

Ultra96: Base TRD Tutorial

Overview

The Zynq UltraScale+ MPSoC Base Targeted Reference Design (TRD) is an embedded video processing application running on a combination of APU (SMP Linux), RPU (bare-metal) and PL.

The design supports the following video interfaces:

- Sources:
 - Virtual video device (*vivid*) implemented purely in software
 - USB webcam connected to the PS (optional)
 - Test pattern generator (TPG) implemented in the PL
 - File source (raw video only)
- Sinks:
 - DP Tx display pipeline in the PS

The following processing accelerators are implemented as memory-to-memory pipelines in the PL:

- 2D-Convolution filter with programmable coefficients
- Dense optical flow algorithm

The TRD demonstrates the value of offloading computation intensive tasks from the PS onto PL, thereby freeing APU resources. The APU load is plotted on the GUI to compare a pure software vs hardware accelerated implementation.

The RPU is used to monitor the live memory throughput of the design by reading the built-in AXI performance monitors (APM) inside the PS. The data is sent to the APU via the OpenAMP communication framework and plotted on the GUI.

This document contains information about:

- How to setup the Ultra96 evaluation board and run the reference design.

Additional material that may be relevant:

- Zynq UltraScale+ MPSoC Base TRD user guide [UG1221](#): contains information about system, software and hardware architecture.

Software Tools and System Requirements

Hardware

Required:

- [Ultra96 evaluation board](#)
- Monitor with DisplayPort supporting one of the following resolutions:
 - 1920x1080 **or**
 - 1280x720
- Mini-Display Port cable (DP certified)
- Micro-USB cable, connected to laptop or desktop for the terminal emulator
- [Xilinx USB3 micro-B adapter](#)
- USB mouse
- microSD card

Optional:

- USB webcam

Compatibility

The reference design has been tested successfully with the following user-supplied components.

Monitors:

Make/Model	Native Resolution
Viewsonic VP2780-4K	3840x2160 (60/30Hz)
Acer S277HK	3840x2160 (60/30Hz)
LG 27UD58	3840x2160 (60/30Hz)
Dell U2718Q	3840x2160 (60/30Hz)
Dell P2415Q	3840x2160 (30Hz)
Dell U2414H	1920x1080 (60Hz)
GeChic On-Lap1303H	1920x1080 (60Hz)

USB Webcams:

Make/Model	Supported Resolutions	Supported Formats
Logitech BRIO	1920x1080 (30fps)	YUYV
Logitech HD Pro Webcam C920	1920x1080 (5fps), 1280x720 (10fps)	YUYV
Logitech HD Webcam C525	1920x1080 (5fps), 1280x720 (10fps)	YUYV

Note: The Logitech C525 webcam takes about 12 seconds to start after selection from the GUI. It will start streaming once the LED is lit.

DisplayPort Cables:

- Cable Matters DisplayPort Cable-E342987
- Monster Advanced DisplayPort Cable-E194698

Software

Required:

