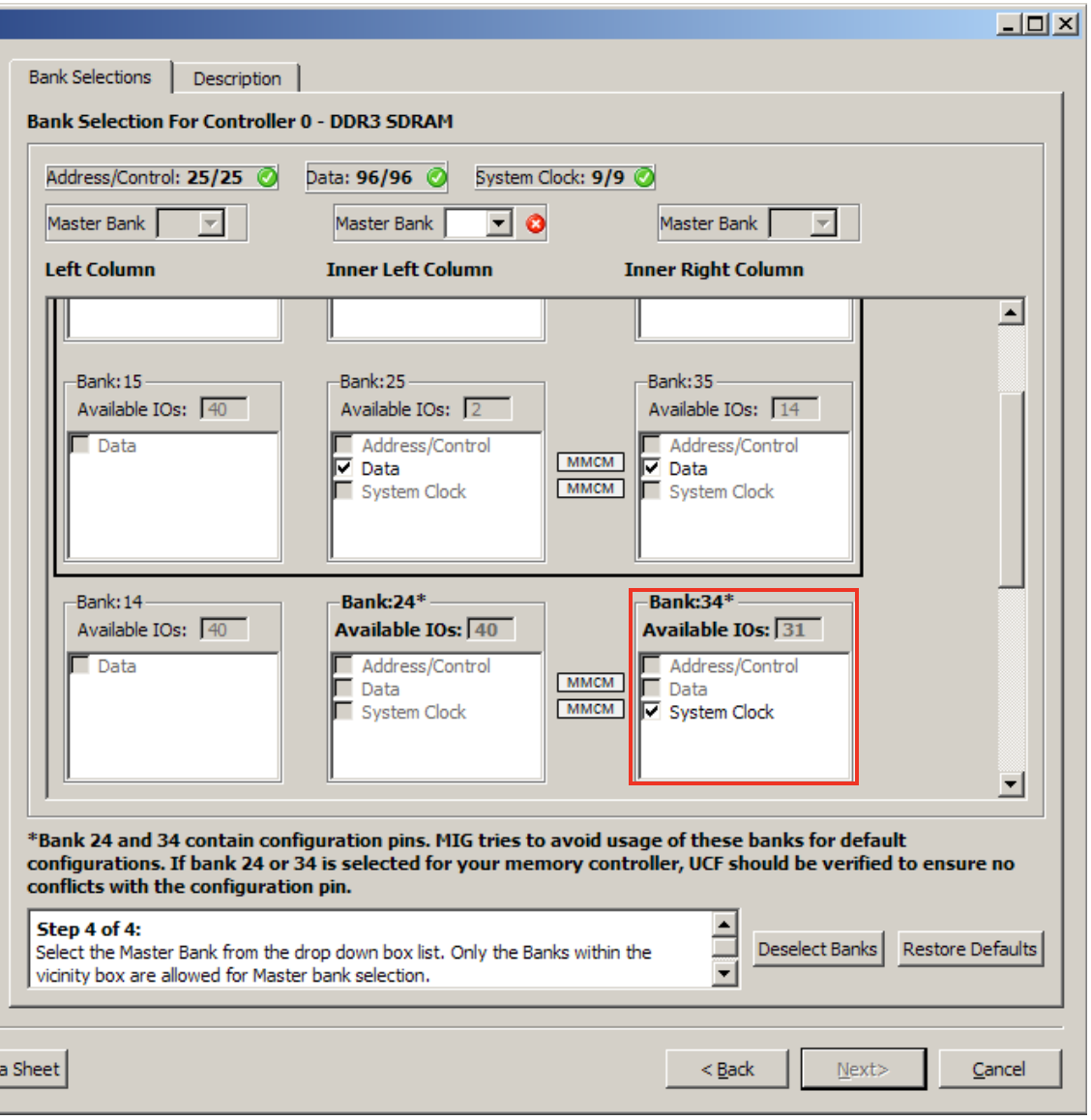
Generate MIG Example Design



- **Select**
  - Bank 34: System Clock

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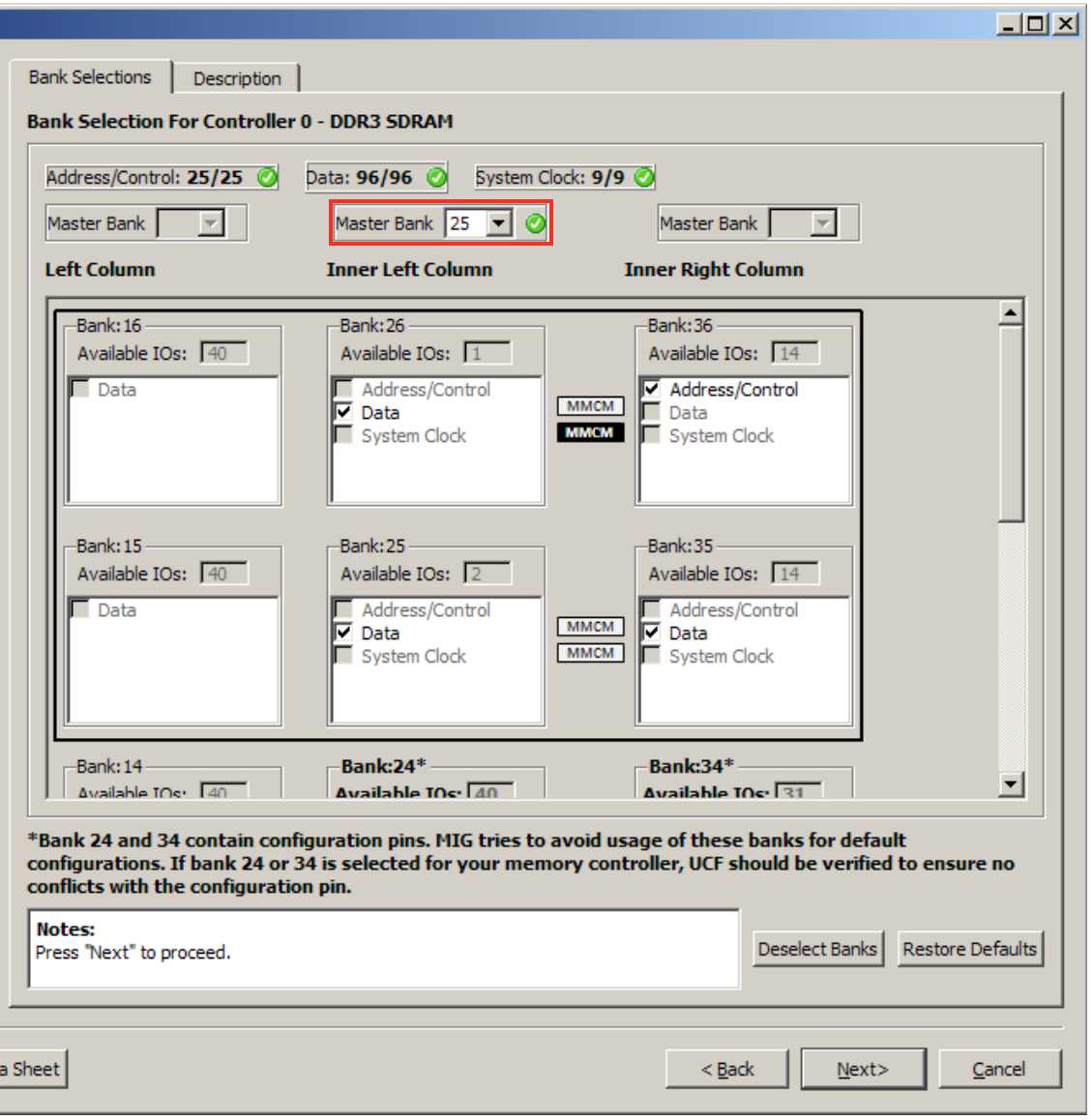
Generate MIG Example Design



- **Select**
  - Master Bank: 25
  - Click Next

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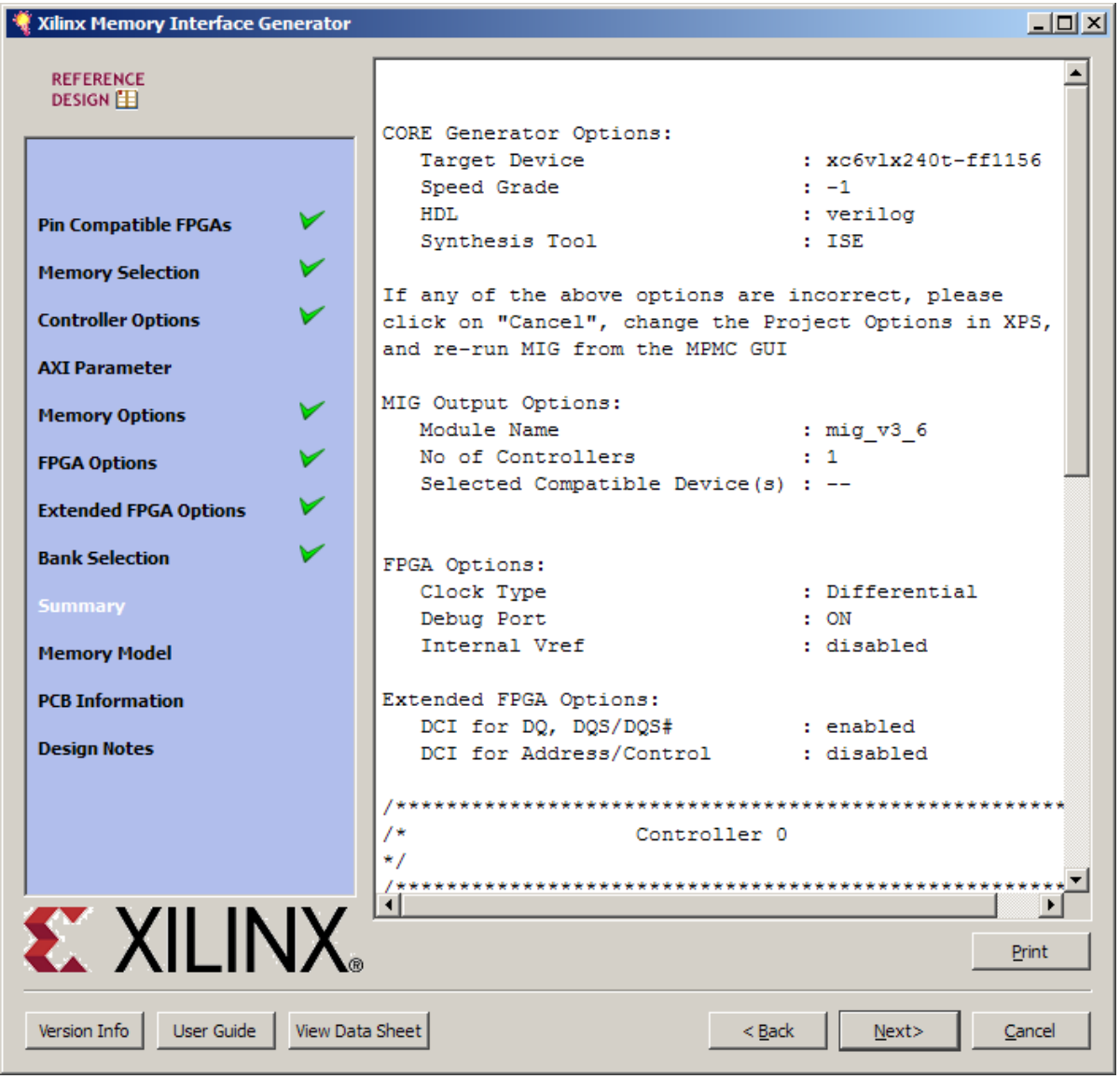
Generate MIG Example Design



- **Leave this page as is**
  - Click Next

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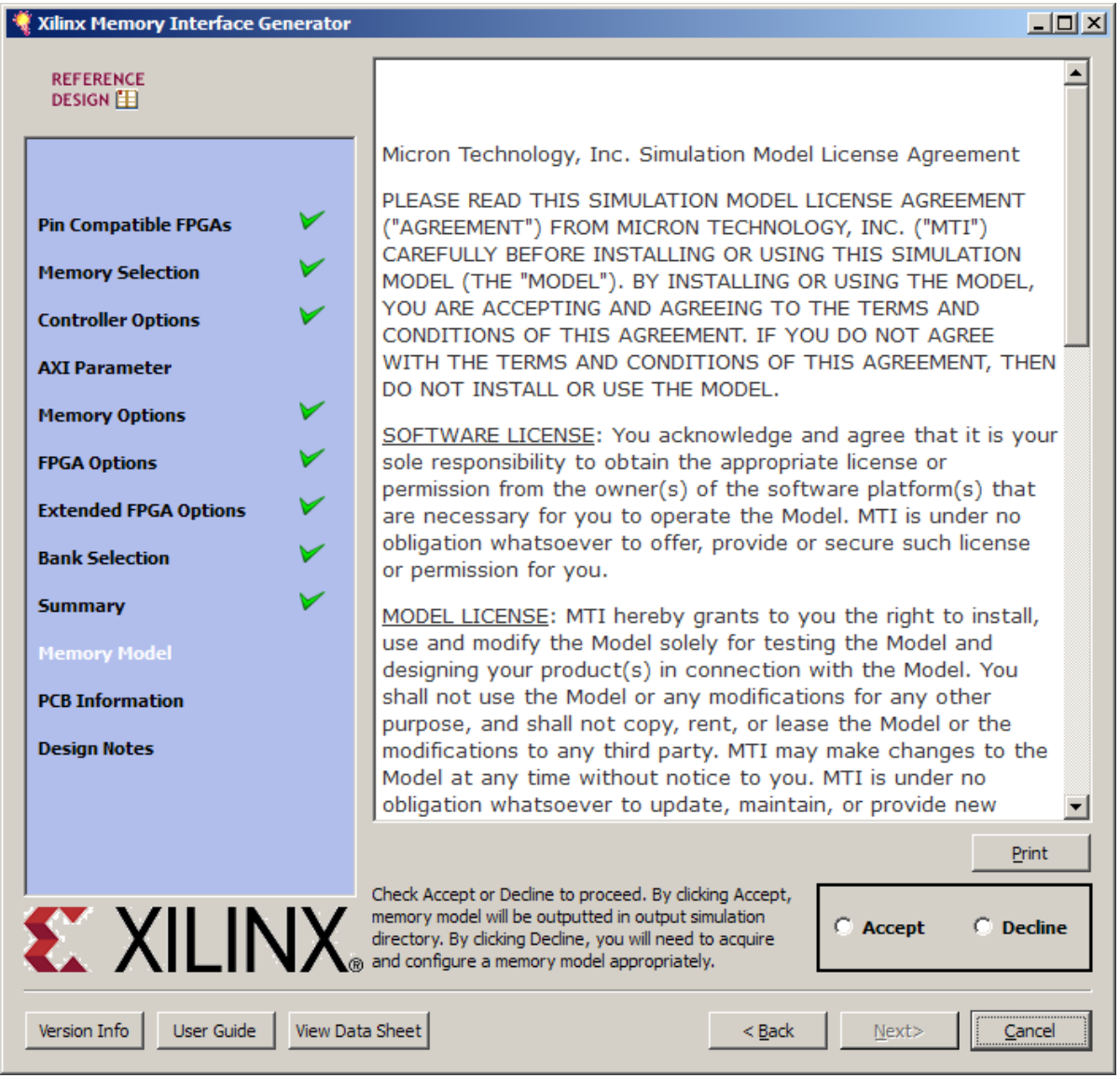
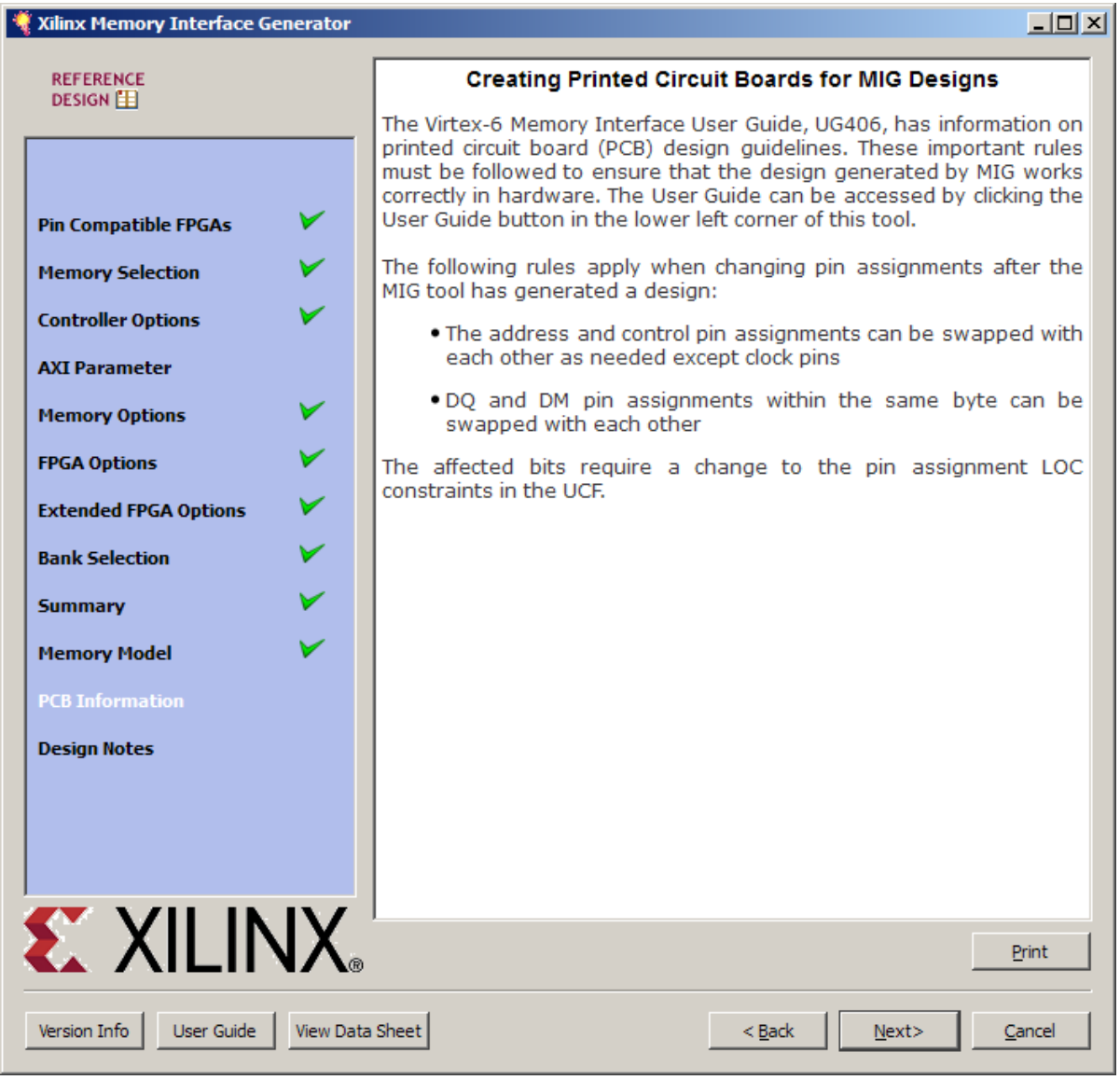
Generate MIG Example Design



