VectorBlox™ Video Kit Demo Guide V1.2

Purpose

This demo is for CoreVectorBlox neural network acceleration on the PolarFire® field-programmable gate array (FPGA) devices. This document provides instructions on how to use the corresponding reference design.

Intended Audience

This demo guide is intended for:

- FPGA designers
- Firmware designers
- System level designers
- Data scientists

References

The following documents are referred in this demo guide.

- *CoreVectorBlox SDK Programmer's Guide*
- *CoreVectorBlox IP Handbook*

Table of Contents

1. Introduction

This document describes how to run the CoreVectorBlox Neural Network using the PolarFire Video Kit, the Dual Camera sensor module, an HDMI monitor, and optionally a HDMI source such as a laptop. The demo design features a fully integrated solution developed using Microchip Libero® SoC software to help customers evaluate PolarFire FPGA in Neural Network Vision applications and to build prototypes quickly. For more information, see Smart Embedded Vision.

The demo demonstrates the following functions:

- MIPI CSI-2 RX to read one of the cameras
- HDMI display controller
- VectorBlox CNN acceleration of Tiny YOLOv3
- VectorBlox CNN acceleration of MobileNet V1
- Vectorblox CNN acceleration of a face recognition solution featuring Retinaface Mobilenet and Arcface
- Image enhancements such as contrast, brightness, and color balance

The PolarFire Video Kit (MPF300-VIDEO-KIT-NS) includes the following components:

- A 300K LE FPGA (MPF300T, FCG1152)
- HDMI 1.4 transmitter (ADV7511) chipset and corresponding connector
- HDMI 2.0 with rail clamps, ReDrivers, and corresponding connectors
- Dual camera sensor featuring IMX334 Sony image sensor
- Image sensor interface to support up to two MIPI CSI-2 cameras
- Display Serial Interface (DSI)
- NVIDIA® Jetson interface (MIPI CSI-2 TX connector)
- A High Pin Count (HPC) FMC connector to connect to high-speed interfaces (such as 12G-SDI and USXGMII)

For more information about the video kit, see PolarFire FPGA Video and Imaging Kit.

1.1 Known Issue

There is a known Reset bug where sometimes the frame buffer management comes out of Reset incorrectly. If the output video is out of sync, try power cycling the board.

2. Design Requirements

The following table lists the hardware and software required to run the demo.

Design Requirements	Description
Hardware Requirements	
PolarFire Video Kit Development Board	MPF300-VIDEO-KIT-NS
USB A to mini-B cable(1)	Required for the following: • FPGA programming and SPI Flash programming • Running the modified Mi-V C code from SoftConsole
HDMI cable(1)	HDMI A Male to Male cable
Power adapter(1)	12V, 5A
HDMI monitor	A 1920 x1080 60 Hz resolution monitor for the HDMI 1.4 TX port
Host PC	A host PC with a USB port and HDMI output
Software Requirements	
Libero® System-on-Chip (SoC) v2021.2	You must install the full Libero SoC software and not just the programming tools to program the SPI Flash, which cannot be done from FPExpress. A Libero license is necessary; the video kit comes with a Gold license or an evaluation license that can be obtained from the **Licensing** tab of the following page. Libero SoC v12.0 and later
CoreVectorblox License	To configure and synthesize the CoreVectorblox IP, a license is required. It is available at SoC portal.