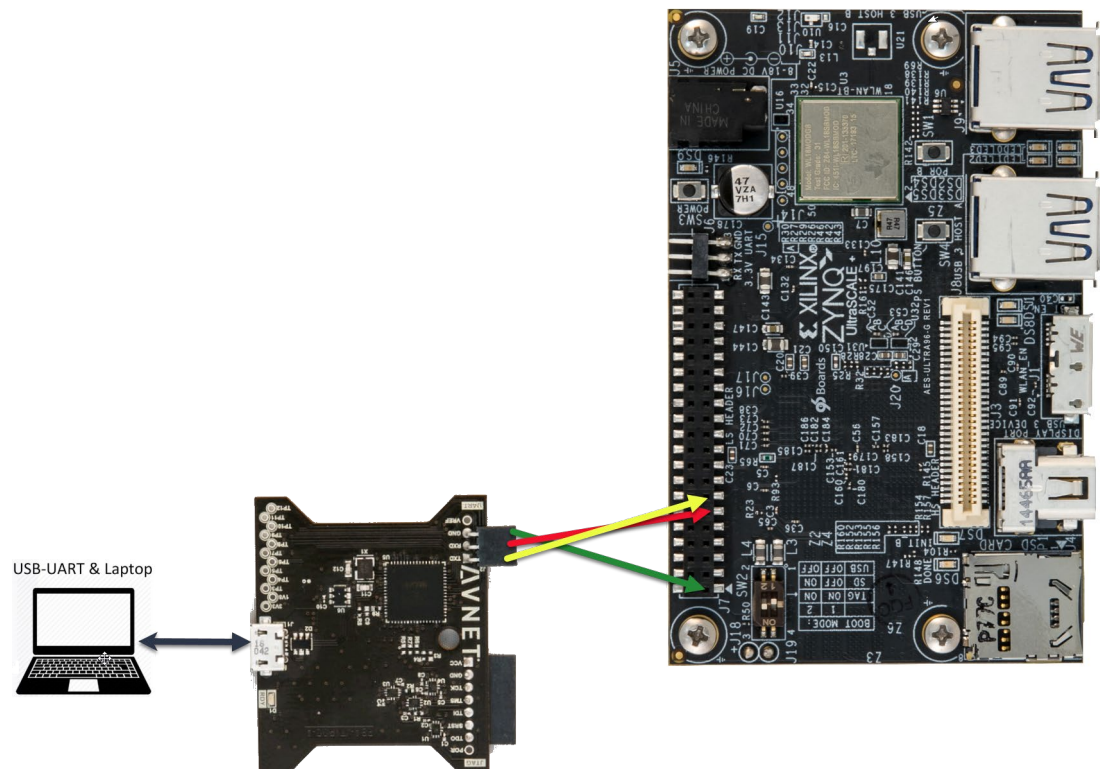
- Serial terminal emulator e.g. [teraterm](#)
 - Reference Design Zip File for [Ultra96](#) including all source code and project files (included with this download).
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Tutorials

Board Setup

Required:

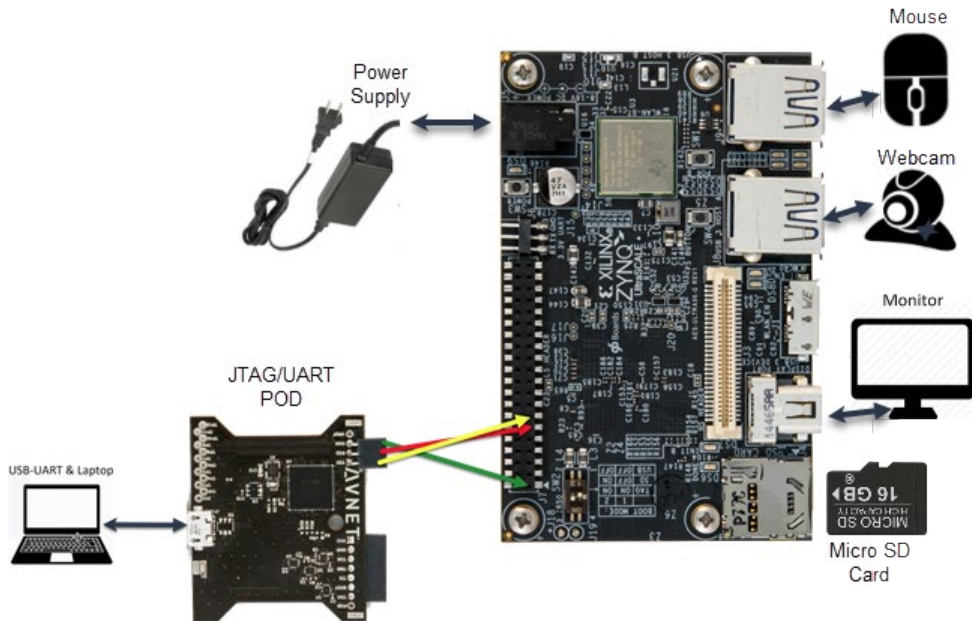
- Connect power supply to 12V power connector.
- Connect USB mouse to the first USB connector.
- Display
 - Connect a DisplayPort cable to mini-DisplayPort connector on the board; connect the other end to a monitor
- Connect your UART Device to the UART on the 40 pin low speed connector.
 - Connect GND on the UART POD to pin 1 GND on low speed connector
 - Connect RXD on UART POD to pin 11 UART1_TXD on low speed connector
 - Connect TXD on UART POD to Pin 13 UART1_RXD on low speed connector



- Use the following settings for your terminal emulator:
 - Baud Rate: 115200
 - Data: 8 bit
 - Parity: None
 - Stop: 1 bit
 - Flow Control: None
- Insert SD card (FAT formatted) with binaries copied from TRD/sd_card/dm10 directory.

