

# TE0725 HyperRAM

## Table of contents

MicroBlaze Design with 10 minutes HyperRAM memory test example.

- 1.1 Key Features

This reference design is bundled with a FREE evaluation edition of the low-cost, commercially proven, high performance memory controller IP supplied by Synaptic Laboratories Ltd (SLL). This free IP evaluation license never expires, and no customer registration or NIC ID is required. [Click here](#) to find the latest free trials of SLL's memory controller IP for HyperBus, OctaBus, Xccela Bus, JEDEC xSPI Profile 1.0 and JEDEC xSPI Profile 2.0 for Intel, Microchip, and Xilinx FPGA. SLL IP is also qualified for use with Trenz H5 CRW enabled boards. Please send all sales enquiry and technical support questions for SLL's IP to [info@synapticlabs.com](mailto:info@synapticlabs.com)

- 1.2 Additional Sources

Refer to <http://trenz.org/te0725-freedom> for the current online version of this manual and other available documentation.

- 1.5.4 Download

- 2 Design Flow
- 3 Launch

- 3.1 Programming

- 3.1.1 Get prebuilt boot binaries
- 3.1.2 QSPI
- 3.1.3 SD
- 3.1.4 JTAG

- 3.2 Usage

- 3.2.1 UART

- 4 System Design - Vivado

- 4.1 Block Design

- 4.1.1

- 4.2 Constraints

- 4.2.1 Basic module constraints
- 4.2.2 Design specific constraints

- 5 Software Design - Vitis

- 5.1 Application

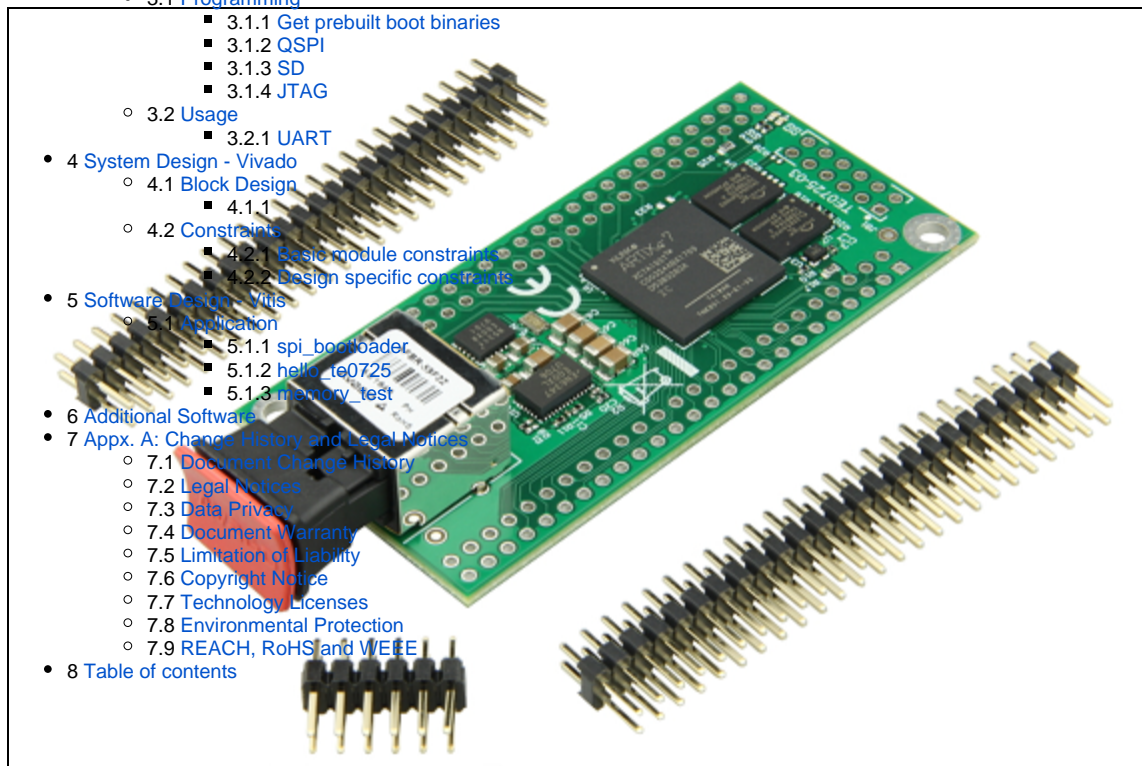
- 5.1.1 spi\_bootloader
- 5.1.2 hello\_te0725
- 5.1.3 memory\_test