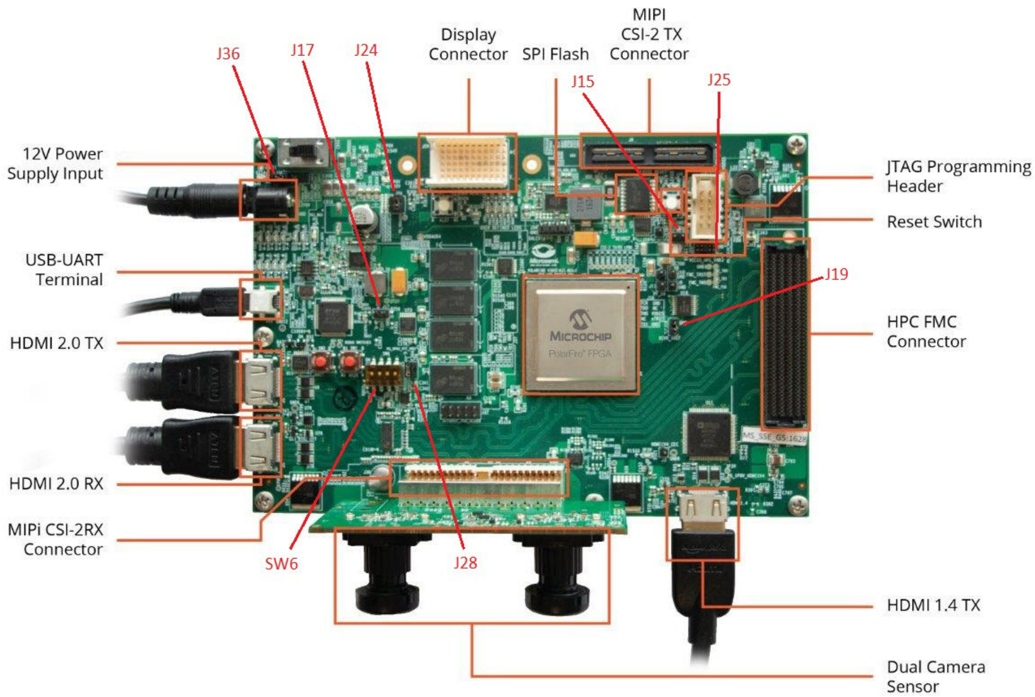
Note:

1. Included with the PolarFire Video Kit.

3. Development Kit for Demo

The following figure highlights the features of PolarFire Video Kit.

Figure 3-1. PolarFire Video Kit Features



The following table provides the jumper position and functionality for the jumper settings.

Table 3-1. Jumper Description

Jumper	Default Position	Functionality
J15	Open	SPI Slave and Master mode selection. Default: SPI master.
J17	Open	100K PD for TRSTn. Default: 1K PD is connected.
J19	Pin1 and 2	Default: XCVR_VREF is connected to GND.
J28	Pin 1 and 2	Default: Programming through the FTDI.
J24	Pin 2 and 4	Default: VDDAUX4 voltage is set to 3V3.
J25	Pin 5 and 6	Default: Bank4 voltage is set to 1V8.
J36	Pin 1 and 2	Default: Board power-up through SW4.
SW6	ON	Chooses between the face recognition demo and the mobilenet/yolo demo.