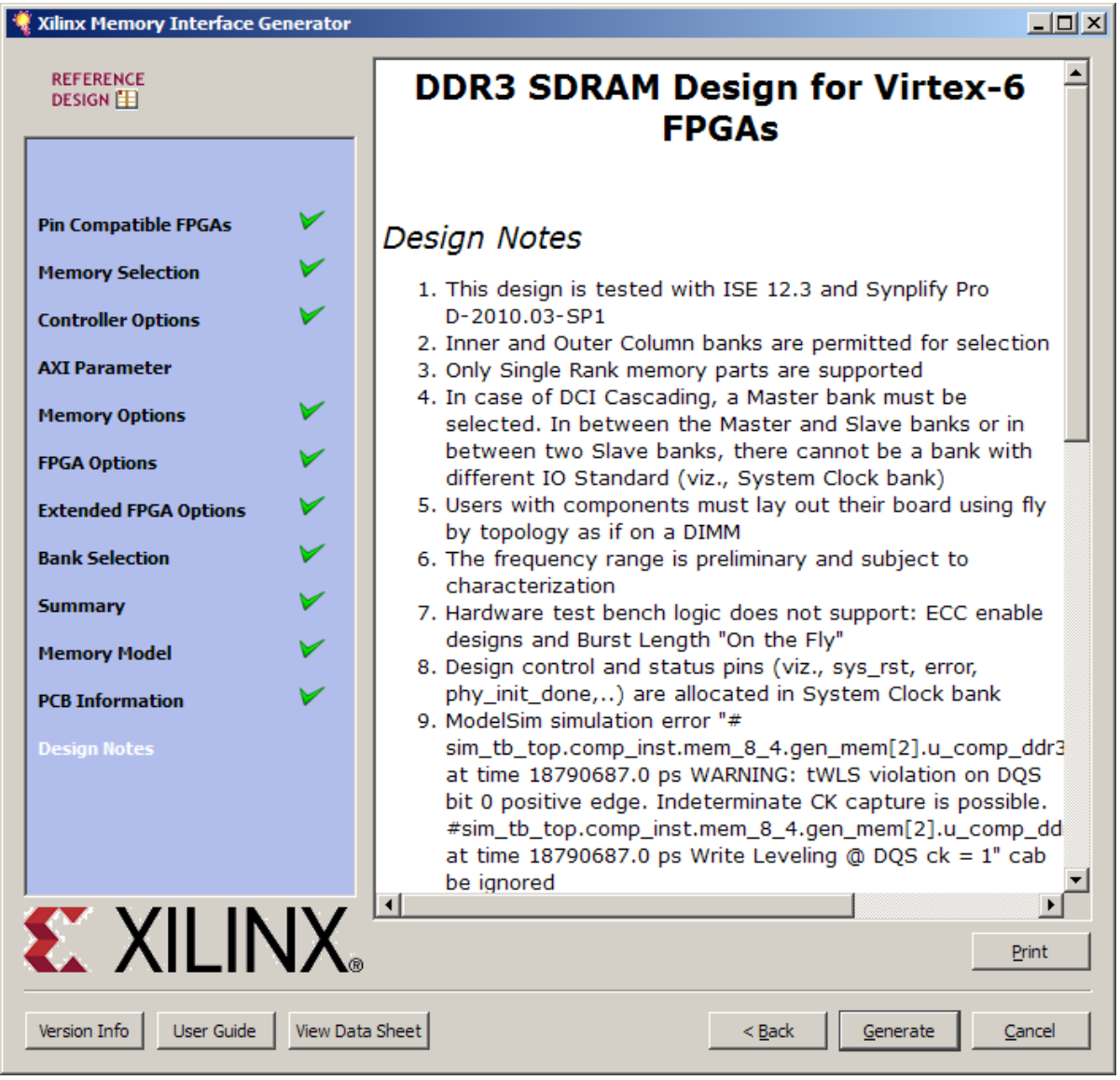
- **Accept Simulation license, if desired**
  - Otherwise, Decline license
  - Click Next

Generate MIG Example Design



- **Leave this page as is**
  - Click Next

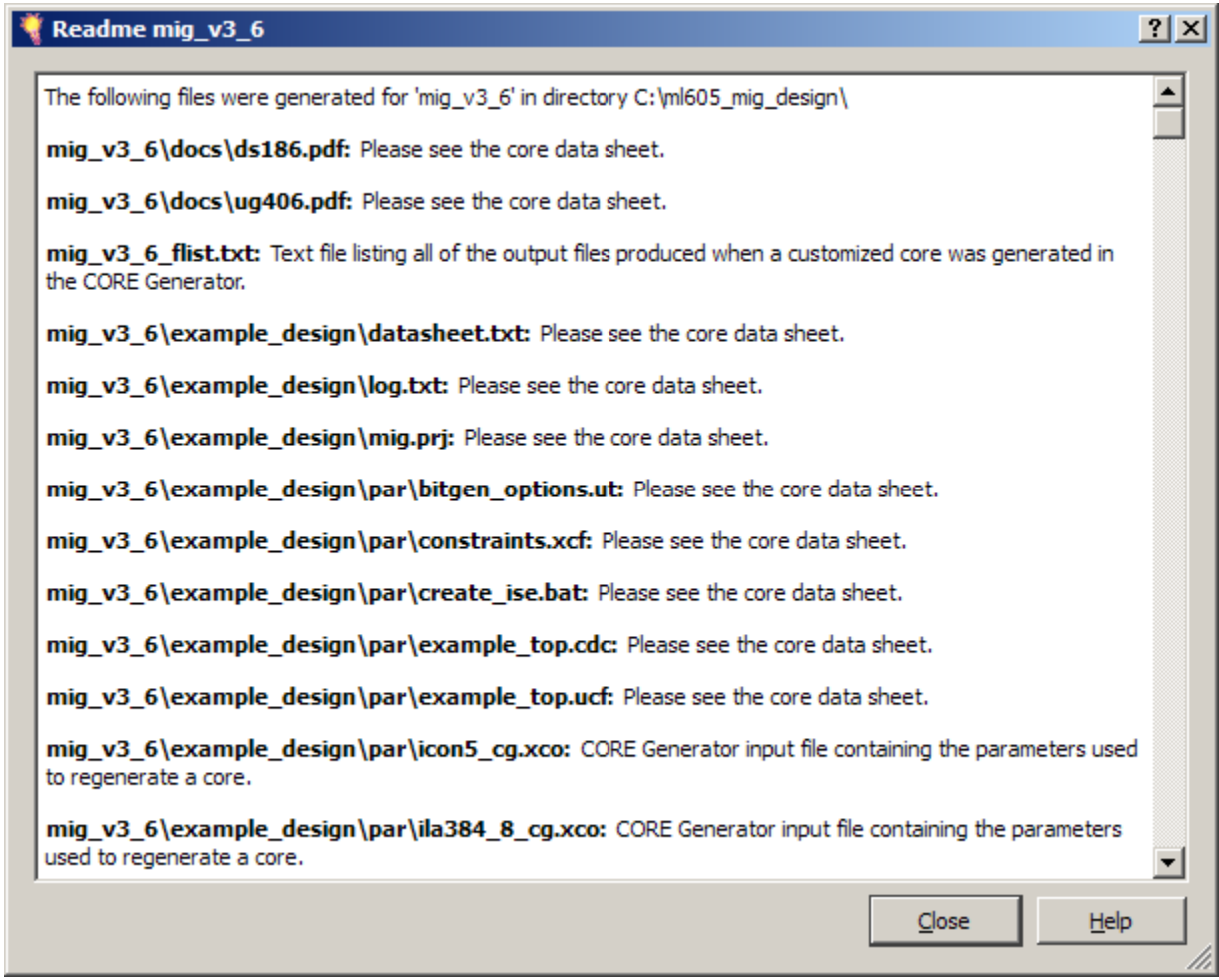
Generate MIG Example Design



- Click Generate

Generate MIG Example Design

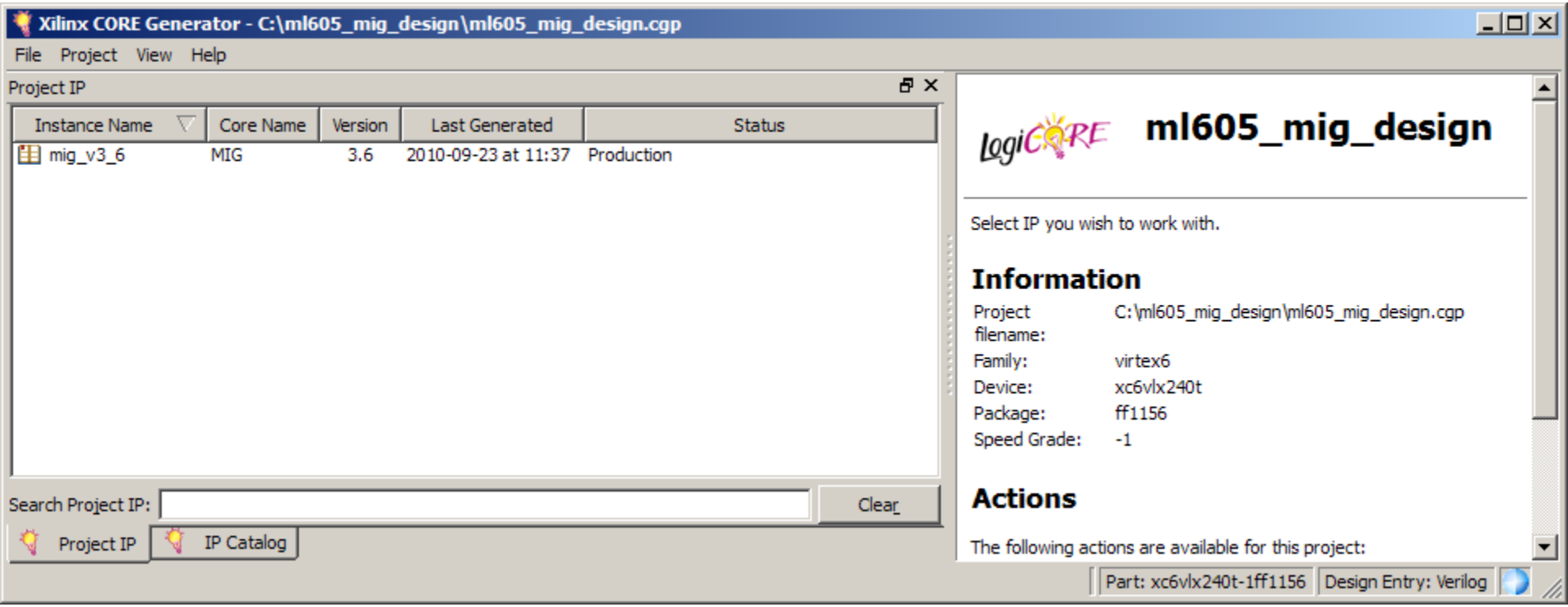
- **After the MIG core finishes generating, click Close on the Datasheet window**



Note: Presentation applies to the ML605

Generate MIG Example Design

- MIG design appears in Project IP



Note: Presentation applies to the ML605

Modifications to Example Design

- **RDF0011.zip includes**
  - ChipScope Project File, UCF, and Verilog Files
- **Modifications to RTL Files for ML605 Example Design**
  - Changed design to support a single 200 MHz LVDS clock input
  - Added Debug display code to drive LEDs
  - Added ChipScope ILA and VIO port assignments for ML605 board debug
  - Removed IIC Signals – sda, scl
  - Changed various parameter to match the ML605 board
    - DIVCLK_DIVIDE = 1 (was 2)
    - nDQS_COLx
    - DQS_LOC_COLx
    - RST_ACT_LOW = 0 (was 1)

Note: Presentation applies to the ML605

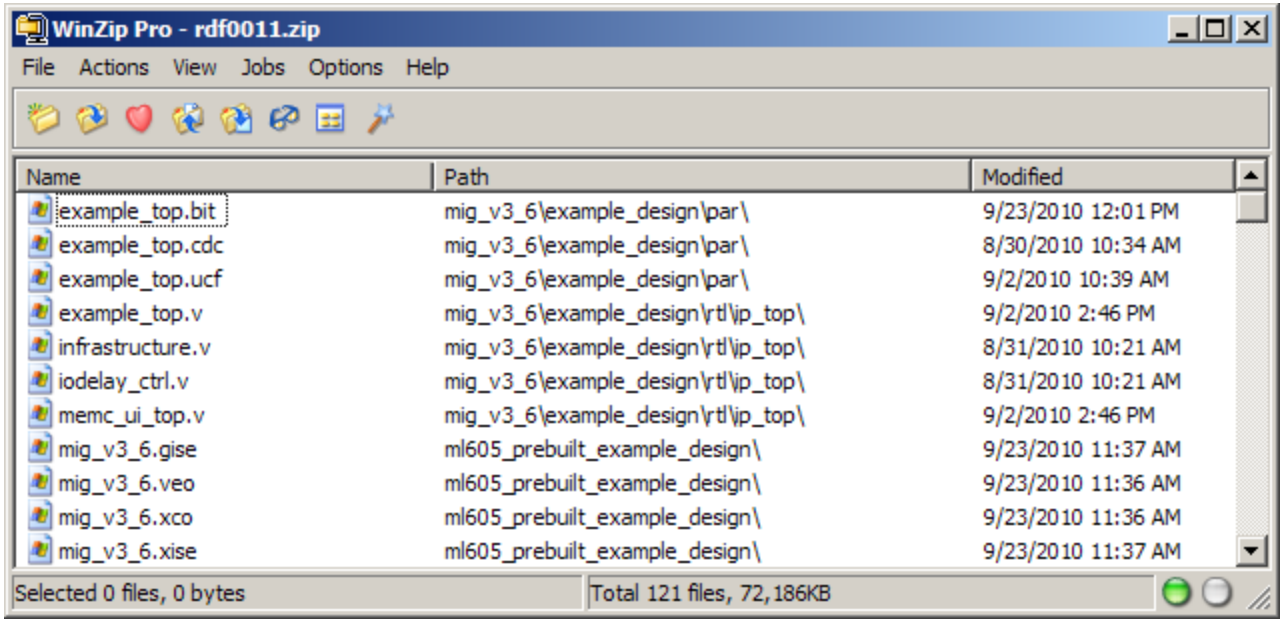
Modifications to Example Design

- **Updates to UCF file specifically required for ML605 board:**
  - Updated IO Locations to match ML605
  - Remove IIC Signals – sda, scl
  - Merged Default two clocks into one clock for ML605
  - Moved sys_reset to CPU_RESET
  - Edited DCI_CASCADE to match ML605
  - Removed CONFIG_PROHIBIT lines
  - Added LOC for GPIO LED signals (2.5V bank voltage)
  - Added LOCs for RSYNC OSERDES and IODELAY