- 6 Additional Software

- 7 Appx. A: Change History and Legal Notices

- 7.1 Document Change History
- 7.2 Legal Notices
- 7.3 Data Privacy
- 7.4 Document Warranty
- 7.5 Limitation of Liability
- 7.6 Copyright Notice
- 7.7 Technology Licenses
- 7.8 Environmental Protection
- 7.9 REACH, RoHS and WEEE

- 8 Table of contents



## Key Features

- Vivado/Vitis 2021.2
- MicroBlaze
- QSPI
- I2C
- UART
- HyperRAM
- S/Labs HBMC IP (Free Trail IP)

## Revision History

| Date       | Vivado | Project Built   | Authors              | Description  |
|------------|--------|---|----------------------|--|
| 2022-08-30 | 2021.2 | TE0725-HyperRAM_noprebui<br>lt-vivado_2021.2-<br>build_15_20220830<br>154134.zip<br>TE0725-HyperRAM-<br>vivado_2021.2-<br>build_15_20220830<br>154134.zip     | Waldemar<br>Hanemann | <ul style="list-style-type: none"><li>• 2021.2 update</li><li>• new<br/>spi_bootloader<br/>to load elf file<br/>from qspi to<br/>hyperram</li><li>• Documentation<br/>style update</li></ul> |
| 2020-04-29 | 2019.2 | TE0725-<br>HyperRAM_noprebui<br>lt-vivado_2019.2-<br>build_10_20200429<br>134457.zip<br>TE0725-HyperRAM-<br>vivado_2019.2-<br>build_10_20200429<br>134447.zip | John Hartfiel        | <ul style="list-style-type: none"><li>• add srec<br/>application<br/>which loads<br/>hello_te0725<br/>from qspi into<br/>hyperram</li></ul>  |
| 2020-04-17 | 2019.2 | TE0725-HyperRAM-<br>vivado_2019.2-<br>build_10_20200427<br>163950.zip<br>TE0725-<br>HyperRAM_noprebui<br>lt-vivado_2019.2-<br>build_10_20200427<br>163959.zip | John Hartfiel        | <ul style="list-style-type: none"><li>• 2019.2 update</li></ul>  |
| 2018-08-09 | 2018.2 | TE0725-<br>HyperRAM_noprebui<br>lt-vivado_2018.2-<br>build_02_20180809<br>122634.zip<br>TE0725-HyperRAM-<br>vivado_2018.2-<br>build_02_20180809<br>122623.zip | John Hartfiel        | <ul style="list-style-type: none"><li>• 2018.2 update</li><li>• new HBMC IP<br/>version<br/>(v1_3_57)</li></ul>  |
| 2018-06-05 | 2017.4 | TE0725-<br>HyperRAM_noprebui<br>lt-vivado_2017.4-<br>build_10_20180605<br>162539.zip<br>TE0725-HyperRAM-<br>vivado_2017.4-<br>build_10_20180605<br>162425.zip | John Hartfiel        | <ul style="list-style-type: none"><li>• initial release</li></ul>  |

Design Revision History

## Release Notes and Know Issues

| Issues          | Description | Workaround | To be fixed version |
|-----------------|-------------|------------|---------------------|
| No known issues | ---         | ---        | ---                 |

Known Issues

## Requirements

## Software

| Software | Version | Note   |
|----------|---------|--|
| Vitis    | 2021.2  | needed, Vivado is included into Vitis installation |

### Software

## Hardware

Basic description of TE Board Part Files is available on [TE Board Part Files](#).