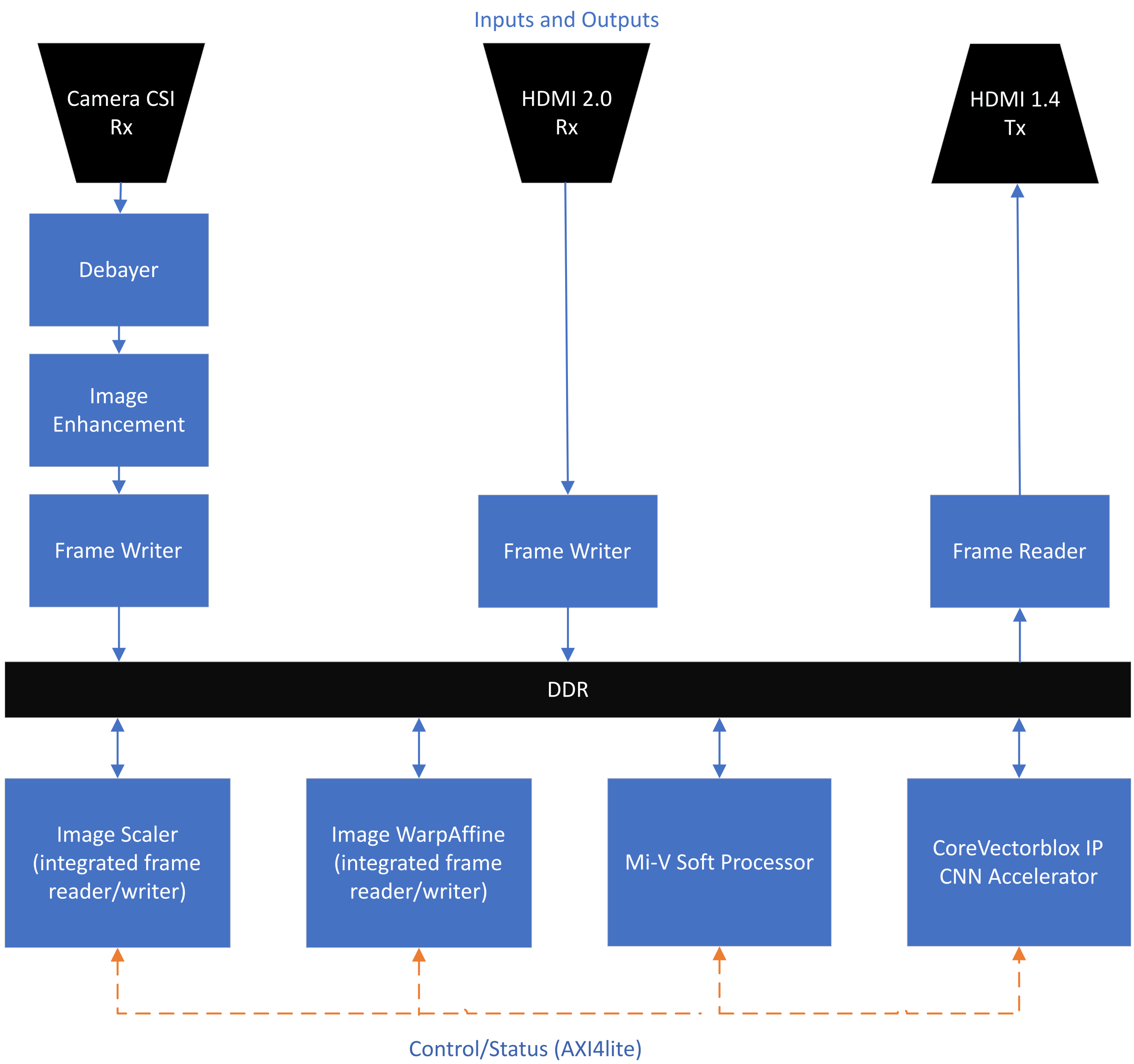
4. Demo Design Description

The following section provides an overview of the dataflow in the demo design. This system design allows the mobilenet/yolo demo and the face recognition demo to run on the same hardware.

4.1 System Design

The following diagram illustrates an overview of the dataflow in the design.

Figure 4-1. System Dataflow



Sequence of data flow shown in the figure above is as follows:

1. Input
    a. Received from MIPI CSI 2: Video frame data is passed through a debayer and Image Enhancement block to a Frame Writer which writes the video data to DDR.
    b. Received from HDMI Rx: If a source is connected to J35, the video frame data is sent directly to a Frame Writer which writes the video data to DDR.
2. Based on demo requirements, Mi-V instructs the Image Scaler and/or the Image WarpAffine block to process the input frame appropriately for CNN(s). If an HDMI source is present, the input frame is taken from HDMI, otherwise it is taken from the camera. The result of scaling and warping is written to DDR.
3. Mi-V instructs CoreVectorBlox IP to run the appropriate CNN using the scaled and warped image as input to CNN. The result of CNN is written back to DDR by CoreVectorBlox IP.
4. Mi-V reads the result of CNN from DDR and runs post-processing software routines. The result is then drawn on the original Input Frame Buffer.
5. The Frame Reader reads the frame and streams the frame data to the HDMI Tx block.

5. Setting Up the Demo

The following steps describe how to setup the demo.

1. Setting up the Hardware
2. Programming the PolarFire Device
3. Programming the SPI Flash

5.1 Setting Up the Hardware

Setting up the hardware involves interfacing the dual camera sensor module and the HDMI monitor with the PolarFire Video Kit, and verifying the jumper settings.

Perform the following steps.

1. Connect the J1 connector of the dual camera sensor module to the J5 interface of the video kit. The video kit is already shipped with this.
2. Connect the Full HD HDMI (1080P) monitor to J2 (HDMI 1.4 TX port) of the video kit using the HDMI cable.
3. Connect the host PC to J12 of the video kit using the USB mini cable.
4. Connect the power supply cable to J20 of the video kit.
5. Ensure that the jumper settings are set on the video kit. The video kit is shipped in this configuration. For jumper position and functionality, see Table 3-1.
6. Power-up the HDMI monitor.
7. Power-up the board using the SW4 slide switch.
8. Optionally, if running the face recognition demo, connect HDMI source playing SampleVideo.mp4 (supplied with the project ZIP file) fullscreen to the HDMI 2.0 RX port (J35).