Note: Presentation applies to the ML605

Modifications to Example Design

- **Unzip the rdf0011.zip file to your C:\ml605_mig_design directory**
  - Available through http://www.xilinx.com/ml605
  - This adds modifications to the example design (1)
  - A fully pre-built ML605 example design is included in the zip file (2)
    - Use the included bitstream to run MIG with ChipScope
    - Run **ise_flow.bat** in <design directory>\ml605_prebuilt_example_design\mig_v3_6\example_design\par to recompile the pre-built example design



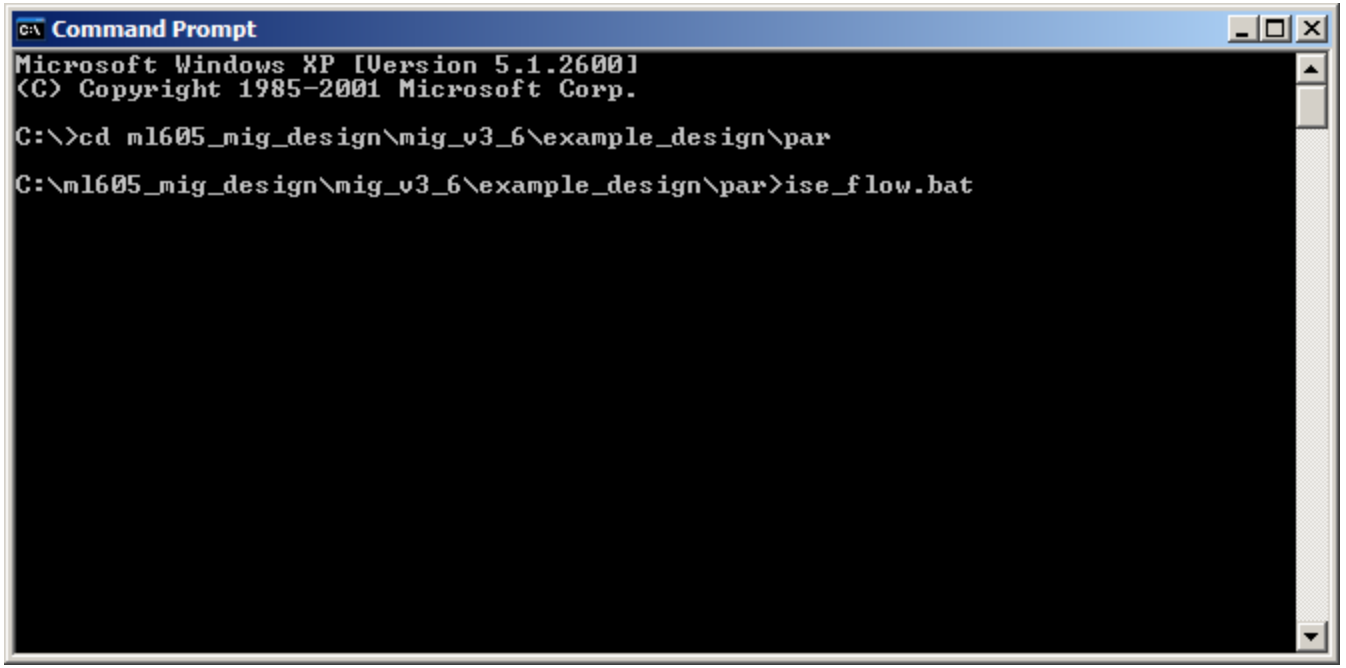
Note: Overwrites Core Generator output files with ML605 specific files

Compile Example Design

- **Start a windows command shell and enter these commands:**

  cd ml605_mig_design\mig_v3_6\example_design\par

  ise_flow.bat



Note: Presentation applies to the ML605

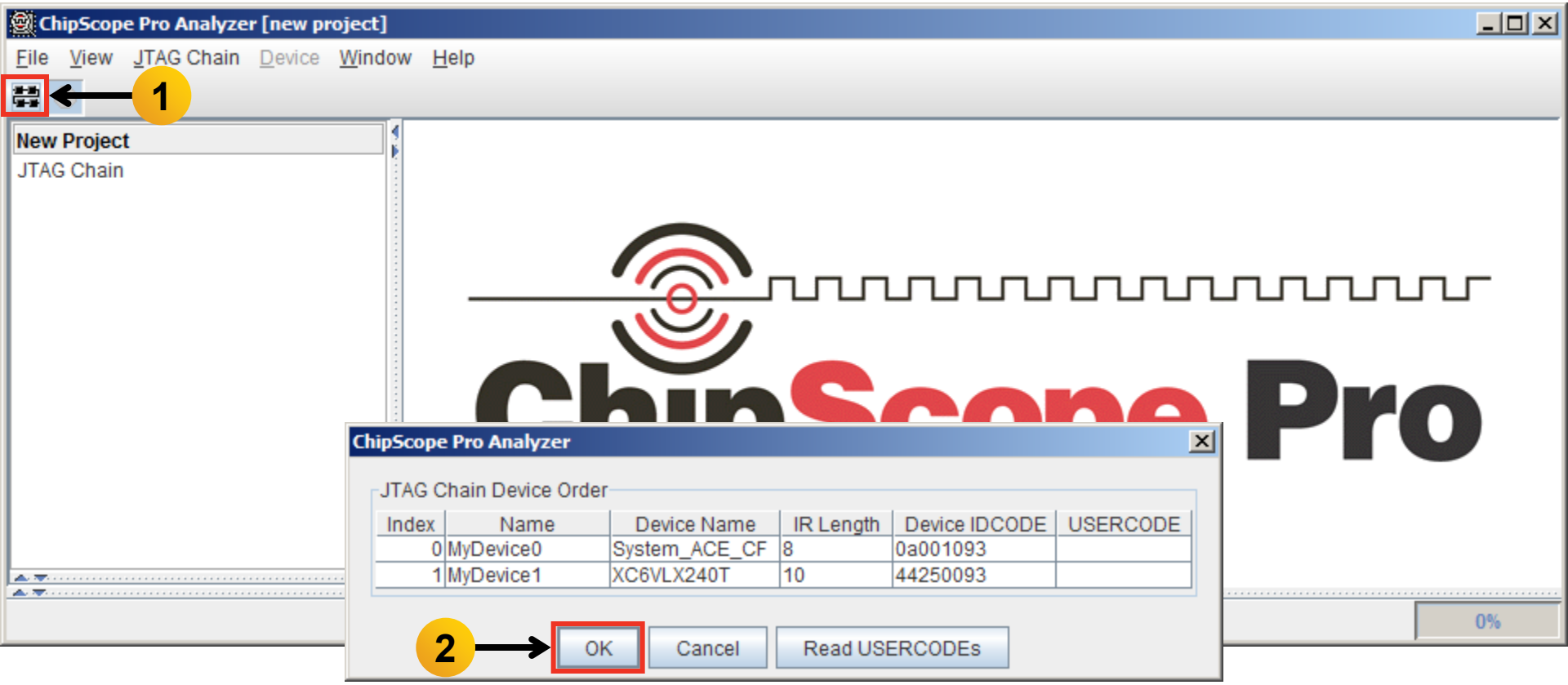
Run MIG Example Design

- **Power on the ML605 board**
- **Connect a USB Type-A to Mini-B cable to the USB JTAG connector on the ML605 board**
  - Connect this cable to your PC

Note: Presentation applies to the ML605

Run MIG Example Design

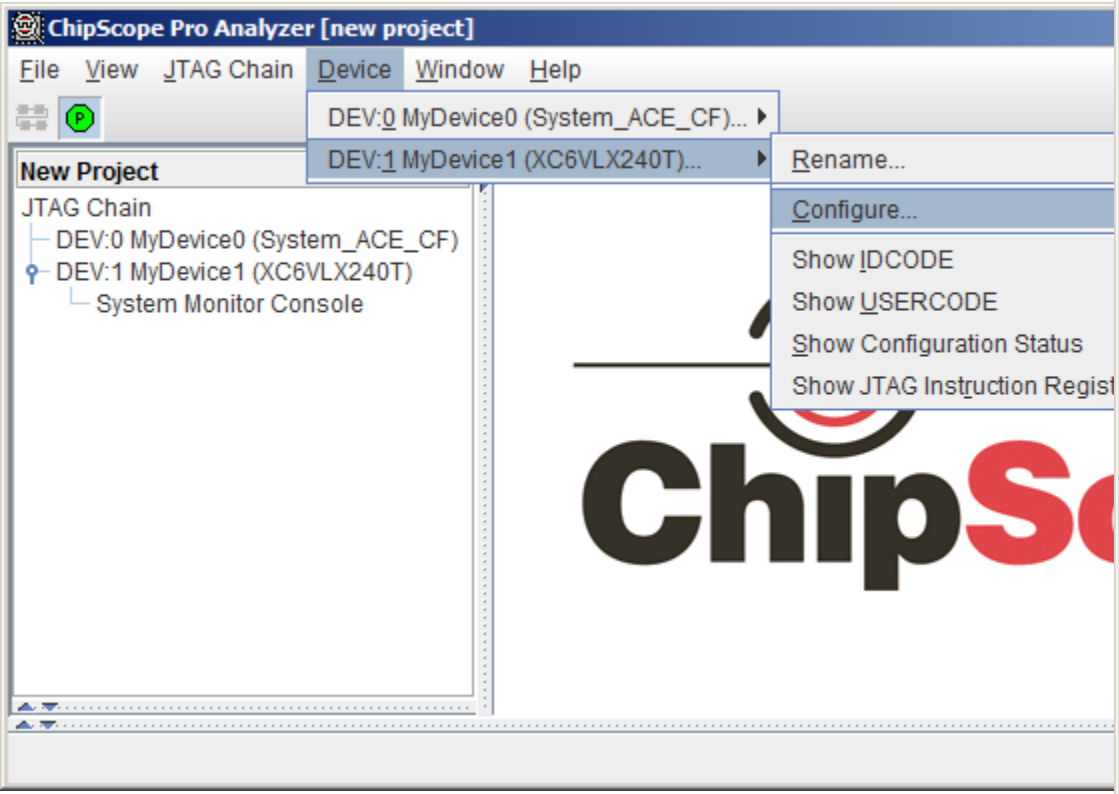
- **After the design compiles, open ChipScope Pro Analyzer**
  - Click on the Open Cable Button (1)
  - Click OK (2)

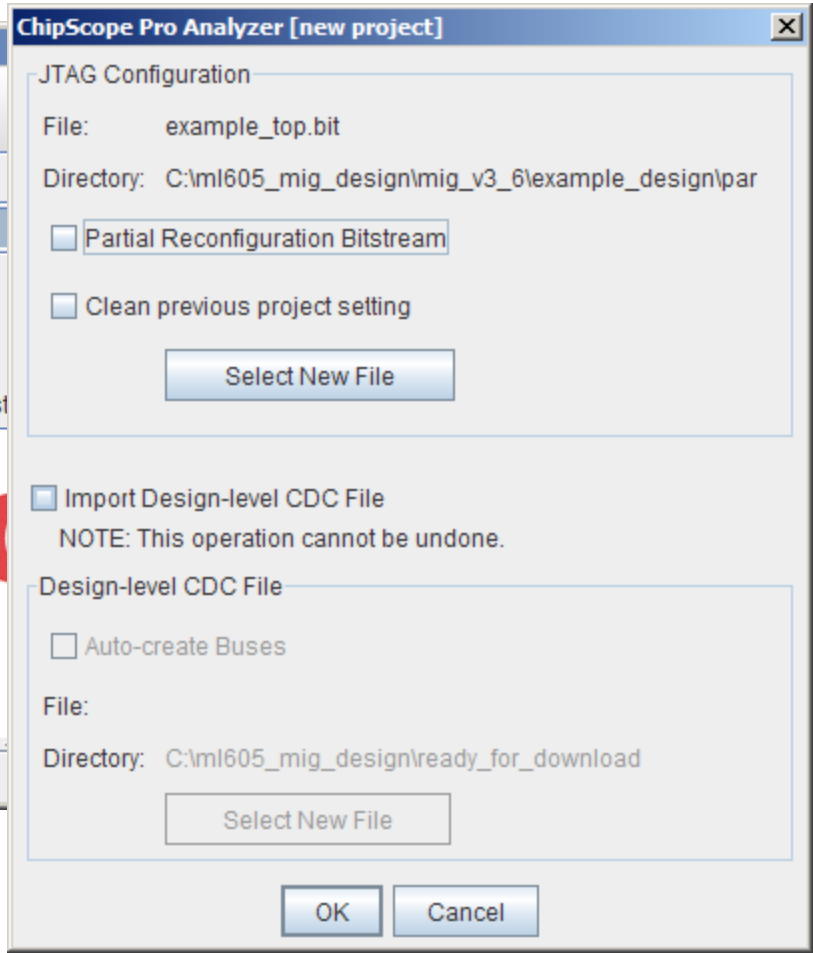


Note: Presentation applies to the ML605

Run MIG Example Design

- Select Device → DEV:0 MyDevice0 (XC6VLX240T) → Configure…
- Select <Design Path>\mig_v3_6\example_design\par\example_top.bit





Note: Presentation applies to the ML605

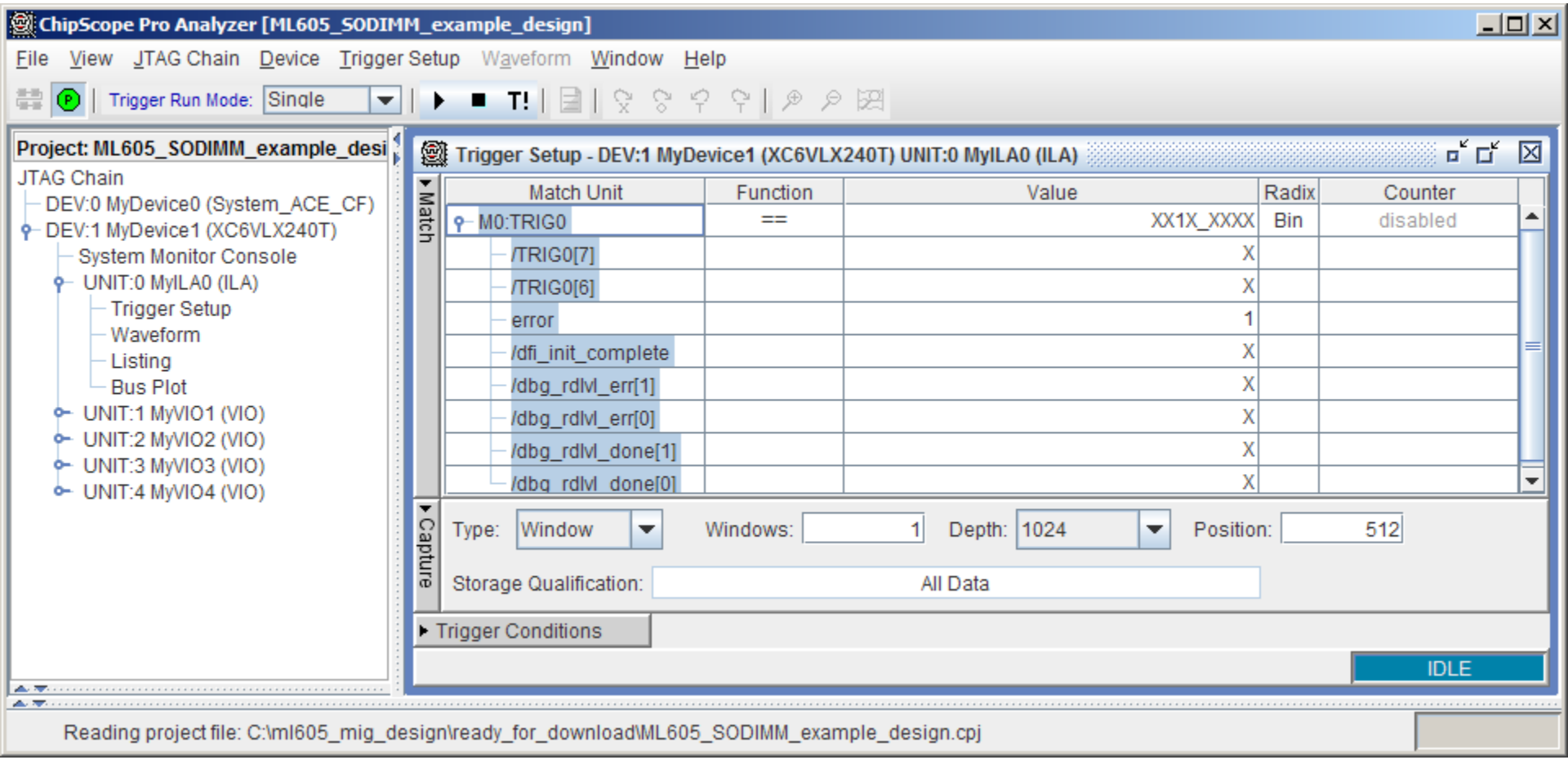
Run MIG Example Design

- Select File → Open Project…
- Select <Design Path>\ready_for_download\ ML605_SODIMM_example_design.cpj