Complete List is available on <design name>/board\_files/\*\_board\_files.csv

Design supports following modules:

| Module Model      | Board Part Short Name | PCB Revision Support | DDR | QSPI Flash | EMMC | Others      | Notes         |
|-------------------|-----------------------|----------------------|-----|------------|------|-------------|---------------|
| TE0725-03-15-1C*  | 15_1c                 | REV03 REV02 REV01    | NA  | 32MB       | NA   | 8MB HypeRAM | NA            |
| TE0725-03-35-2C   | 35_2c                 | REV03 REV02 REV01    | NA  | 32MB       | NA   | 8MB HypeRAM | NA            |
| TE0725-03-100-2C  | 100_2c                | REV03 REV02 REV01    | NA  | 32MB       | NA   | 8MB HypeRAM | NA            |
| TE0725-03-100-2CF | 100_2c                | REV03 REV02 REV01    | NA  | 32MB       | NA   | 8MB HypeRAM | POF assembled |
| TE0725-03-100-2I9 | 100_2i                | REV03 REV02 REV01    | NA  | 32MB       | NA   | 8MB HypeRAM | NA            |
| TE0725-03-35-2I   | 35_2i                 | REV03 REV02 REV01    | NA  | 32MB       | NA   | 8MB HypeRAM | NA            |

\*used as reference

### Hardware Modules

Design supports following carriers:

| Carrier Model | Notes |
|---------------|-------|
| ---           |       |

### Hardware Carrier

Additional HW Requirements:

| Additional Hardware    | Notes  |
|------------------------|--|
| TE0790 JTAG Programmer | It's not recommended to use TE0790 for power supply( <a href="#">TE0790 TRM#PowerandPower-OnSequence</a> ) |
| External power supply  |  |

### Additional Hardware

## Content

For general structure and of the reference design, see [Project Delivery - AMD devices](#)

## Design Sources

| Type   | Location   | Notes   |
|--------|--|---|
| Vivado | <project folder>\block_design<br><project folder>\constraints<br><project folder>\ip_lib<br><project folder>\board_files | Vivado Project will be generated by TE Scripts  |
| Vitis  | <project folder>\sw_lib  | Additional Software Template for Vitis and apps_list.csv with settings automatically for Vitis app generation |

Design sources

## Additional Sources

| Type | Location | Notes |
|------|----------|-------|
| --   | --       | --    |

Additional design sources

## Prebuilt

| File                                  | File-Extension | Description  |
|---------------------------------------|----------------|--|
| BIT-File                              | *.bit          | FPGA (PL Part) Configuration File  |
| DebugProbes-File                      | *.ltx          | Definition File for Vivado/Vivado Labtools Debugging Interface                           |
| Diverse Reports                       | ---            | Report files in different formats  |
| Hardware-Platform-Specification-Files | *.xsa          | Exported Vivado Hardware Specification for Vitis and PetaLinux                           |
| LabTools Project-File                 | *.lpr          | Vivado Labtools Project File   |
| MCS-File                              | *.mcs          | Flash Configuration File with Boot-Image (MicroBlaze or FPGA part only)                  |
| MMI-File                              | *.mmi          | File with BRAM-Location to generate MCS or BIT-File with *.elf content (MicroBlaze only) |
| Software-Application-File             | *.elf          | Software Application for Zynq or MicroBlaze Processor Systems                            |
| SREC-File                             | *.srec         | Converted Software Application for MicroBlaze Processor Systems                          |

Prebuilt files (only on ZIP with prebuilt content)

## Download

Reference Design is only usable with the specified Vivado/Vitis/PetaLinux version. Do never use different Versions of Xilinx Software for the same Project.

Reference Design is available on:

- [TE0725 "HyperRAM" Reference Design](#)

## Design Flow

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Reference Design is available with and without prebuilt files. It's recommended to use TE prebuilt files for first lunch.

Trenz Electronic provides a tcl based built environment based on Xilinx Design Flow.

See also:

- [AMD Development Tools#XilinxSoftware-BasicUserGuides](#)
- [Vivado Projects - TE Reference Design](#)
- [Project Delivery](#).

The Trenz Electronic FPGA Reference Designs are TCL-script based project. Command files for execution will be generated with "\_create\_win\_setup.cmd" on Windows OS and "\_create\_linux\_setup.sh" on Linux OS.