Optional:

- Connect a USB webcam to the second USB connector.
Note: The USB webcam needs to output YUYV pixel format. Other formats are not supported in this design.



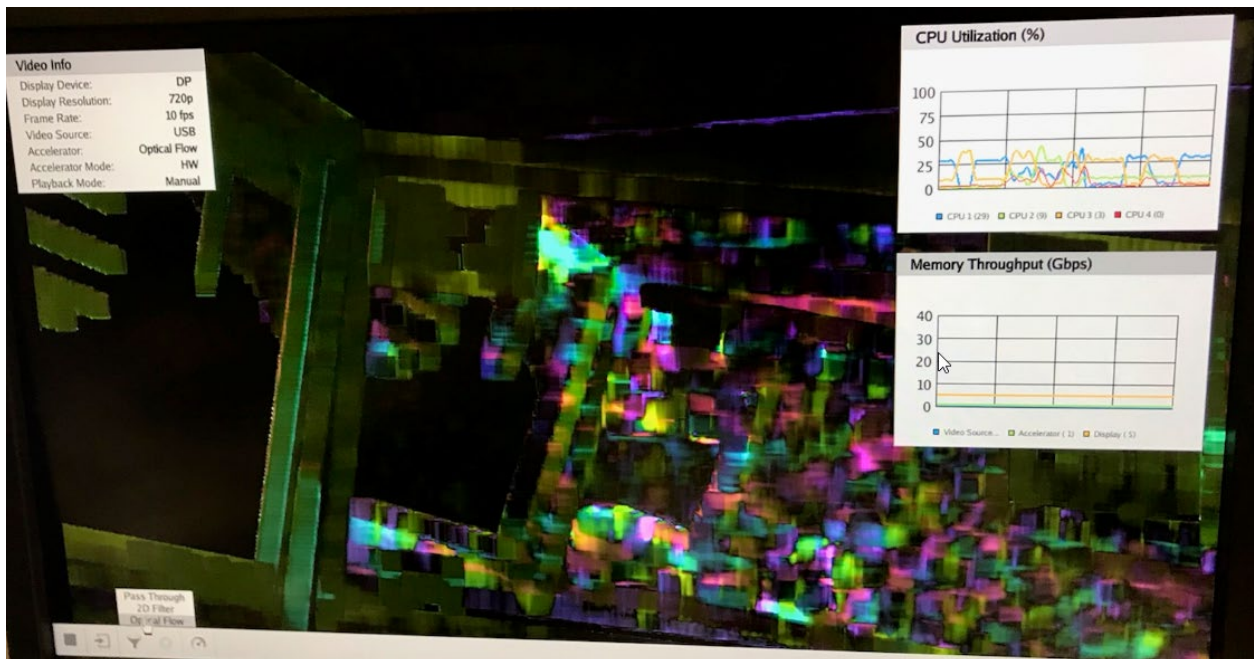
Switches:

- Set boot mode to SD card: [1,2] = Off, On



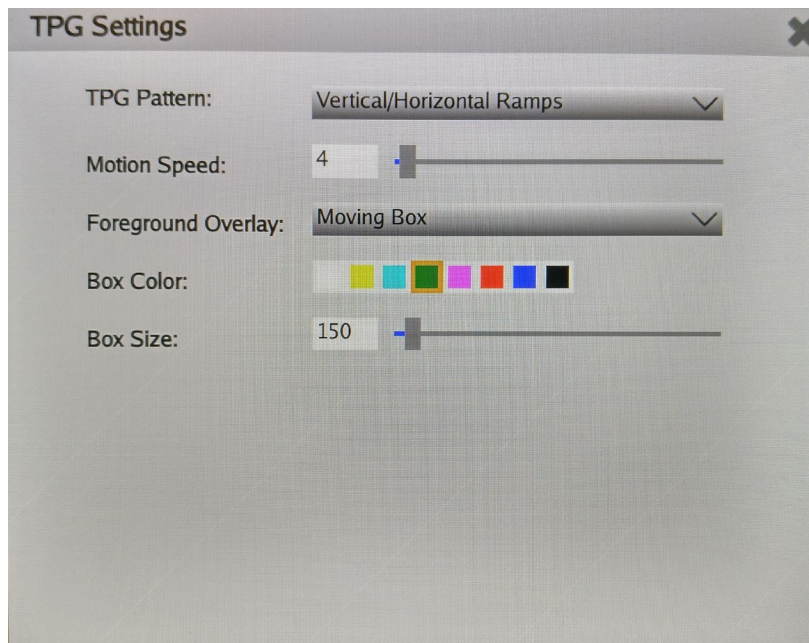
Run Flow

- Copy all the files from the TRD/sd_card/dm10 directory to a FAT formatted SD card.
- Power on the board to boot the image; make sure INIT_B LED is off and done LED is on.
- After ~30 seconds, the display will turn on and the application will start automatically, targeting the max supported resolution of the monitor (one of 1920x1080 or 1280x720).
- To re-start the TRD application with the max supported resolution, run
 - **% run_video.sh**
- To re-start the TRD application with a specific supported resolution use the -r switch e.g. for 1920x1080, run
 - **% run_video.sh -r 1920x1080**
- The user can now control the application from the GUI's control bar (bottom) displayed on the monitor.

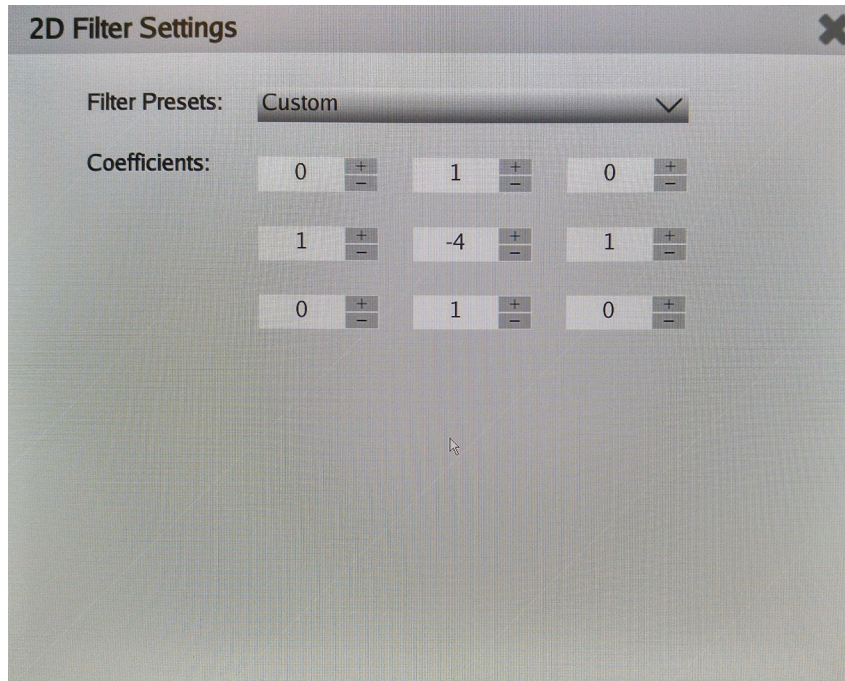


- The user can select from the following video source options:
 - TPG (SW): virtual video device that emulates a USB webcam purely in software
 - USB: USB Webcam using the universal video class (UVC) driver
 - TPG (PL): Test Pattern Generator implemented in the PL
 - File: Read input from a raw video file