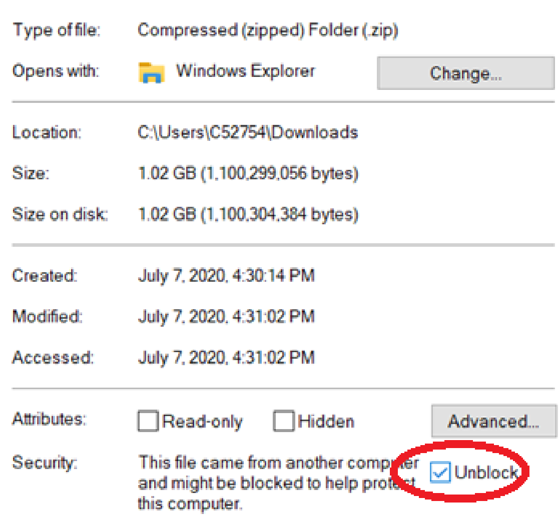
The PolarFire dual camera video and imaging hardware setup is completed.

5.2 Programming the PolarFire Video Kit

The following section describes how to program the PolarFire device and run the demo.

5.2.1 Extracting the Source files and Opening the Project

Before unzipping the archive containing the libero project, first “unblock” the file. This is necessary to ensure that Windows does not change the timestamps of the files during extraction. To unblock the file, right click the zip file, select **Properties** and check **Unblock**, then click **OK**.



After unzipping the archive, launch Libero SoC v2021.2, and open the `vectorblox_videokit_v1.2/vectorblox_videokit_v1.2.prjx` project file.

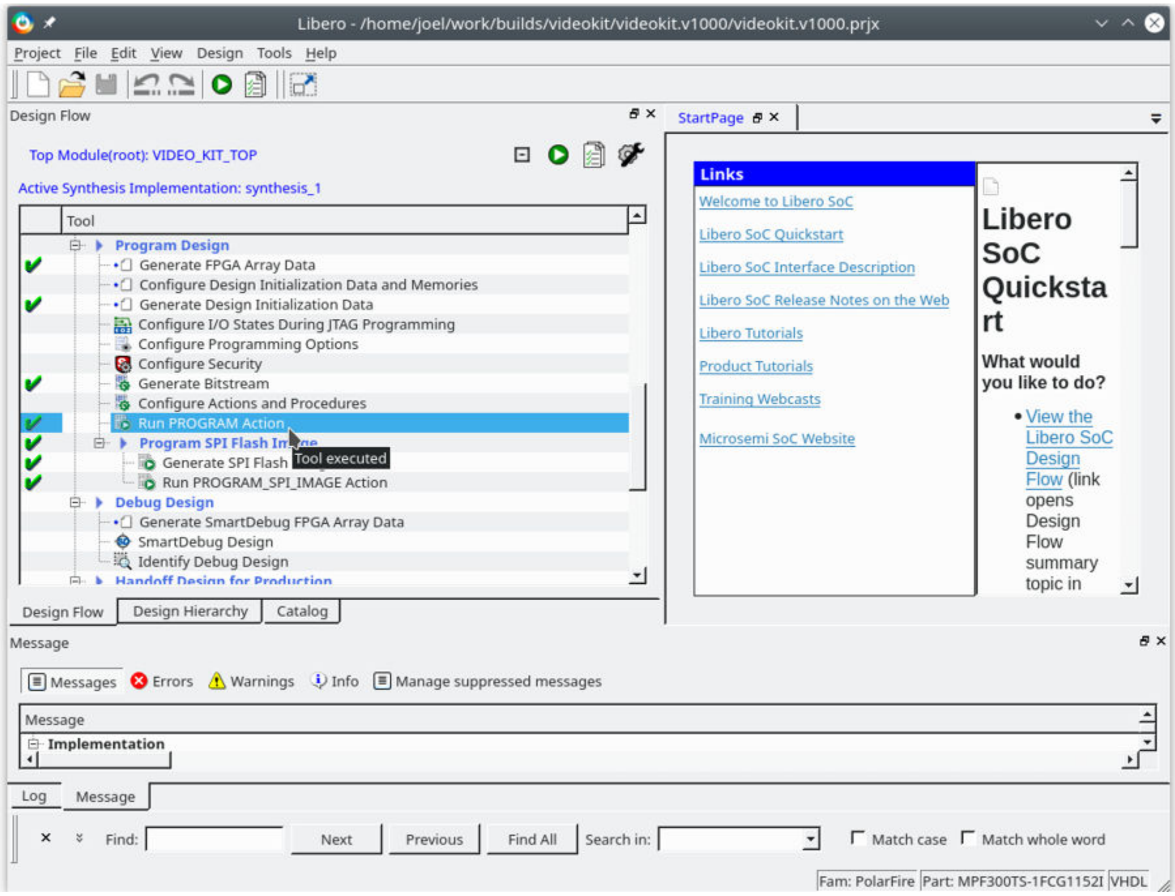
Note: You may be prompted to update Libero SoC or individual IP cores, ignore these prompts.