TE Scripts are only needed to generate the vivado project, all other additional steps are optional and can also executed by Xilinx Vivado/Vitis GUI. For currently Scripts limitations on Win and Linux OS see: [Project Delivery Currently limitations of functionality](#)



**Caution!** Win OS has a 260 character limit for path lengths which can affect the Vivado tools. To avoid this issue, use Virtual Drive or the shortest possible names and directory locations for the reference design (for example "x:\<project folder>")

1. Run \_create\_win\_setup.cmd/\_create\_linux\_setup.sh and follow instructions on shell:

#### `_create_win_setup.cmd/_create_linux_setup.sh`

```
-----Set design paths-----
-- Run Design with: _create_win_setup
-- Use Design Path: <absolute project path>
-----
-----TE Reference
Design-----
-----
-- (0) Module selection guide, project creation...prebuilt export...
-- (1) Create minimum setup of CMD-Files and exit Batch
-- (2) Create maximum setup of CMD-Files and exit Batch
-- (3) (internal only) Dev
-- (4) (internal only) Prod
-- (c) Go to CMD-File Generation (Manual setup)
-- (d) Go to Documentation (Web Documentation)
-- (g) Install Board Files from Xilinx Board Store (beta)
-- (a) Start design with unsupported Vivado Version (beta)
-- (x) Exit Batch (nothing is done!)
-----
Select (ex.: '0' for module selection guide):
```

2. Press 0 and enter to start "Module Selection Guide"
3. Create project and follow instructions of the product selection guide, settings file will be configured automatically during this process.
  - optional for manual changes: Select correct device and Xilinx install path on "design\_basic\_settings.cmd" and create Vivado project with "vivado\_create\_project\_gui mode.cmd"



Note: Select correct one, see also [Vivado Board Part Flow](#)

- a. Create hardware description file (.xsa file) for PetaLinux project and export to prebuilt folder

**run on Vivado TCL (Script generates design and export files into  
"<project folder>\prebuilt\hardware\<short name>")**

```
TE::hw_build_design -export_prebuilt
```



Using Vivado GUI is the same, except file export to prebuilt folder.

4. Generate Programming Files with Vitis

**run on Vivado TCL (Script generates applications and bootable files, which are  
defined in "test\_board\sw\_lib\apps\_list.csv")**

```
TE::sw_run_vitis -all
TE::sw_run_vitis (optional; Start Vitis from Vivado GUI or start
with TE Scripts on Vivado TCL)
```



Note: Scripts generate applications and bootable files, which are defined in "sw\_lib\apps\_list.csv"

App from Firmware folder will be add into BlockRAM. If you add other app, you must select \*.elf

manually on Vivado



TCL scripts generate also platform project, this must be done manually in case GUI is used. See [Vitis](#)

5. (optional) Copy Application (spi\_bootloader.elf) from prebuilt-folder into \firmware\microblaze\_0\ and regenerate design with

**run on Vivado TCL (Script generates design and export files into "<project folder>\prebuilt\hardware\<short name>")**

```
TE::hw_build_design -export_prebuilt
```

## Launch

## Programming



Check Module and Carrier TRMs for proper HW configuration before you try any design.

Reference Design is also available with prebuilt files. It's recommended to use TE prebuilt files for first launch.

Xilinx documentation for programming and debugging: [Vivado/SDK/SDSoC-Xilinx Software Programming and Debugging](#)

## Get prebuilt boot binaries

1. Run \_create\_win\_setup.cmd/\_create\_linux\_setup.sh and follow instructions on shell
2. Press 0 and enter to start "Module Selection Guide"
  - a. Select assembly version
  - b. Validate selection
  - c. Select create and open delivery binary folder



Note: Folder "<project folder>\\_binaries\_<Article Name>" with subfolder "boot\_<app name>" for different applications will be generated

## QSPI

1. Connect JTAG and power on carrier with module
2. Open Vivado Project with "vivado\_open\_existing\_project\_gui\_mode.cmd" or if not created, create with "vivado\_create\_project\_gui\_mode.cmd"

#### run on Vivado TCL (Script programs .mcs-File on QSPI flash)

```
TE::pr_program_flash -swapp hello_te0725
```

3. Press the reset button to start the application and see the output in the console

## SD

Not used on this Example.

## JTAG

1. Connect JTAG and power on PCB
2. Open Vivado HW Manager
3. Program FPGA with Bitfile from "prebuilt\hardware\<short dir>\"

## Usage



HBMC IP is a 10 minute run-time limited evaluation version of the full-edition

1. Prepare HW like described on section [Programming](#)
2. Connect UART USB (most cases same as JTAG)
3. 1. FPGA Loads Bitfile from Flash

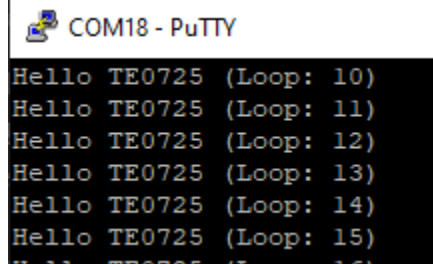
3. Hello Trenz will be run on UART console.

info: Do not reboot, if Bitfile programming over JTAG is used as programming method.