Note: Presentation applies to the ML605

Run MIG Example Design

- Click on Trigger Setup to view trigger settings
- The error bit value should be set to 1



Note: Presentation applies to the ML605

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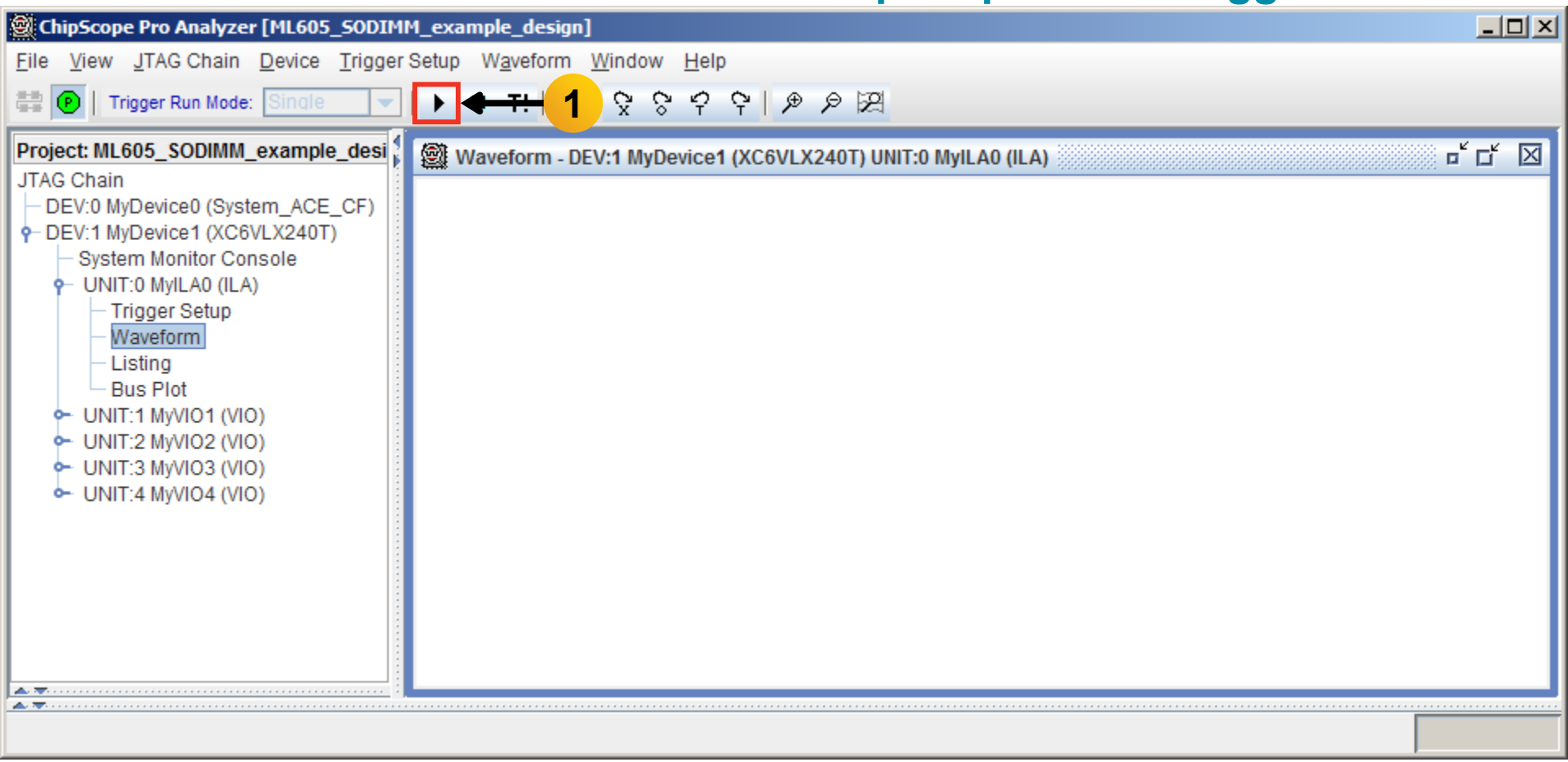
Run MIG Example Design

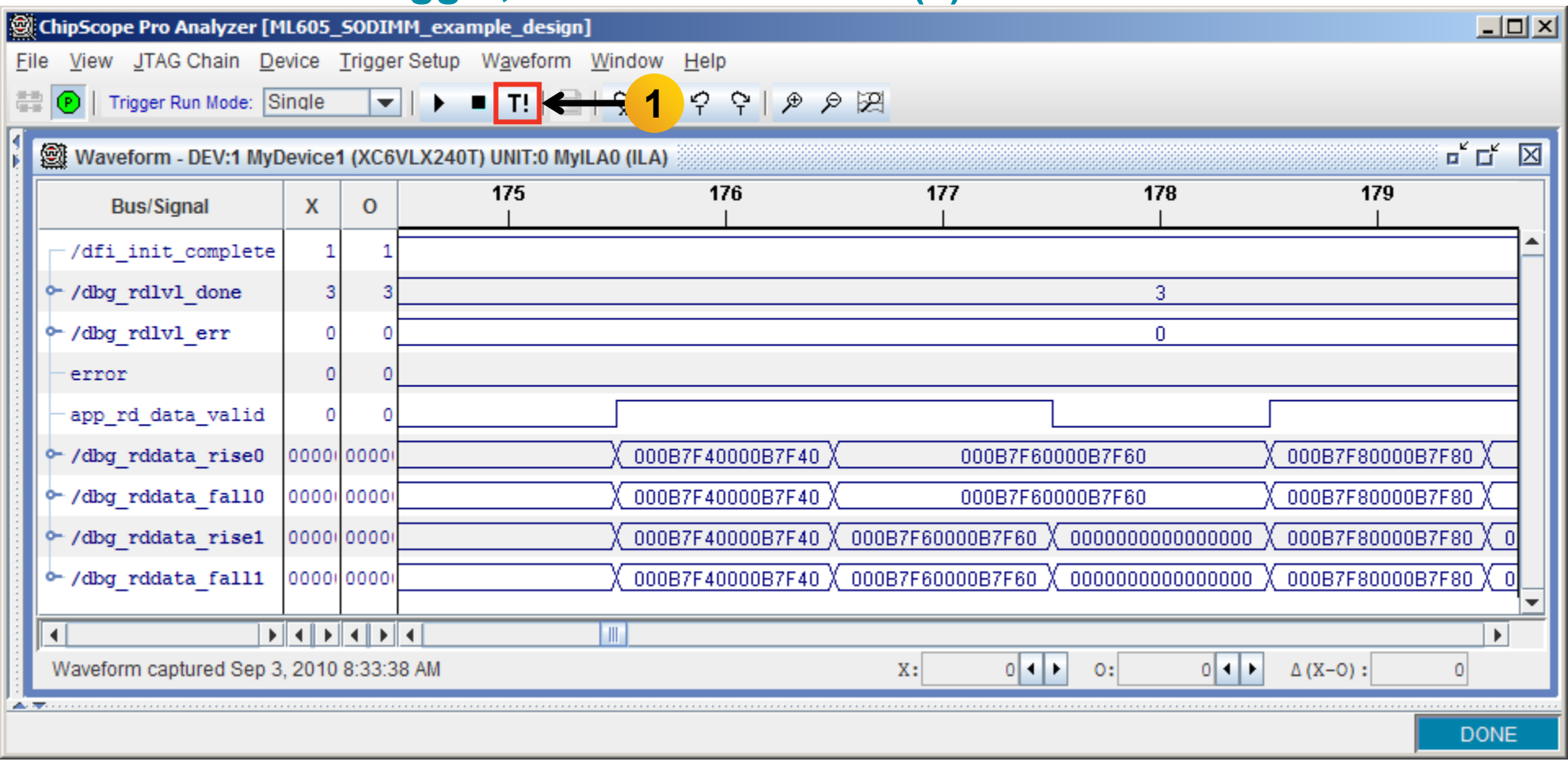
- Click on Waveform; click the Arm Trigger button (1)
- Detection of an error will cause ChipScope Pro to trigger



Note: Presentation applies to the ML605

Run MIG Example Design

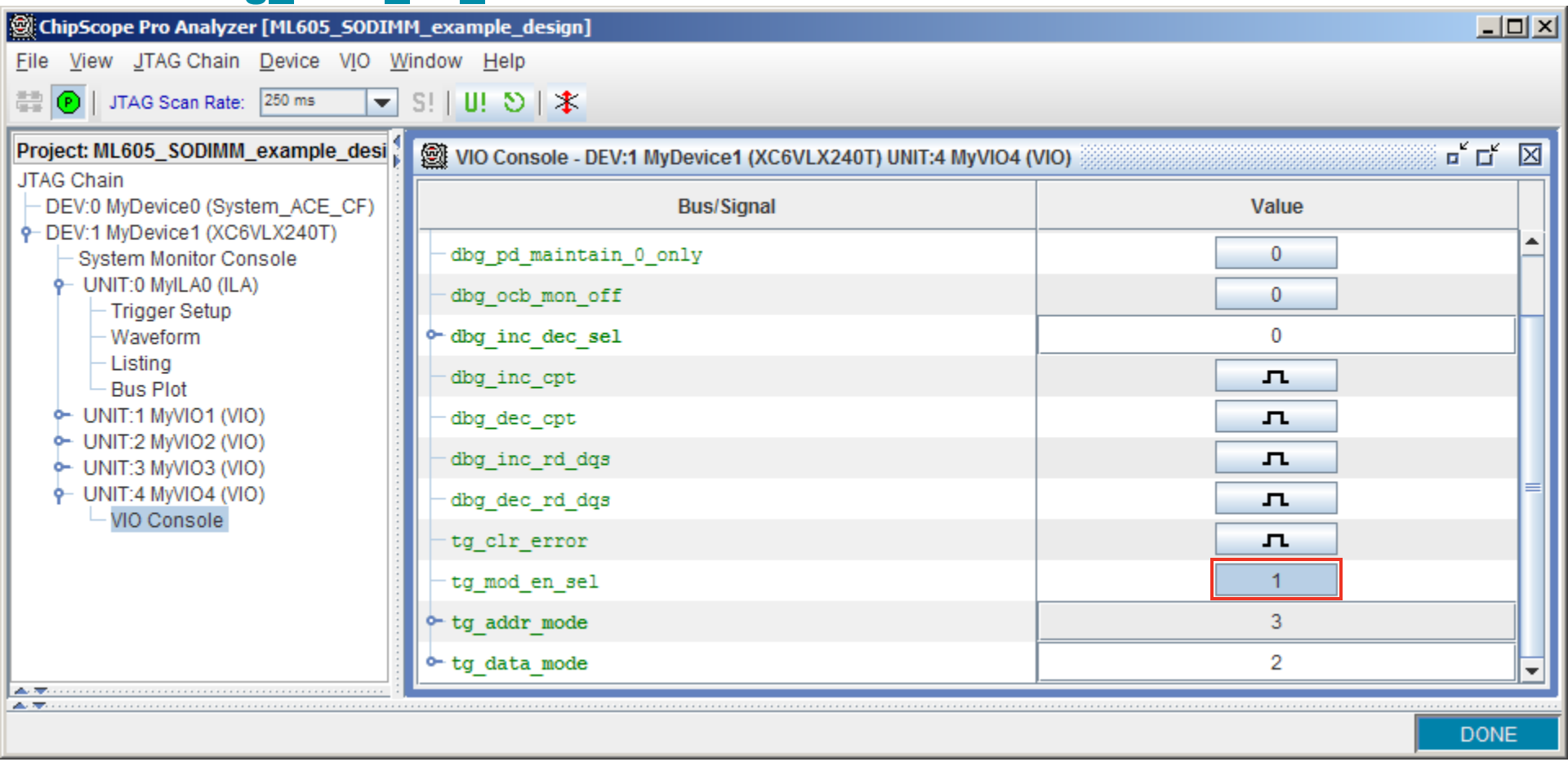
- The Example Design should run error free (no trigger on error)
- To force a trigger, click the T! button (1)



Note: Presentation applies to the ML605

Adjust Data Pattern using VIO Console

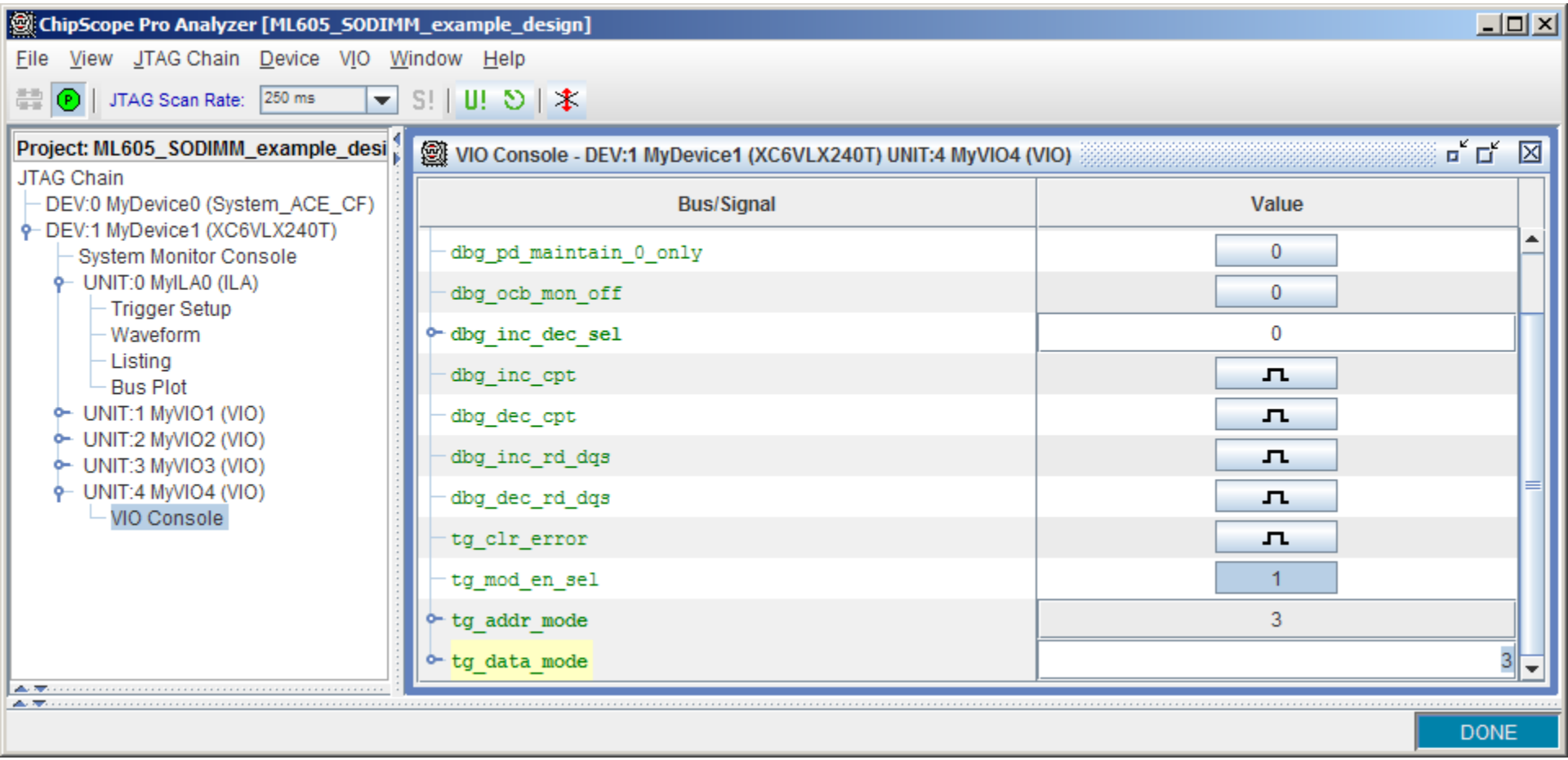
- Select VIO Console 4
- Set tg_mod_en_sel to 1