5.2.2 Programming the Device

Perform the following steps.

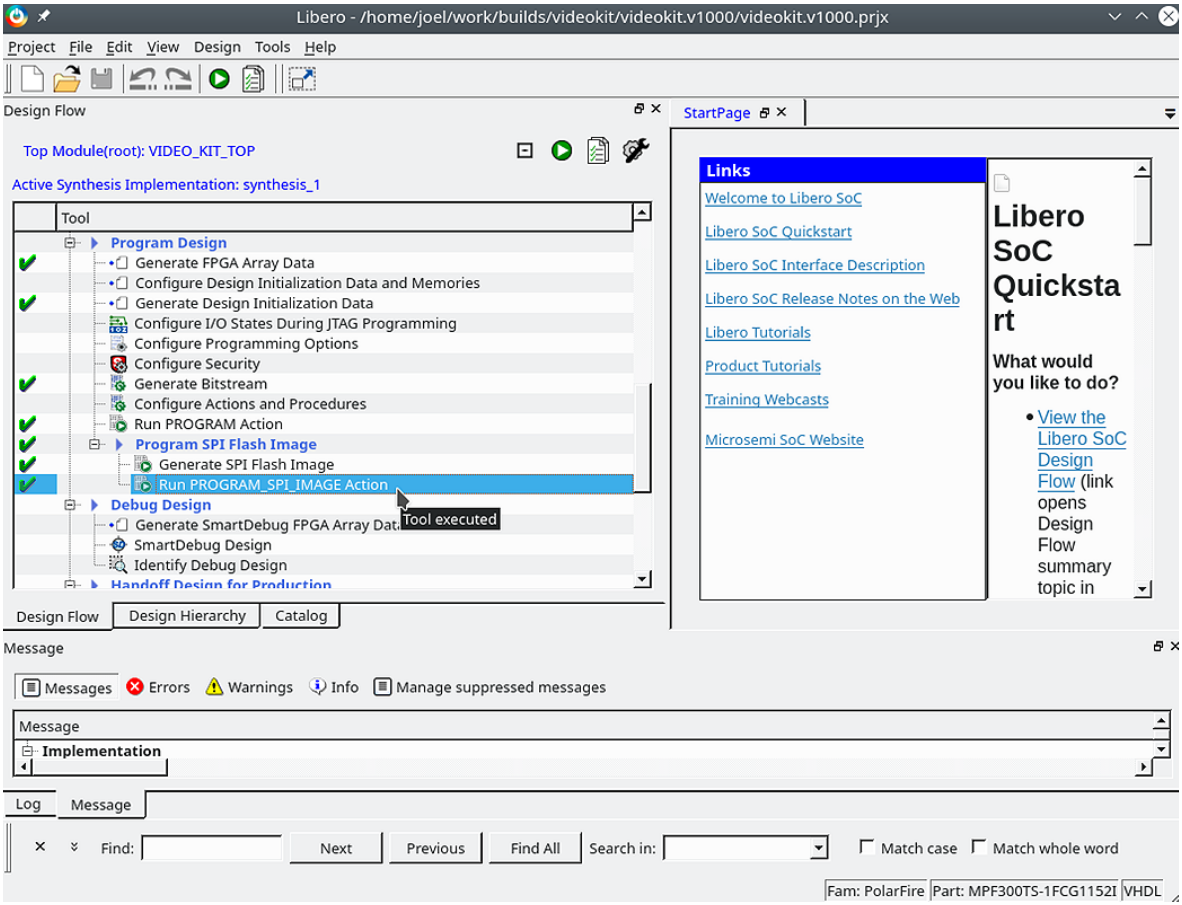
1. In the **Design Flow** window, double click **Run PROGRAM Action**.