### a. UART

Open Serial Console (e.g. putty) Hello TE0725 will run on endless loop.

- i. Speed: 9600
- ii. COM Port: Win OS, see device manager, Linux OS see `dmesg |grep tty` (UART is \*USB1)

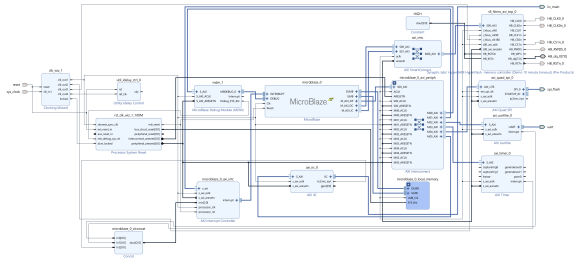


Power On PCB (Do not restart, if you use Bitfile programming)

## System Design - Vivado



## Block Design



## Constraints

### Basic module constraints

#### \_i\_bitgen\_common.xdc

```
set_property BITSTREAM.GENERAL.COMPRESS TRUE [current_design]
set_property BITSTREAM.CONFIG.CONFIGRATE 50 [current_design]
set_property CONFIG_VOLTAGE 3.3 [current_design]
set_property CFGBVS VCC0 [current_design]
set_property BITSTREAM.CONFIG.SPI_32BIT_ADDR YES [current_design]
set_property BITSTREAM.CONFIG.SPI_BUSWIDTH 4 [current_design]
set_property BITSTREAM.CONFIG.M1PIN PULLNONE [current_design]
set_property BITSTREAM.CONFIG.M2PIN PULLNONE [current_design]
set_property BITSTREAM.CONFIG.M0PIN PULLNONE [current_design]

set_property BITSTREAM.CONFIG.USR_ACCESS TIMESTAMP [current_design]
```

### Design specific constraints

#### \_i\_hyperram.xdc

```
set_property PACKAGE_PIN A13 [get_ports HB_CLK0_0]
set_property PACKAGE_PIN A14 [get_ports HB_CLK0n_0]

set_property PACKAGE_PIN E17 [get_ports {HB_dq_0[0]}]
set_property PACKAGE_PIN B17 [get_ports {HB_dq_0[1]}]
set_property PACKAGE_PIN F18 [get_ports {HB_dq_0[2]}]
set_property PACKAGE_PIN F16 [get_ports {HB_dq_0[3]}]
set_property PACKAGE_PIN G17 [get_ports {HB_dq_0[4]}]
set_property PACKAGE_PIN D18 [get_ports {HB_dq_0[5]}]
set_property PACKAGE_PIN B18 [get_ports {HB_dq_0[6]}]
set_property PACKAGE_PIN A16 [get_ports {HB_dq_0[7]}]

set_property PACKAGE_PIN E18 [get_ports HB_RWDS_0]
```

```

set_property PACKAGE_PIN D17 [get_ports HB_CS1n_0]
set_property PACKAGE_PIN J17 [get_ports HB_RSTn_0]

#set_property PACKAGE_PIN A18 [get_ports HB_CS0n_0 ]
#set_property PACKAGE_PIN J18 [get_ports HB_INTn_0 ]
#set_property PACKAGE_PIN C17 [get_ports HB_RSTOn_0]

#
# FPGA Pin Voltage assignment
#
set_property IOSTANDARD LVCMOS18 [get_ports HB_CLK0_0]
set_property IOSTANDARD LVCMOS18 [get_ports HB_CLK0n_0]
set_property IOSTANDARD LVCMOS18 [get_ports {HB_dq_0[*]}]
set_property IOSTANDARD LVCMOS18 [get_ports HB_CS1n_0]
set_property IOSTANDARD LVCMOS18 [get_ports HB_RSTn_0]
set_property IOSTANDARD LVCMOS18 [get_ports HB_RWDS_0]

#set_property IOSTANDARD LVCMOS18 [get_ports HB_CS0n_0]
#set_property IOSTANDARD LVCMOS18 [get_ports HB_INTn_0]
#set_property IOSTANDARD LVCMOS18 [get_ports HB_RSTOn_0]

#set_property PULLUP true [get_ports HB_RSTOn_0]
#set_property PULLUP true [get_ports HB_INTn_0]

#
#Hyperbus Clock - change according to clk pin on PLL
#
create_generated_clock -name clk_0 -source [get_pins msys_i/clk_wiz_0
/inst/mmcm_adv_inst/CLKIN1] -master_clock sys_clock [get_pins msys_i
/clk_wiz_0/inst/mmcm_adv_inst/CLKOUT0]
create_generated_clock -name clk_90 -source [get_pins msys_i/clk_wiz_0
/inst/mmcm_adv_inst/CLKIN1] -master_clock sys_clock [get_pins msys_i
/clk_wiz_0/inst/mmcm_adv_inst/CLKOUT1]
create_generated_clock -name clk_180 -source [get_pins msys_i/clk_wiz_0
/inst/mmcm_adv_inst/CLKIN1] -master_clock sys_clock [get_pins msys_i
/clk_wiz_0/inst/mmcm_adv_inst/CLKOUT2]

#
#100Mhz clock frequency - change accordingly
#
set hbus_freq_ns 10

set dqs_in_min_dly -0.5
set dqs_in_max_dly 0.5

set HB_dq_ports [get_ports HB_dq_0[*]]

#
#Create RDS clock and RDS virtual clock
#
create_clock -period $hbus_freq_ns -name rwds_clk [get_ports
HB_RWDS_0]
create_clock -period $hbus_freq_ns -name virt_rwds_clk

#
#Input Delay Constraint - HB_RWDS-HB_DQ
#
set_input_delay -clock [get_clocks virt_rwds_clk] -max
${dqs_in_max_dly} ${HB_dq_ports}
set_input_delay -clock [get_clocks virt_rwds_clk] -clock_fall -max