Note: Presentation applies to the ML605

Adjust Data Pattern using VIO Console

- Set tg_data_mode to “3” for HAMMER_DATA_MODE



Note: Presentation applies to the ML605

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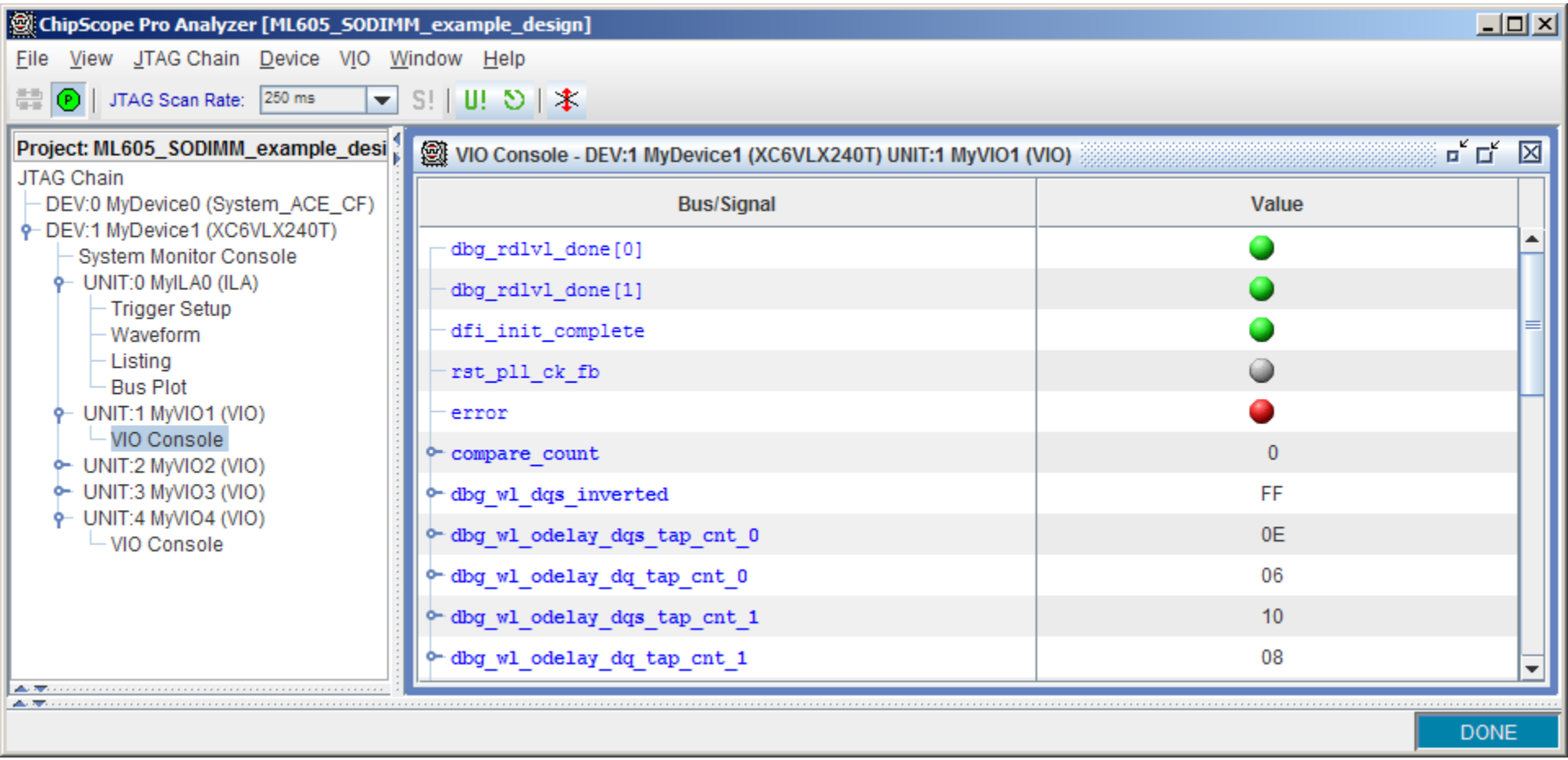
Adjust Data Pattern using VIO Console

- Select VIO Console 1
- Note error is active



Note: Presentation applies to the ML605

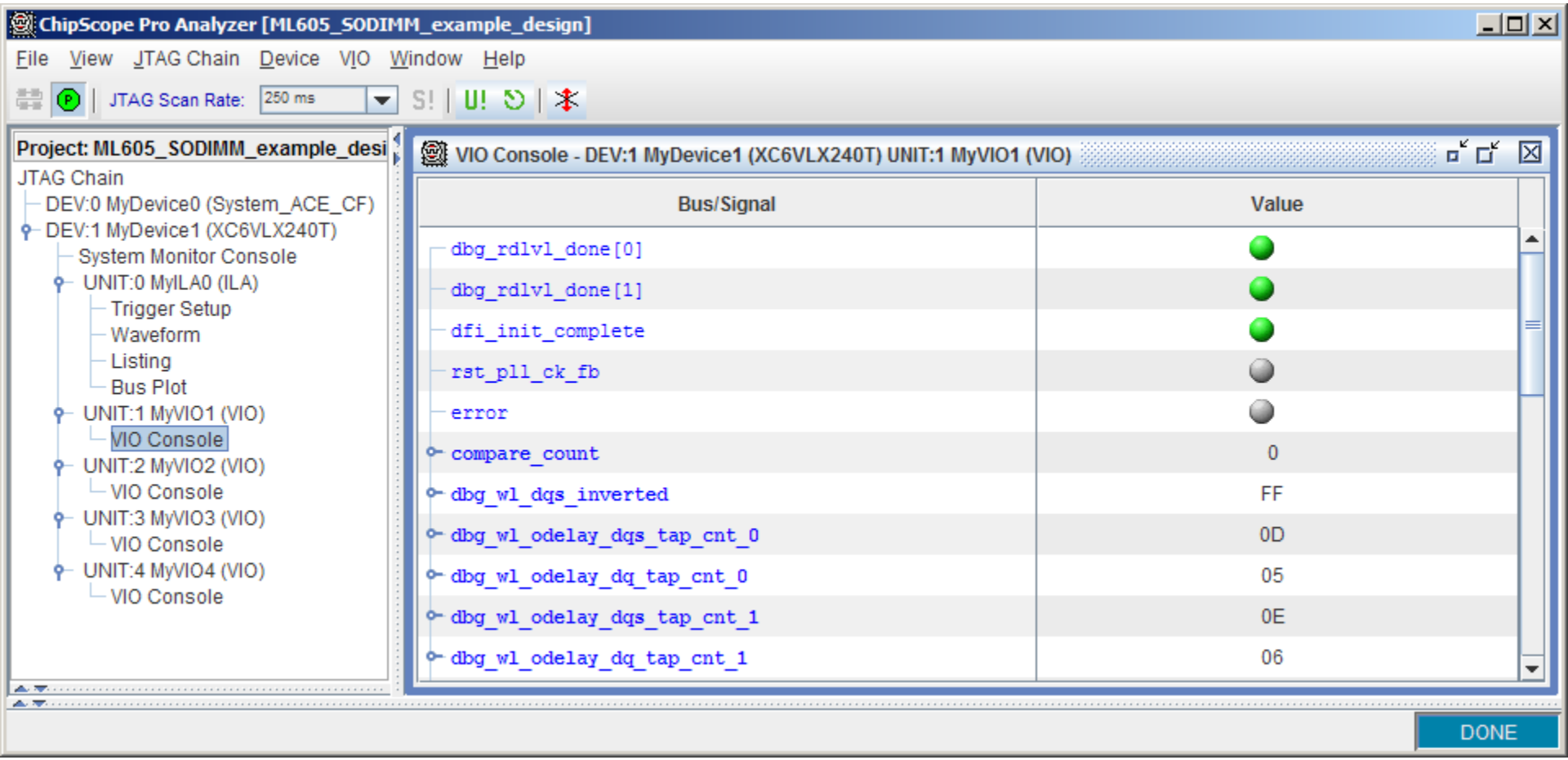
Adjust Data Pattern using VIO Console

- Press and release the CPU RESET switch, SW10, after each change to tg_mod_en_sel or tg_data_mode

Note: Presentation applies to the ML605

Adjust Data Pattern using VIO Console

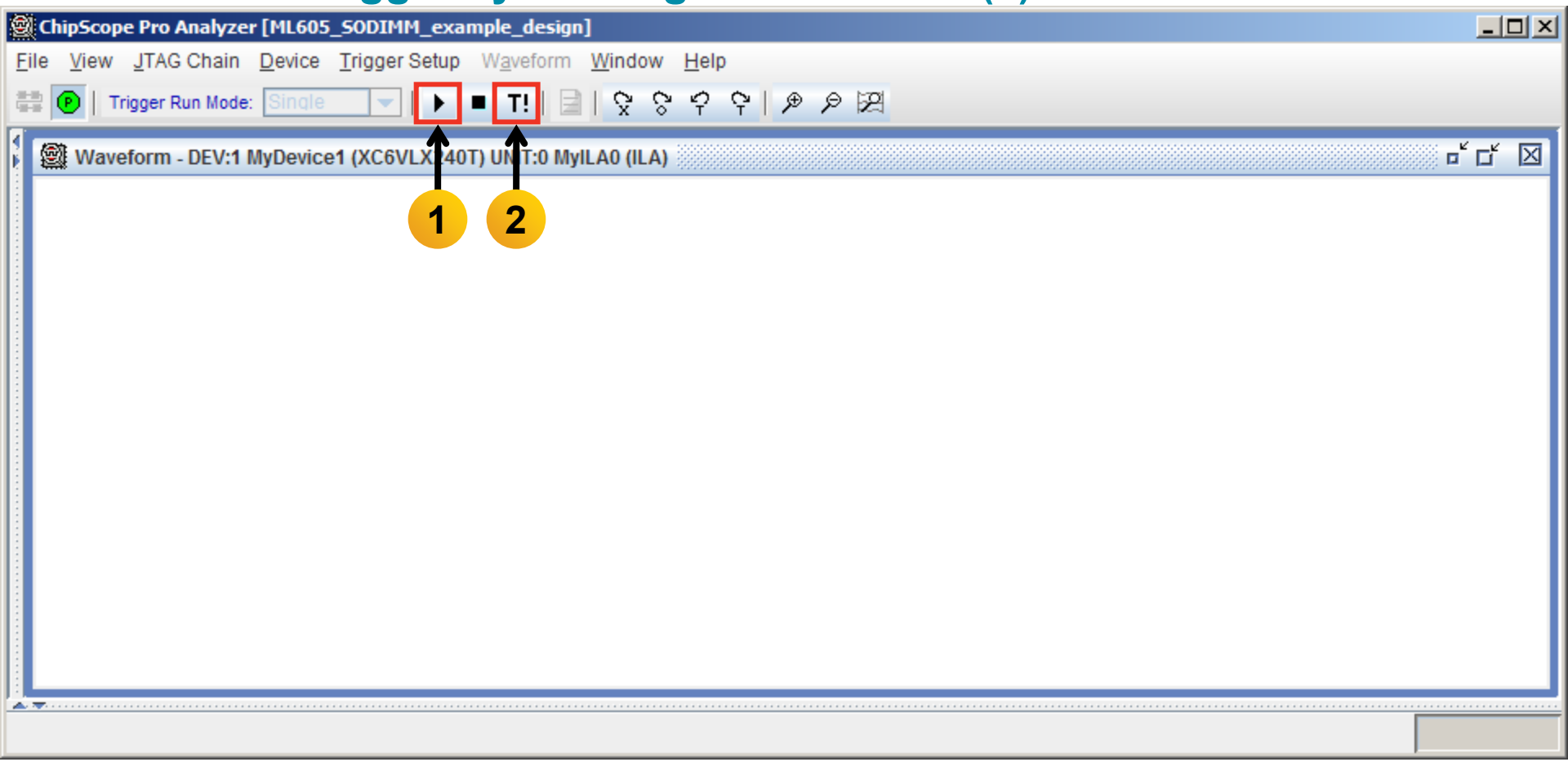
- Error is now cleared



Note: Presentation applies to the ML605

Adjust Data Pattern using VIO Console

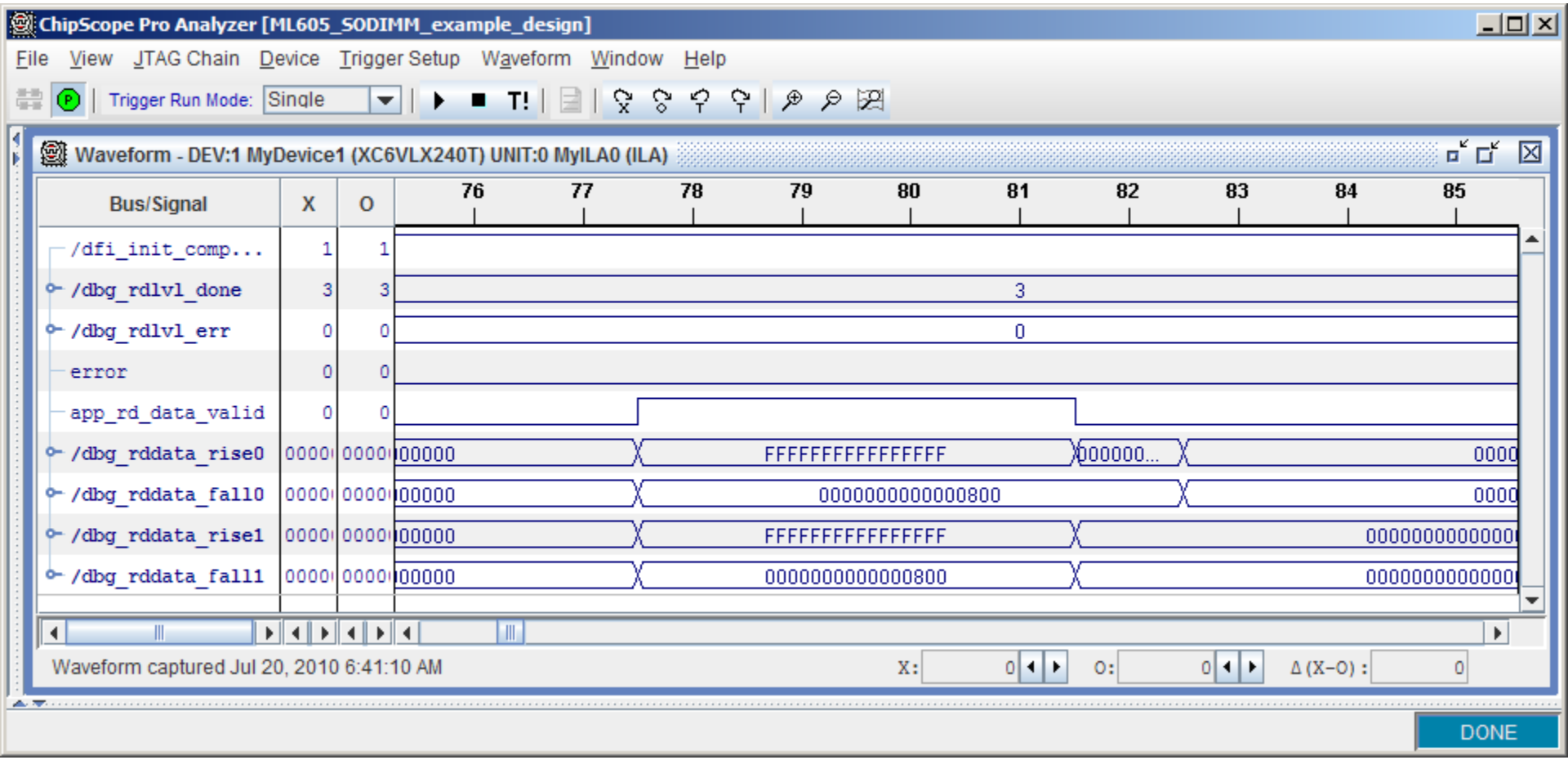
- Click on Waveform; click the Arm Trigger button (1)
- Force a trigger by clicking the T! button (2)