Figure 5-1. Run PROGRAM ACTION



2. Double click **Run PROGRAM_SPI_IMAGE Action** and wait. This will take some time.
Notes:
   - In Windows, you might be prompted with a firewall popup.
   - Ignore any warnings about misaligned sectors.

Figure 5-2. Run PROGRAM_SPI_IMAGE Action



5.2.3 Running the Demo

Power cycle the board with SW4 to start the demo.

Note: Sometimes the demo might appear to start correctly without a power cycle but actually be in an Incoherent state.

The startup takes a few minutes. The following events occur during the startup: the camera is calibrated to the brightness of the environment, the firmware and models are read from the Flash into DDR.

After the startup is completed, one of the following occurs:

- With SW6.1 set to “ON”, the demo will switch every 5 seconds between MobileNet V1 and TinyYoloV3.
- With SW6.1 set to “OFF”, the demo will run Retinaface Mobilenet to find faces in the frame.
  Note: The device (for example, laptop) should be running the mp4 video connected over HDMI to J35 for this.

  If faces are found, it will run Arcface for one of the faces to identify the face. If more than one face is found, the other faces will rely on the Kalman filter tracking to keep track of the name of the face.

For face recognition and mobilenet demos, you can select the source of the frames that needs to be processed by the network. The source is determined by connecting to the J35 connector. An HDMI cable connecting a video source (for example, from a laptop) will take priority over the image sensor coming with the video kit. If the HDMI cable is not connected to J35, the image sensor will be selected as the source.

6. Running Alternate Models

When SW6.1 is set to “ON”, the project that is provided here runs only two models: MobileNet V1 and Tiny YOLOv3. However, it is capable of running many other networks. In this document, you will see an example of swapping out Tiny YOLOv3 for Tiny YOLOv2.

In this demo, four models are required in the specified order:

- A face detection model
- A face recognition model
- Two classification/object-detection models

The first two are used in the Face Recognition mode, and the latter two are cycled between in the Classification/Object-Detection mode.

Currently, post-processing routines exist for TinyYoloV2 (VOC), TinyYoloV3 (COCO), Retinaface, Blazeface, Sphereface/Arcface (face recognition), and Imagenet networks. Users will have to write additional post-processing code to run other networks.

The following sections describe how to run the alternate models.

6.1 Obtaining Model File

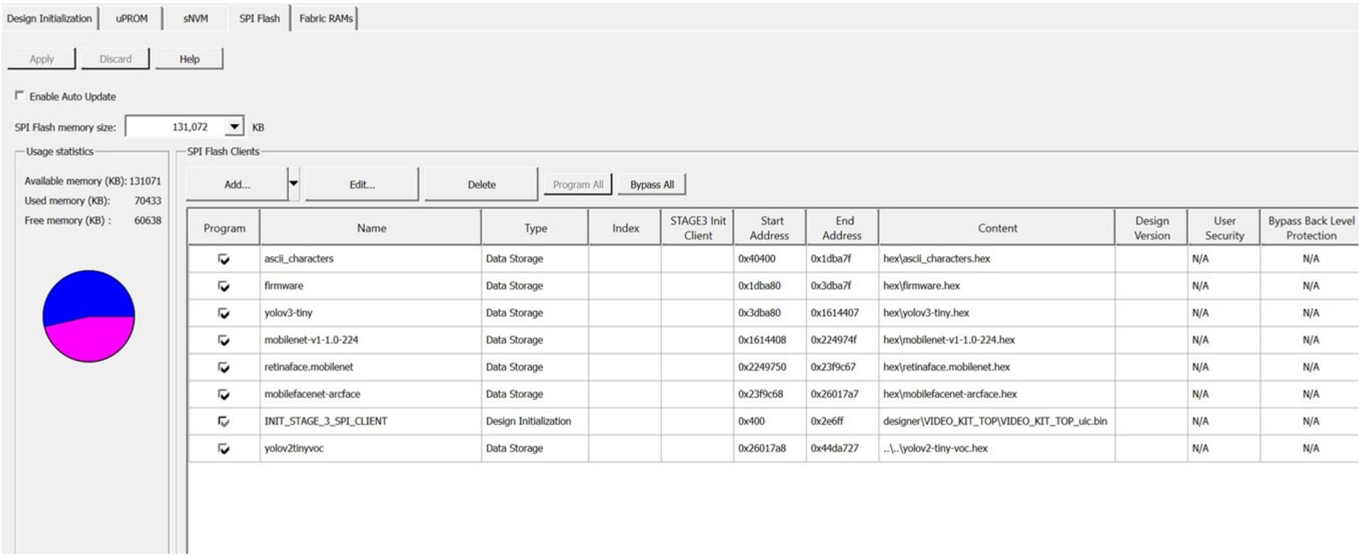
The model files can be obtained by running the tutorial available in the VectorBlox SDK in Github. Instructions for running the tutorials can be found in the Programmer's Guide available as part of the SDK documentation. The artifact generated from the tutorial that needs to be stored is `yolov2-tiny-voc.hex`. This hex file will be added to the SPI Flash on the board.