```

```

${dqs_in_max_dly} ${HB_dq_ports} -add_delay

set_input_delay -clock [get_clocks virt_rwds_clk] -min
${dqs_in_min_dly} ${HB_dq_ports} -add_delay
set_input_delay -clock [get_clocks virt_rwds_clk] -clock_fall -min
${dqs_in_min_dly} ${HB_dq_ports} -add_delay

set_multicycle_path -setup -end -rise_from [get_clocks virt_rwds_clk] -
rise_to [get_clocks rwds_clk] 0
set_multicycle_path -setup -end -fall_from [get_clocks virt_rwds_clk] -
fall_to [get_clocks rwds_clk] 0

set_false_path -fall_from [get_clocks virt_rwds_clk] -rise_to [get_clocks
rwds_clk] -setup
set_false_path -rise_from [get_clocks virt_rwds_clk] -fall_to [get_clocks
rwds_clk] -setup
set_false_path -fall_from [get_clocks virt_rwds_clk] -fall_to [get_clocks
rwds_clk] -hold
set_false_path -rise_from [get_clocks virt_rwds_clk] -rise_to [get_clocks
rwds_clk] -hold

set_false_path -from [get_clocks clk_0] -to [get_clocks rwds_clk]
set_false_path -from [get_clocks rwds_clk] -to [get_clocks clk_0]

#
#Output Delay Constraint - HB_CLK0-HB_DQ
#

create_generated_clock -name HB_CLK0_0 -source [get_pins */*/U_IO/U_CLK0
/dq_idx[0].ODDR_inst/C] -multiply_by 1 -invert [get_ports HB_CLK0_0]

set_output_delay -clock [get_clocks HB_CLK0_0] -min -1.000 ${HB_dq_ports}
set_output_delay -clock [get_clocks HB_CLK0_0] -max 1.000 ${HB_dq_ports}
set_output_delay -clock [get_clocks HB_CLK0_0] -min -1.000 ${HB_dq_ports} -
clock_fall -add_delay
set_output_delay -clock [get_clocks HB_CLK0_0] -max 1.000 ${HB_dq_ports} -
clock_fall -add_delay

set_false_path -from [get_pins */*/U_HBC*/dq_io_tri_reg/C] -to
${HB_dq_ports}

set_false_path -from * -to [get_pins */*/inst*/i_iavs0_270_rstn_1_reg/CLR]
set_false_path -from * -to [get_pins */*/inst*/i_iavs0_270_rstn_2_reg/CLR]
set_false_path -from * -to [get_pins */*/inst*/i_iavs0_270_rstn_3_reg/CLR]

set_false_path -from [get_clocks rwds_clk] -to [get_clocks -of_objects
[get_pins msys_i/clk_wiz_1/inst/mmcm_adv_inst/CLKOUT0]]
set_false_path -from [get_clocks virt_rwds_clk] -to [get_clocks rwds_clk]

```

## Software Design - Vitis

For SDK project creation, follow instructions from:

[Vitis](#)

## Application

Template location: ./sw\_lib/sw\_apps/

### spi\_bootloader

TE modified SPI Bootloader from [Henrik Brix Andersen](#).