Note: Presentation applies to the ML605

Adjust Data Pattern using VIO Console

- **Hammer PRBS Data Mode**
  - 64 bit DQ data bus hammer pattern



Note: Presentation applies to the ML605

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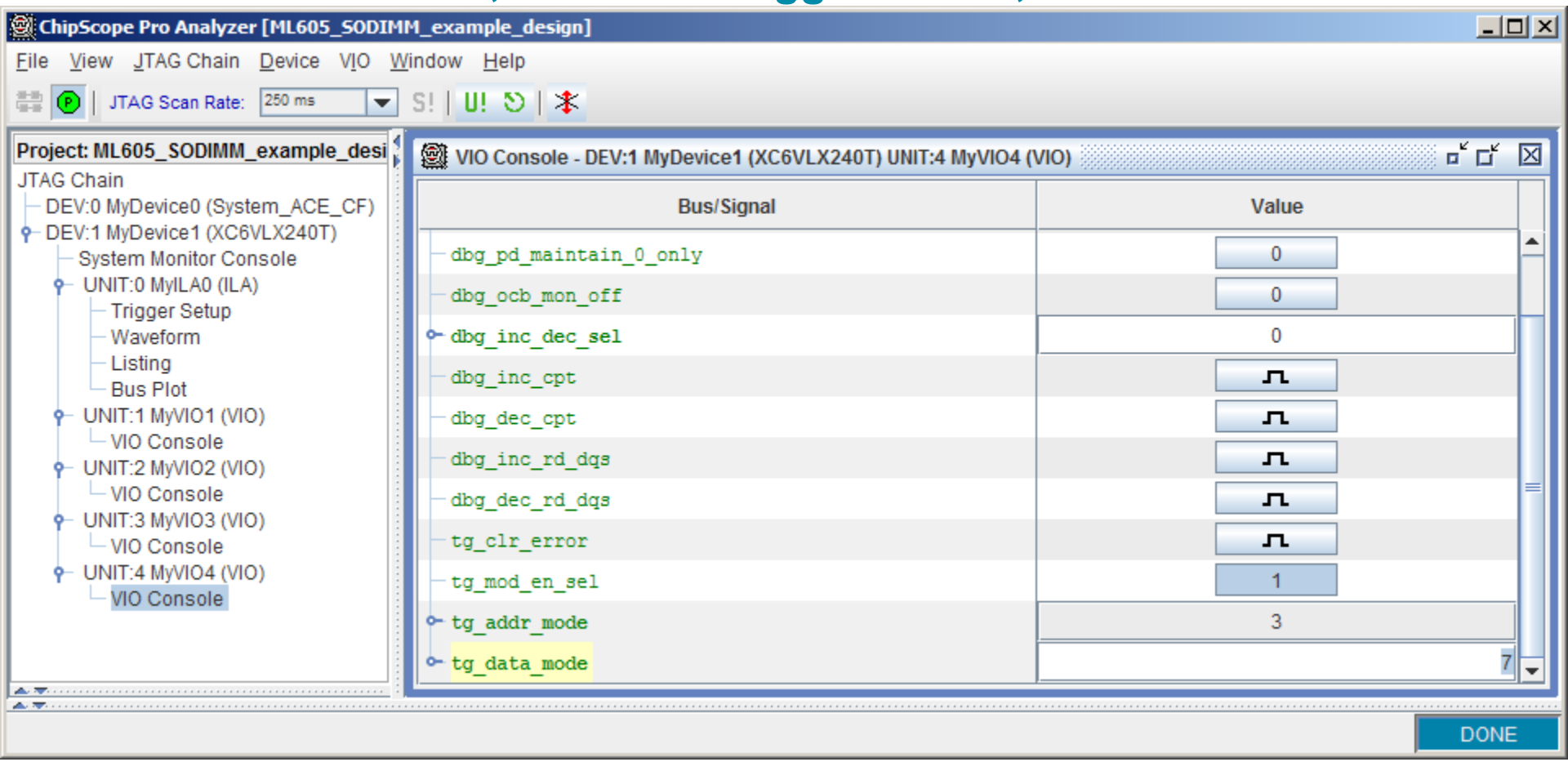
Adjust Data Pattern using VIO Console

- Set tg_data_mode to “7” for PRBS data pattern
- Push CPU Reset, click Arm Trigger button, click T! button



Note: Presentation applies to the ML605

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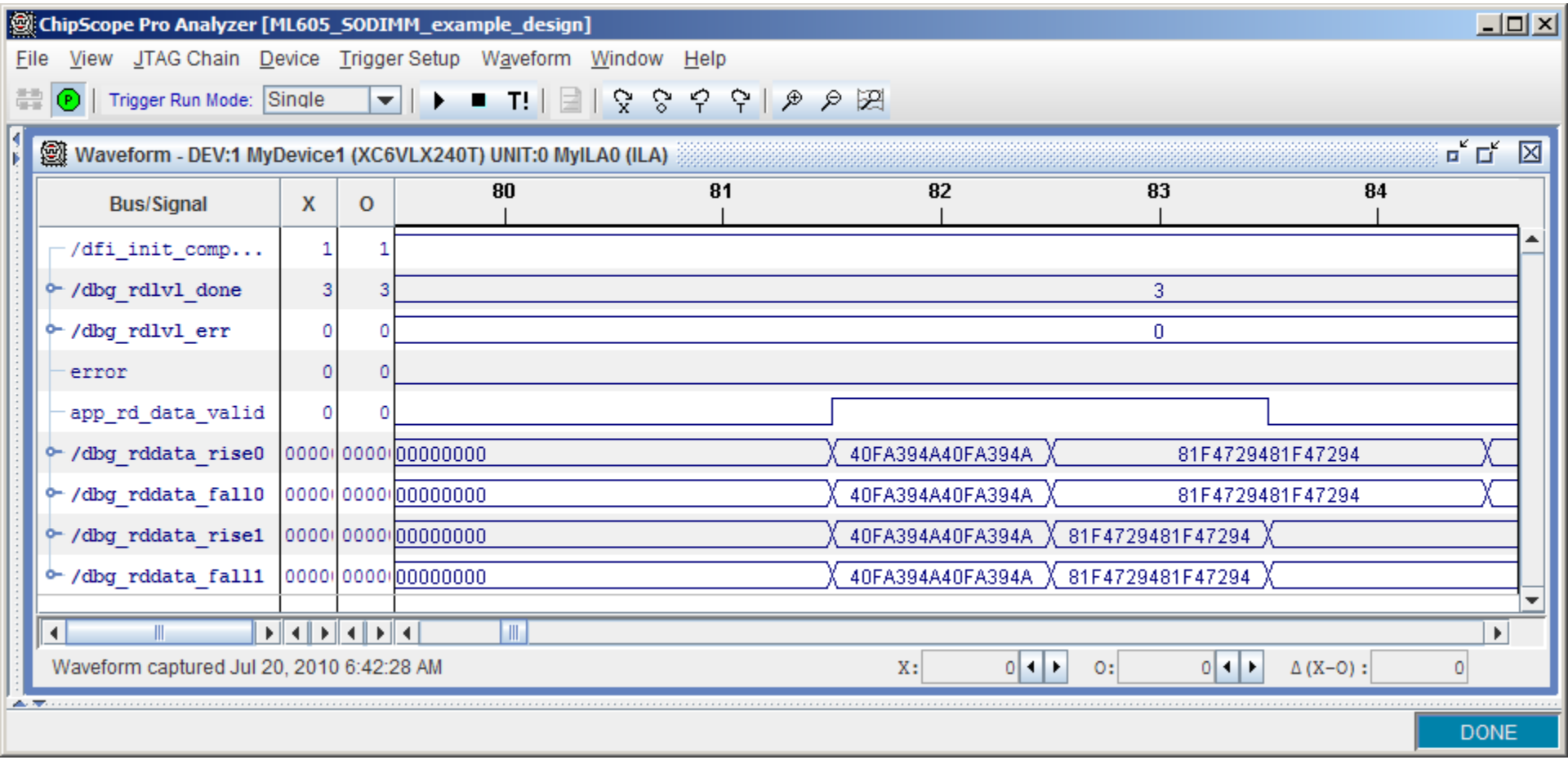
Adjust Data Pattern using VIO Console

- **PRBS Data Mode**

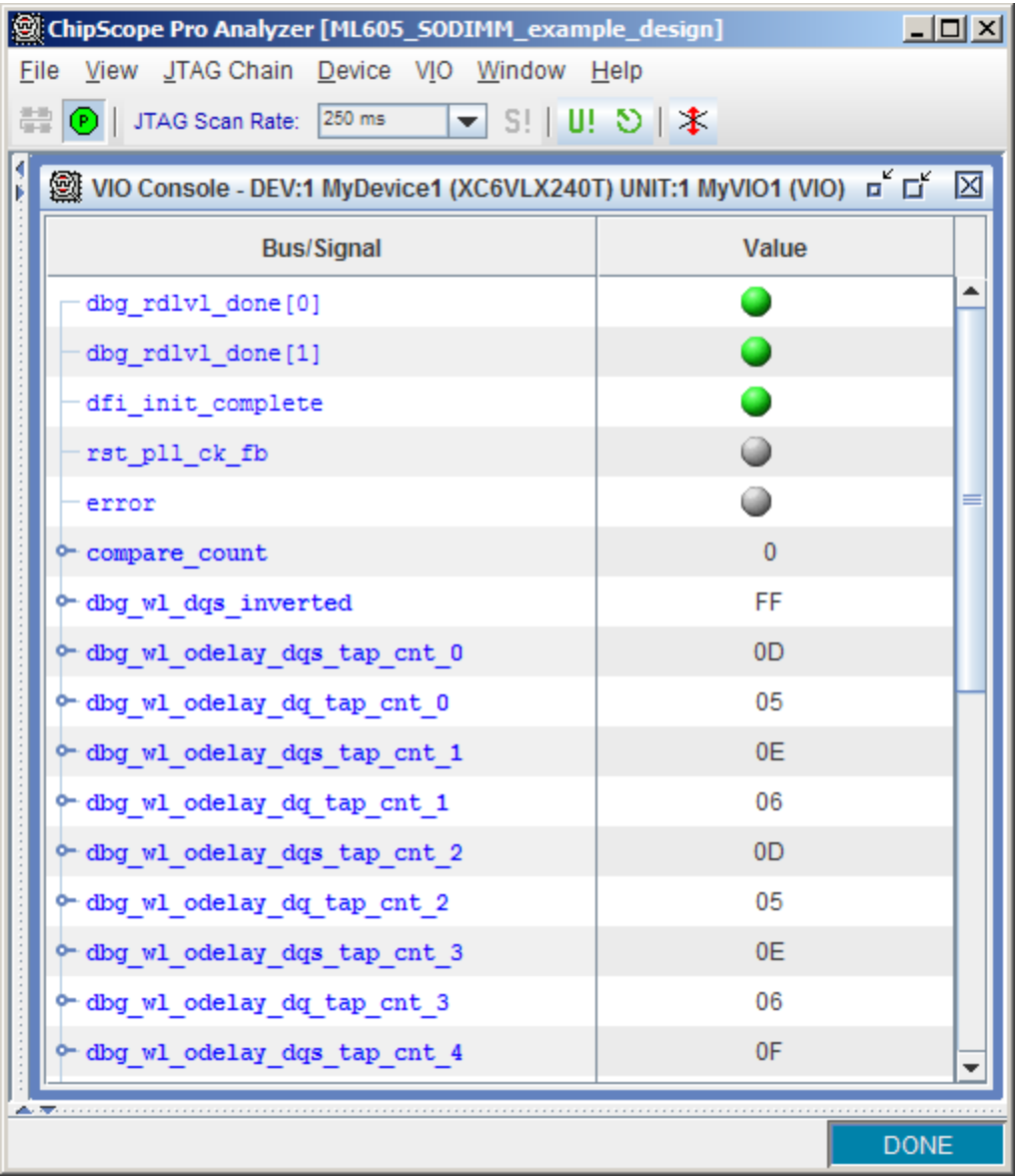


Note: Presentation applies to the ML605

Example Design VIO Consoles

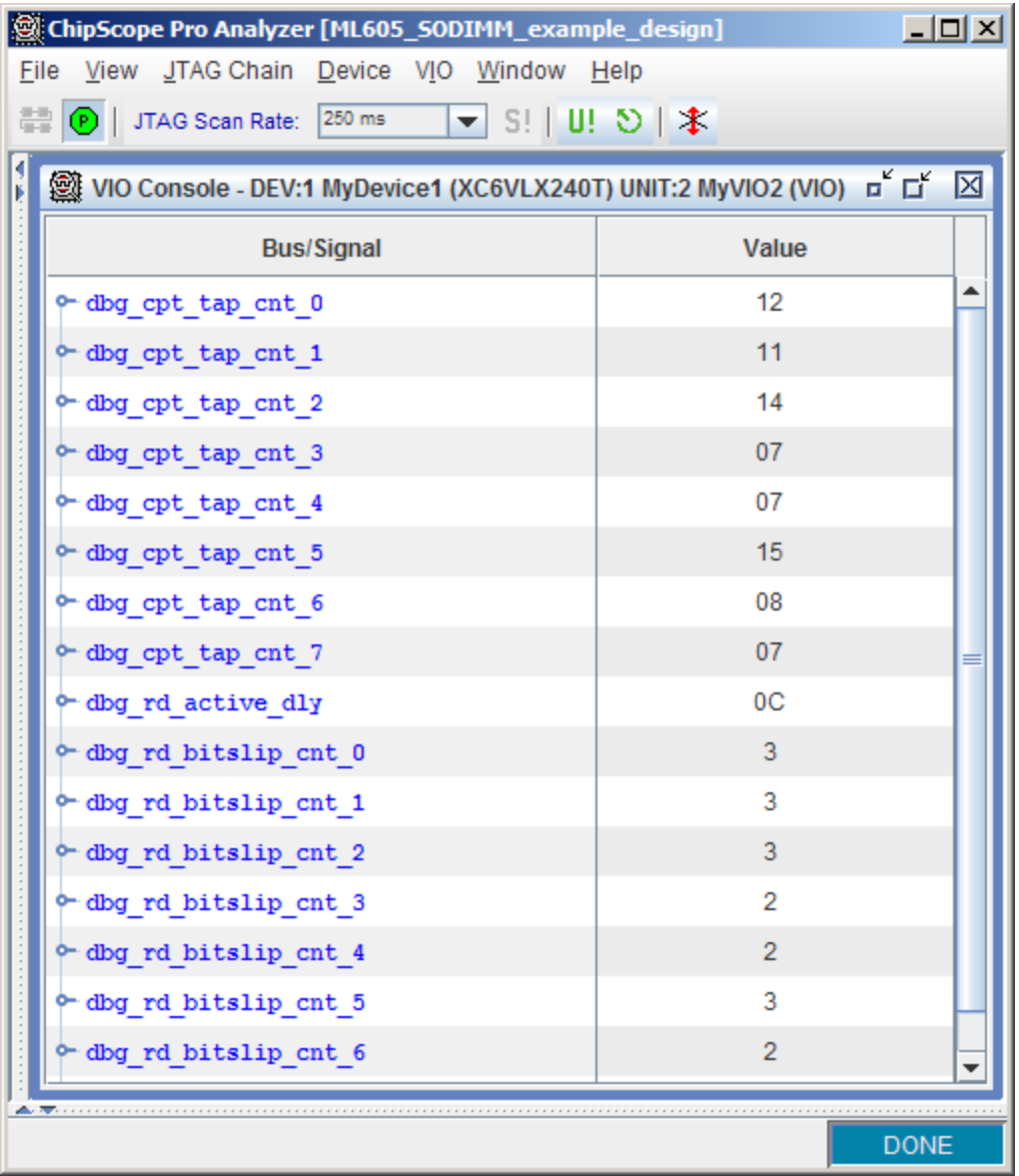
- **Useful for PHY layer logic debug and status**
- **Available if "debug" option is checked in MIG GUI**
  - Monitor PHY outputs
    - Status of write calibration
    - Status of read calibration
  - Phase detector control
  - Read data capture clock adjustment
  - Disable selected PHY features
- **Reference documentation in UG406**
  - "PHY Layer Debug Port" section
  - Table 1-25 for signal definitions and descriptions
- **VIO port assignments (4 cores) defined in "example_top.v"**