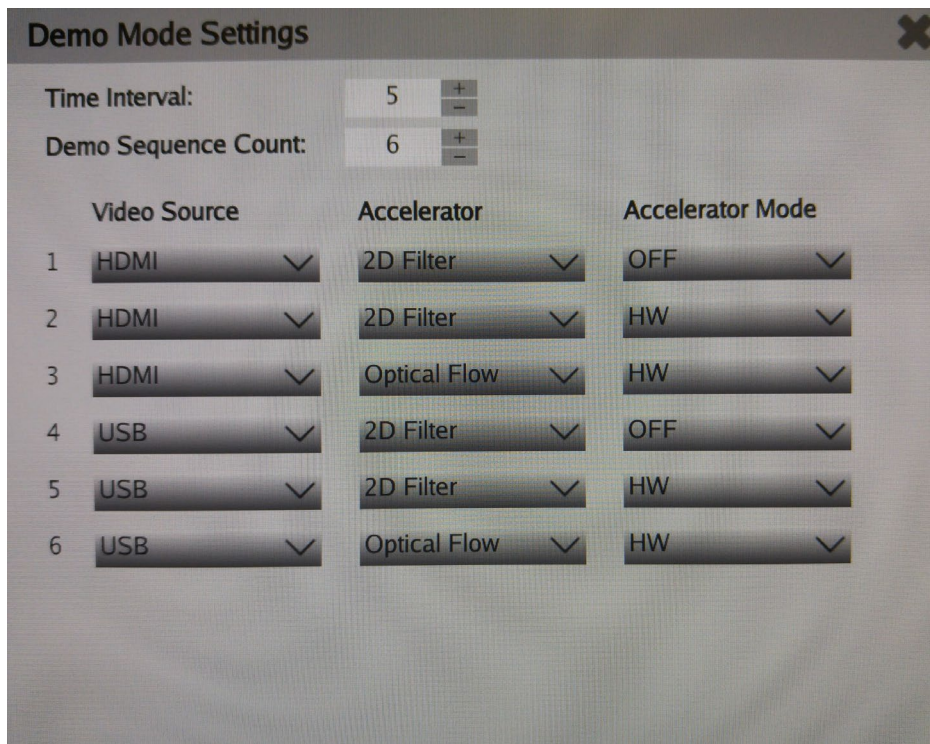
- The user can select from the following accelerator options:
 - Passthrough (no accelerator)
 - 2D convolution filter with configurable coefficients
 - Dense optical flow algorithm
- The supported accelerator mode on selected filter: (Note : SW accelerator is only available in 2D Filter)
 - HW - accelerator is run on PL
 - SW – accelerator is run on A53 (filter2d only)
- The video info panel (top left) shows essential settings/statistics.
- The CPU utilization graph (top right) shows CPU load for each of the four A53 cores.
- The memory throughput graph (bottom right) shows memory traffic generated by video source, accelerator and display.
- The TPG settings panel gives access to advanced TPG (PL) controls:



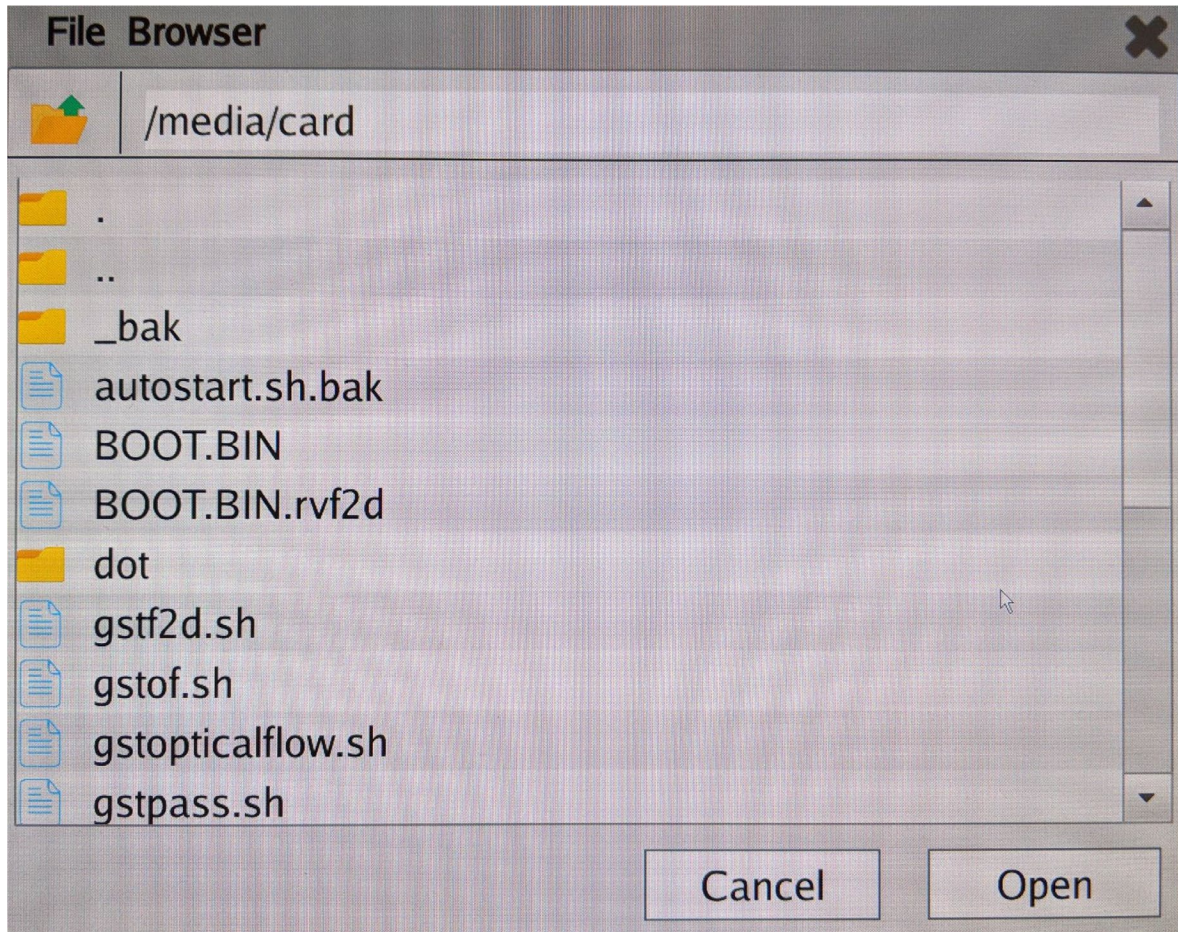
- The 2D filter settings panel gives access to advanced filter controls:



- The demo mode settings panel allows the user to create a demo sequence combining video sources, accelerators, and modes:



- The file browser allows the user to select a video file for play back when file source is selected:



Raw Video File Capture

To capture a raw video file for playback, use the serial console and the `gst-launch` utility e.g.

- `% gst-launch-1.0 videotestsrc pattern=ball num-buffers=240 ! "video/x-raw, width=1280, height=720, format=YUY2" ! filesink location=/home/root/test.yuv`

Parameters:

- `num-buffers` is the number of video frames to be captured
- `width` and `height` define the video resolution and should be matched with the display resolution
- `format` should always be set to `YUY2` as that is the expected format by the display and accelerator devices

Other Information

Known Issues

There is a GLIB memory leak when switching modes in the GUI if an accelerator is part of the pipeline and set to HW mode.

- Frequency: Common
- Workaround: Already implemented in the 2018.2 release (by setting environment variable "G_SLICE=always-malloc" before executing video_qt2 application)

Limitations

- SDSoC accelerator code runs very slow in pure software implementation when Debug configuration is used. For faster execution, set project build configuration to Release which sets SDSoC compiler to optimize most (-O3).
- The application only supports the following display resolutions: 1920x1080 and 1280x720.
- The application does not support audio.
- USB webcams:
 - Need to support the YUYV pixel format.
 - Most webcams don't support resolutions > 1080p using uncompressed video. Make sure you start the GUI in 1080p or 720p mode using the -r switch if you want to use your webcam as video source.
 - For USB2 webcams, it is expected to see increased latency and low frame rate.
- Make sure the mini-DisplayPort
- DP-to-HDMI adapters are not supported, see [AR 67462](#)
- SDSoC does not support "Estimate Performance" for the xfpopenCV library and in general for all the C++ templates (the part of Performance Estimation flow not yet supported is the estimate of software performance for function templates). Once the HLS estimate of HW resources pops up, the Ethernet P2P communication process between the SDSoC GUI and the board stalls forever and no error message is displayed.
- CPU idle and frequency scaling have been disabled in the kernel bootargs according to SDSoC guidelines (see [UG1146](#), pg 46) and to enable debug with xsdb (see [AR69143](#)).

Support

To obtain technical support for this reference design, go to the:

- [Xilinx Answers Database](#) to locate answers to known issues
- [Xilinx Community Forums](#) to ask questions or discuss technical details and issues. Please make sure to browse the existing topics first before filing a new topic. If you do file a new topic, make sure it is filed in the sub-forum that best describes your issue or question e.g. Embedded Linux for any Linux related questions. Please include "Ultra96 Base TRD" and the release version in the topic name along with a brief summary of the issue.