Bootloader to load app or second bootloader from flash into DDR.

Here it loads the hello\_te0725.elf from QSPI-Flash to RAM. Hence \*.srec becomes redundant.

Descriptions:

- Modified Files: bootloader.c
- Changes:
  - Change the SPI defines in the header
  - Add some reiteration in the frist spi read call

### hello\_te0725

Hello TE0725 is a Xilinx Hello World example as endless loop instead of one single console output.

### memory\_test

Xilinx default memory test.

## Additional Software

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No additional software is needed.

## Appx. A: Change History and Legal Notices

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### Document Change History

To get content of older revision got to "Change History" of this page and select older document revision number.

| Date | Document Revision | Authors | Description  |
|------|-------------------|---------|--|
|      |                   |         | <ul style="list-style-type: none"><li>• 2021.2 update</li><li>• new spi_bootloader to load elf file from qspi to hyperram</li><li>• Documentation style update</li></ul> |

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| 2021-07-17   | v.9  | John Hartfiel  | <ul style="list-style-type: none"> <li>update block design image</li> </ul>                         |
| 2021-07-06   | v.8  | John Hartfiel  | <ul style="list-style-type: none"> <li>new overview description</li> </ul>                          |
| 2020-04-29   | v.7  | John Hartfiel  | <ul style="list-style-type: none"> <li>Design SW update with SREC Bootloader</li> </ul>             |
| 2020-04-27   | v.5  | John Hartfiel  | <ul style="list-style-type: none"> <li>2019.2 update</li> <li>Documentation style update</li> </ul> |
| 2018-08-09   | v.4  | John Hartfiel  | <ul style="list-style-type: none"> <li>2018.2 update</li> </ul>                                     |
| 2018-06-06   | v.3  | John Hartfiel  | <ul style="list-style-type: none"> <li>Documentation update</li> </ul>                              |
| 2018-06-05   | v.2  | John Hartfiel  | <ul style="list-style-type: none"> <li>2017.4 release</li> </ul>                                    |
|  | All  | <div> Error<br/> renderi<br/> ng<br/> macro<br/> 'page-<br/> info'<br/> <br/> Ambiguo<br/> us<br/> method<br/> overload </div> |   |

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Information for users within the European Union in accordance with Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE).

Users of electrical and electronic equipment in private households are required not to dispose of waste electrical and electronic equipment as unsorted municipal waste and to collect such waste electrical and electronic equipment separately. By the 13 August 2005, Member States shall have ensured that systems are set up allowing final holders and distributors to return waste electrical and electronic equipment at least free of charge. Member States shall ensure the availability and accessibility of the necessary collection facilities. Separate collection is the precondition to ensure specific treatment and recycling of waste electrical and electronic equipment and is necessary to achieve the chosen level of protection of human health and the environment in the European Union. Consumers have to actively contribute to the success of such collection and the return of waste electrical and electronic equipment. Presence of hazardous substances in electrical and electronic equipment results in potential effects on the environment and human health. The symbol consisting of the crossed-out wheeled bin indicates separate collection for waste electrical and electronic equipment.

Trenz Electronic is registered under WEEE-Reg.-Nr. DE97922676.

#### **Error rendering macro 'page-info'**

Ambiguous method overloading for method jdk.

proxy279.\$Proxy4022#hasContentLevelPermission. Cannot resolve which method to invoke for [null, class java.lang.String, class com.atlassian.confluence.pages.Page] due to overlapping prototypes between: [interface com.atlassian.confluence.user.ConfluenceUser, class java.lang.String, class com.atlassian.confluence.core.ContentEntityObject] [interface com.atlassian.user.User, class java.lang.String, class com.atlassian.confluence.core.ContentEntityObject]