Example Design VIO Consoles



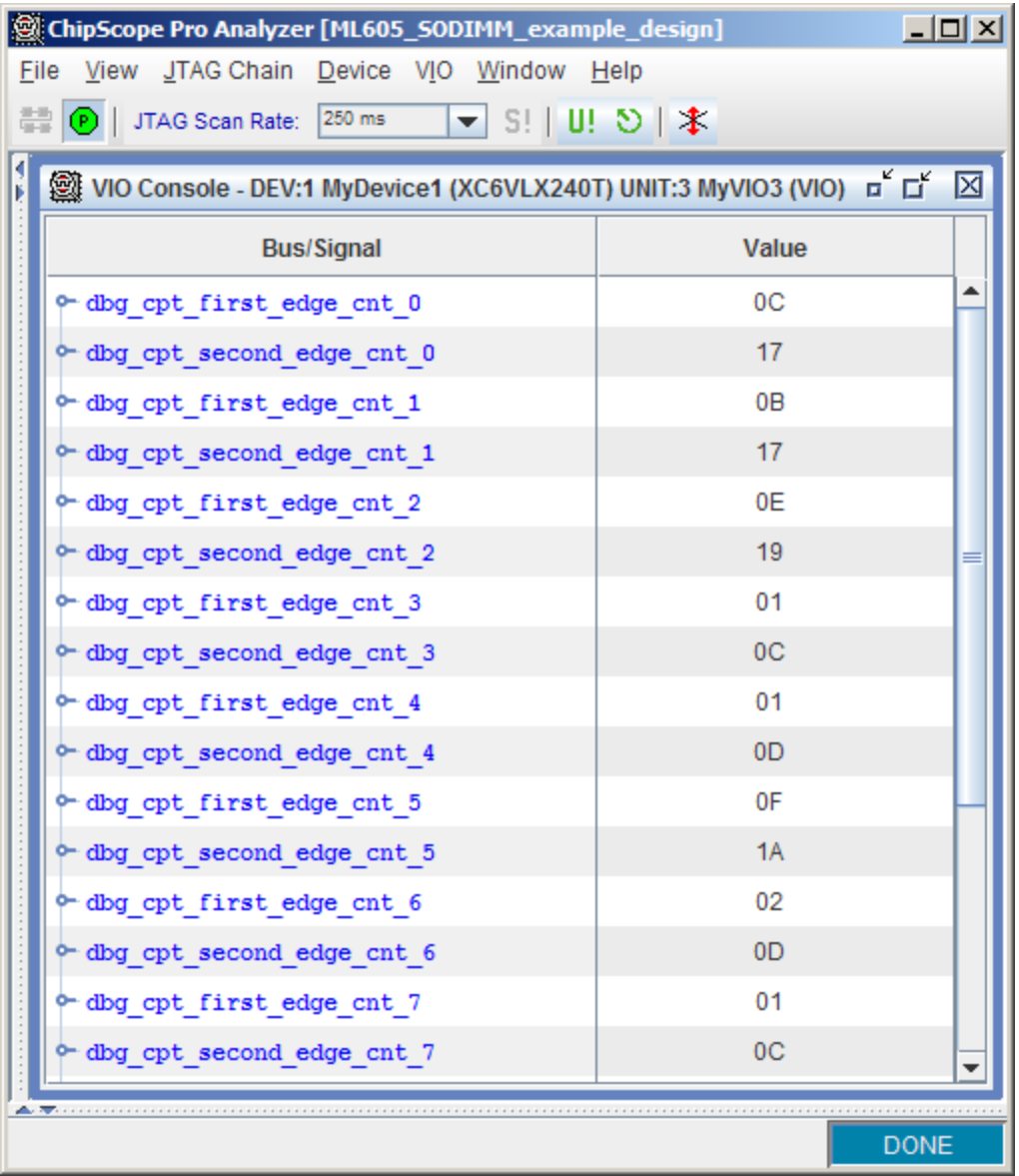
- **VIO Console 1**
  - Write Path Calibration Status
  - Read Leveling Done, Read Leveling Error
  - Initialization complete, PLL reset
  - Note: Press CPU RESET to clear error status in this VIO console

Example Design VIO Consoles



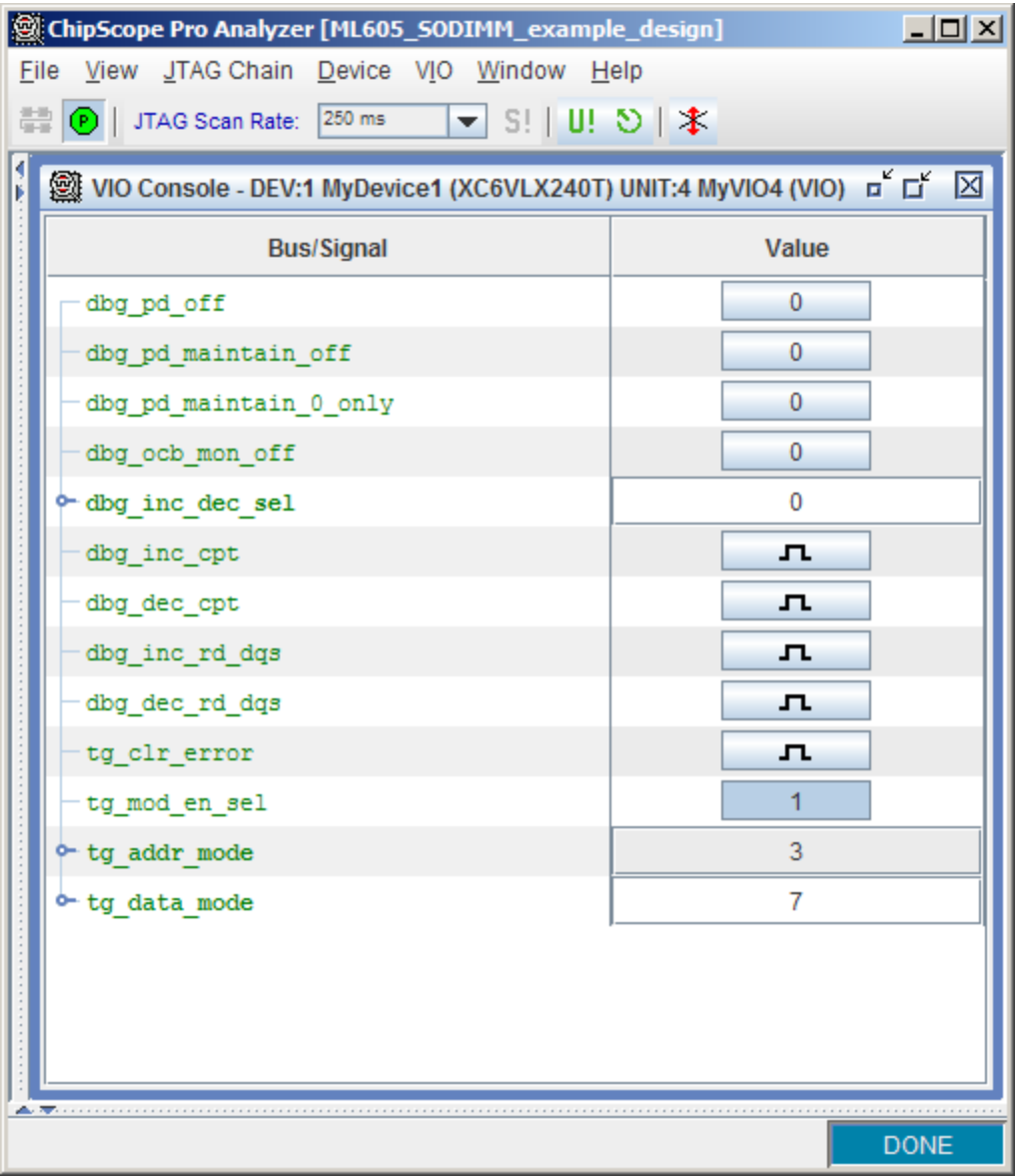
- **VIO Console 2 & VIO Console 3**
  - Read Path Calibration Status

Example Design VIO Consoles



- **VIO Console 2 & VIO Console 3**
  - Read Path Calibration Status

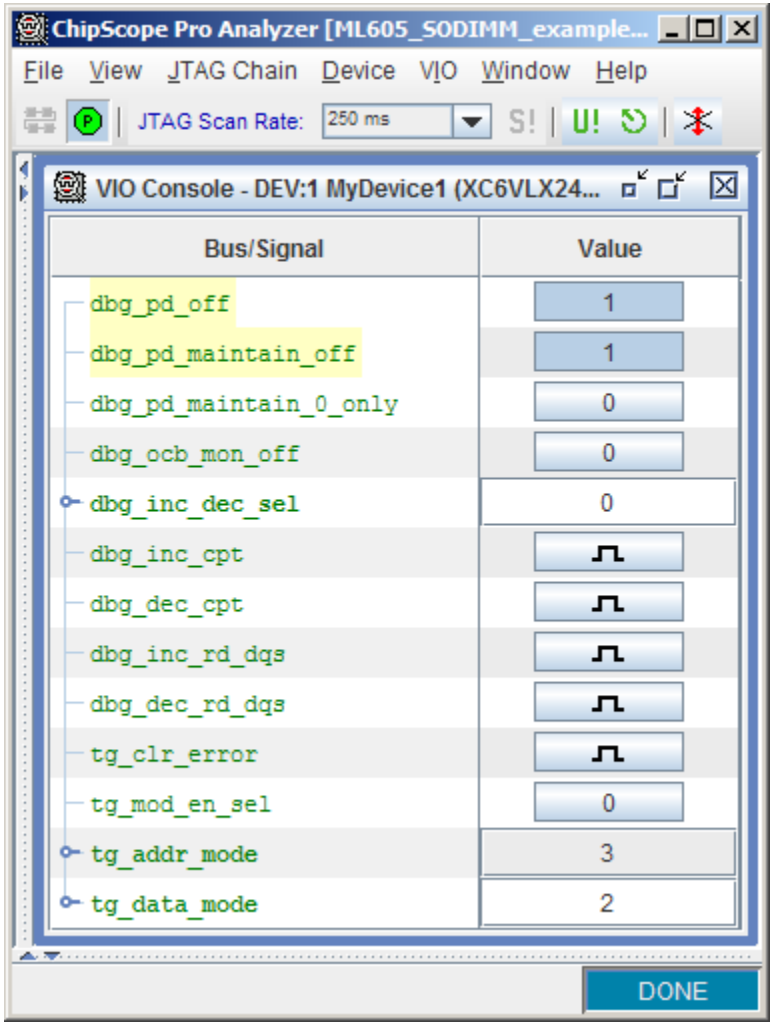
Example Design VIO Consoles



- **VIO Console 4**
  - Phase Detector Controls
  - Read Data Capture Clock Adjustment

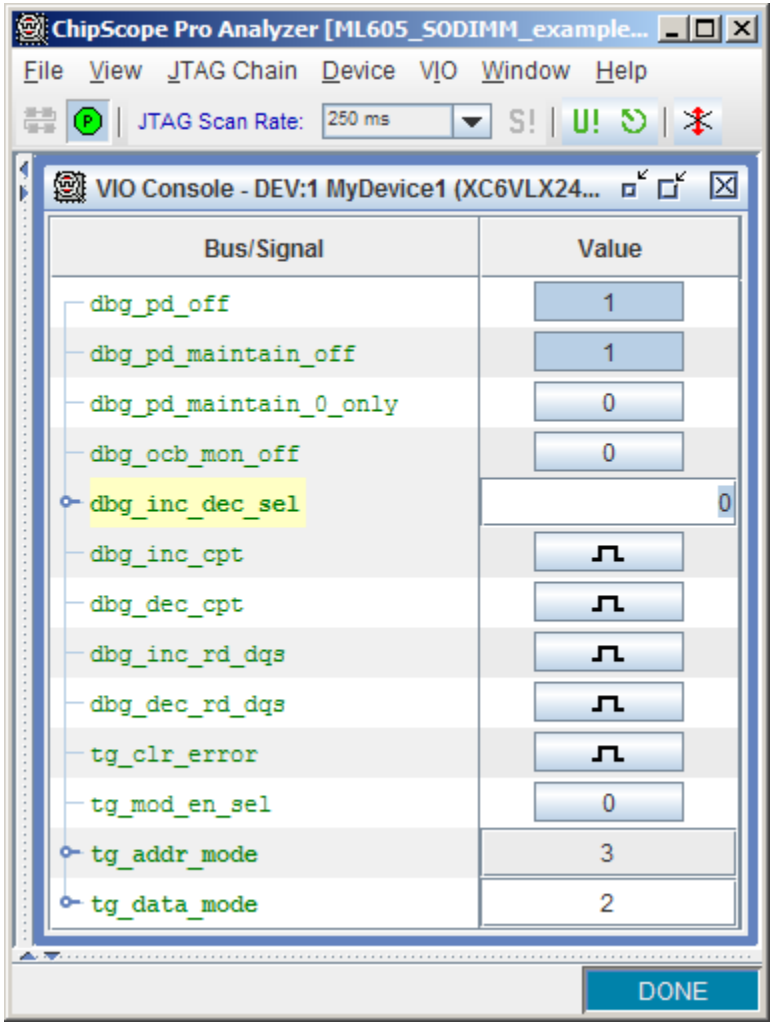
Measure Read Data Window with VIO

- **VIO Console 4**
  - Set **dbg_pd_off** to 1
  - This turns off the Phase Detector
  - Set **dbg_pd_maintain_off** to 1
  - This turns off the Phase Detector Maintenance
  - Select data group (0, 1, 2, etc,)



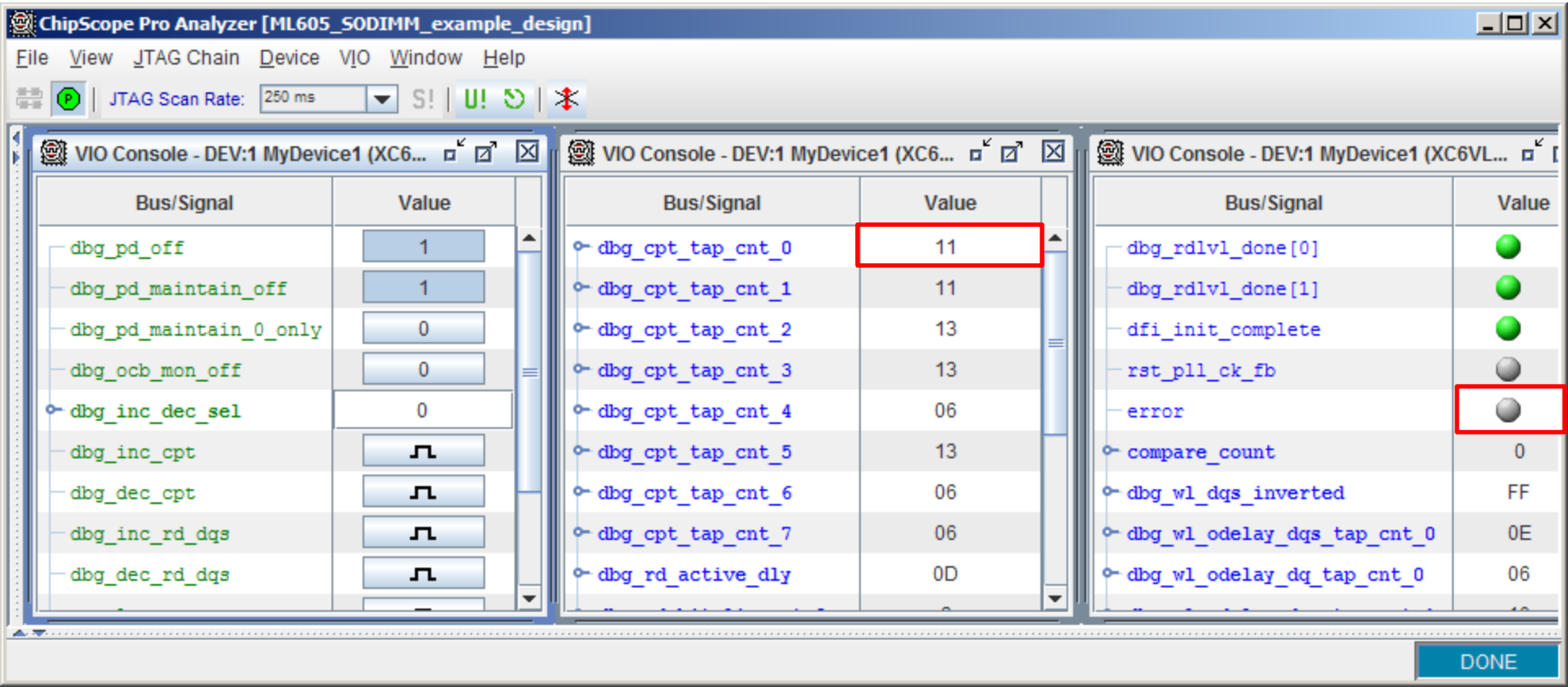
Measure Read Data Window with VIO

- **VIO Console 4**
  - Set **dbg_inc_dec_sel** to 0
  - This selects the data group (0, 1, 2, etc,)