6.2 Modifying the SPI Flash Configuration

Perform the following steps in Libero.

1. Invoke the “Configure Design Initialization Data and Memories” tool in the Libero Design Flow.
2. To add a new model, click the **Add** button, and select the **Add Data Storage Client** option. Change the path to point to `yolov2-tiny-voc.hex` (file described in the preceeding section, Obtaining Model File).
   Note: Ensure the address range does not overlap with other clients in the Flash memory.
3. Click **Apply**.
4. In the **Design Flow** window, double click **Run PROGRAM_SPI_FLASH Action** (see Step 3 in the Programming the Device section).
5. After the SPI programming is complete, power cycle the board using SW4.

Figure 6-1. SPI Configuration after Modification



6.3 SoftConsole Project

Before the new model is run on the FPGA, the software running on Mi-V must be modified as described in this section.

A SoftConsole project is located in the Libero Design zip archive at `Download_Directory/vectorblox_videokit_v1.1/softconsole`. Open that directory as a workspace with SoftConsole 6.2 or later.

In the VideoKit project locate and open `main.c`. The following code can be seen on line 187.

```
struct model_descr_t models[] = {
                {"Retinaface",0x2249750, 256, RETINAFACE,30},
                {"Arcface",0x23f9c68, 112, ARCFACE, 30},
                {"MobileNet V1",0x1614408 , 224, IMAGENET, 10},
                {"Tiny Yolo V3 COCO",0x3dba80 , 416, TINYYOLOV3, 30},
};
```

Change the code to the following.

```
struct model_descr_t models[] = {
                {"Retinaface",0x2249750, 256, RETINAFACE,30},
                {"Arcface",0x23f9c68, 112, ARCFACE, 30},
                {"MobileNet V1",0x1614408 , 224, IMAGENET, 10},
                {"Tiny Yolo V2 VOC",0x26017a8 , 416, TINYYOLOV2, 30},
};
```

Where, parameters in the structure are as follows:

- Display name of the model
- Address in the SPI Memory in which the model is stored.
- Resolution of the square input image needed for the network.
  Note: Resolution of the network should be documented by the network provider. For instance, OpenVino's open-model-zoo; it can link to https://github.com/openvinotoolkit/open_model_zoo.
- The type of postprocessing for displaying the network. Currently, IMAGENET (Resnet/Mobilenet/etc.), Retinaface, Blazeface, Sphereface/Arcface (face recognition), TinyYoloV2, and TinyYoloV3 are implemented.
- The maximum number of frames per second to display. Used to reduce the rate of change of displayed labels to make the network output readable.

Ensure you have the four models listed for full demo functionality, in the following order:

- A face detection model
- A face recognition model

- Two classification/object-detection models

After these modifications are performed, save the `main.c` file, and build the project. The software is now ready to run and models can be executed.

6.4 Running the Mi-V Program

Make sure to use FP5 and jumper J28 connects Pin 1 to Pin 2. To run the Mi-V program, click the  button in the toolbar.

7. Revision History

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

Revision	Date	Description
D	09/2021	Updated to 1.2 Release
C	05/2021	Updated to 1.1 Release
B	11/2020	Updated to 1.0 Release
A	08/2020	Initial Revision

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