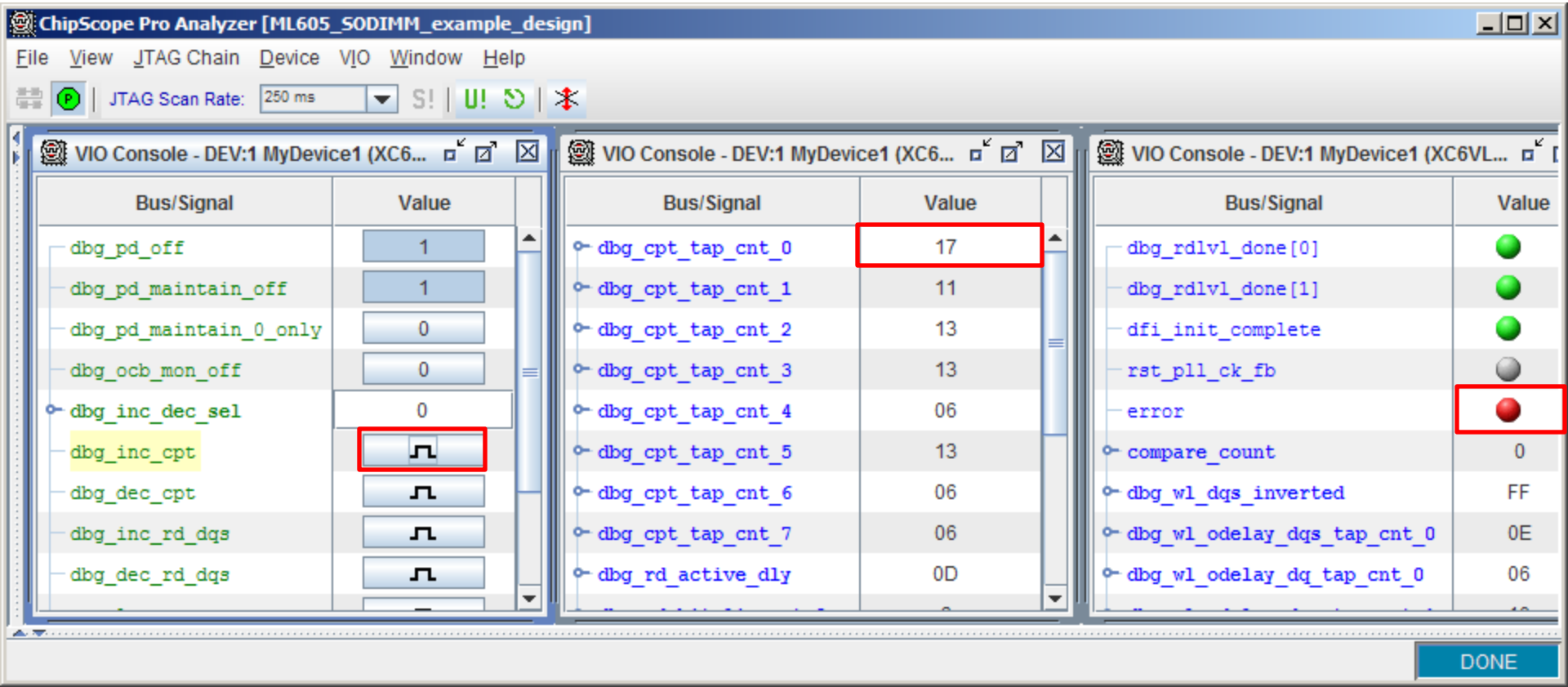
Change tap delays to measure window

- **Increment Taps**
  - Note the initial value of **dbg_cpt_tap_cnt_0**, in this case 11
  - The error LED should be off



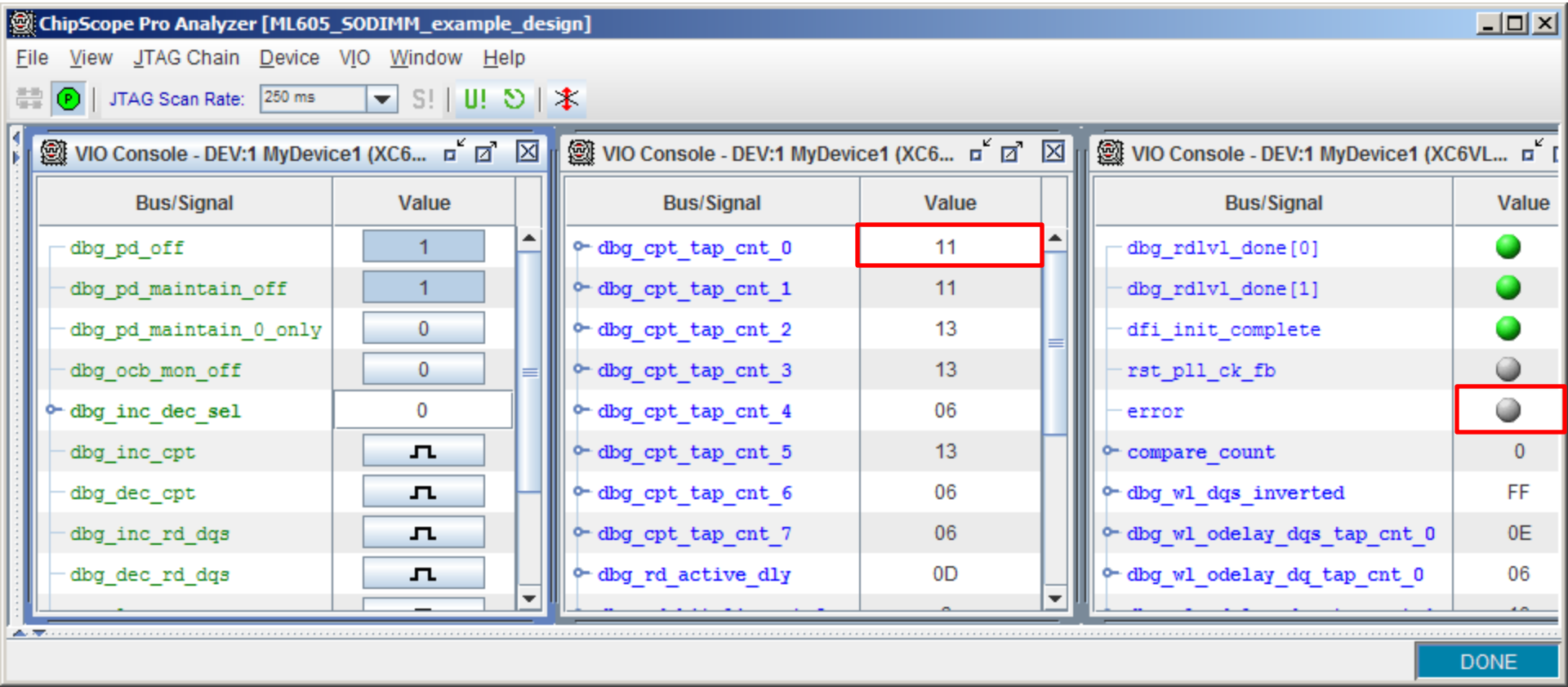
Change tap delays to measure window

- **Increment Taps**
  - Increment tap delay by clicking on **dbg_inc_cpt** until an error occurs
  - Note tap value that causes the error and subtract one: 17 – 1 = 16
  - Take the difference of the final value and the initial value: 16 – 11 = 5



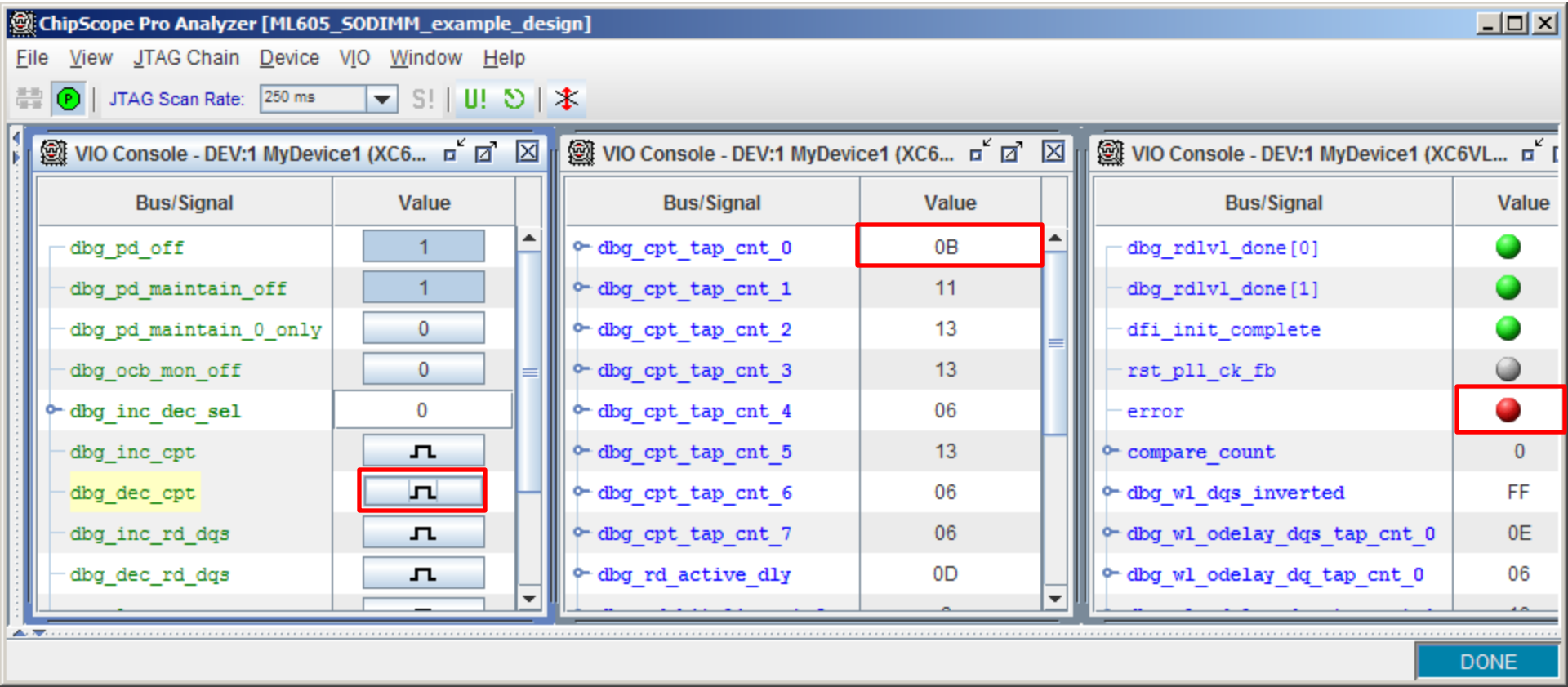
Change tap delays to measure window

- **Reset using Switch SW10**
  - Note that **dbg_cpt_tap_cnt_0** returns to its original value, 11
  - The error LED should be off



Change tap delays to measure window

- **Decrement Taps**
  - Decrement tap delays by clicking on **dbg_dec_cpt** until an error occurs
  - Note tap value that causes the error and add one: 0B + 1 = 0C
  - Take the difference of the initial value and the final value: 11 – 0C = 5



Change tap delays to measure window

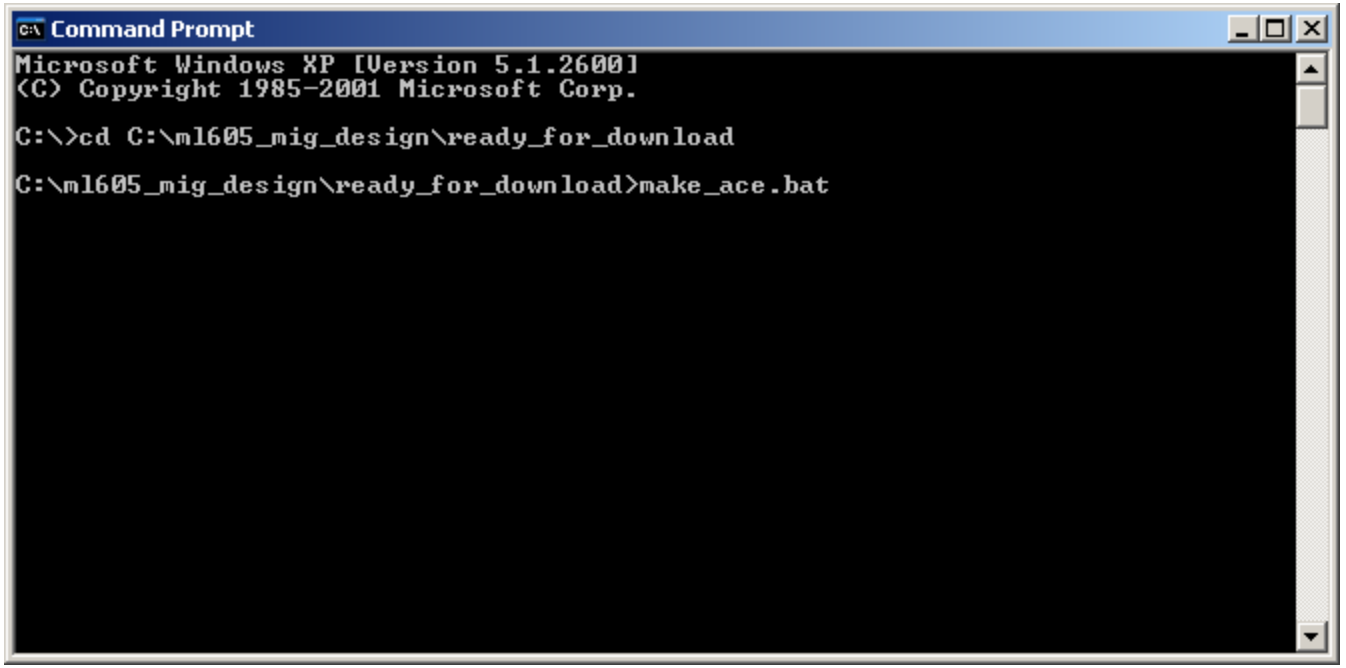
- **Add the two values and multiply by the average tap delay:**
  - 10 x 78 ps = 780 ps
- **Total data period = 1250 ps (800 Mbps)**
  - From DS152, page 35: “Average Tap Delay at 200 MHz = 78 ps”

Generate MIG ACE File (Optional)

- **Type these commands in a windows command shell:**

  cd C:\ml605_mig_design\ready_for_download

  make_ace.bat



Note: Presentation applies to the ML605

References

References

- **Virtex-6 Memory**
  - Virtex-6 FPGA Memory Interface Solutions User Guide – UG406
    http://www.xilinx.com/support/documentation/ip_documentation/ug406.pdf
  - Virtex-6 FPGA Memory Interface Solutions – DS186
    http://www.xilinx.com/support/documentation/ip_documentation/ds186.pdf
  - Virtex-6 FPGA Data Sheet: DC and Switching Characteristics – DS152
    http://www.xilinx.com/support/documentation/data_sheets/ds152.pdf

Documentation

Documentation

- **Virtex-6**
  - Virtex-6 FPGA Family
    http://www.xilinx.com/products/virtex6/index.htm
- **ML605 Documentation**
  - Virtex-6 FPGA ML605 Evaluation Kit
    http://www.xilinx.com/products/devkits/EK-V6-ML605-G.htm
  - ML605 Getting Started Guide
    http://www.xilinx.com/support/documentation/boards_and_kits/ug533.pdf
  - ML605 Hardware User Guide
    http://www.xilinx.com/support/documentation/boards_and_kits/ug534.pdf
  - ML605 Reference Design User Guide
    http://www.xilinx.com/support/documentation/boards_and_kits/ug535.pdf