VectorBlox Video Kit Demo Guide V1.0

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, and an HDMI monitor. 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
- 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.

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
Software Requirements	
Libero® System-on-Chip (SoC) v12.5	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

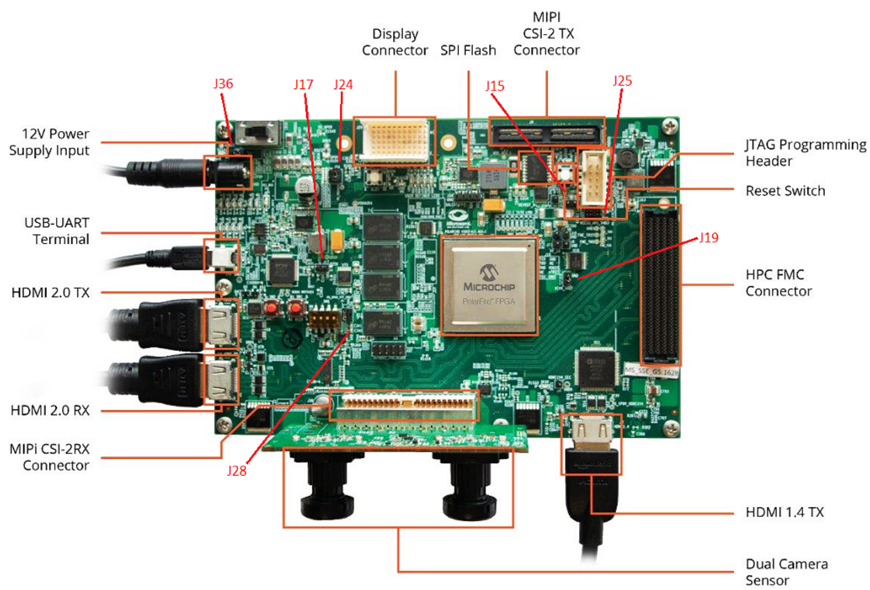
Note:

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.

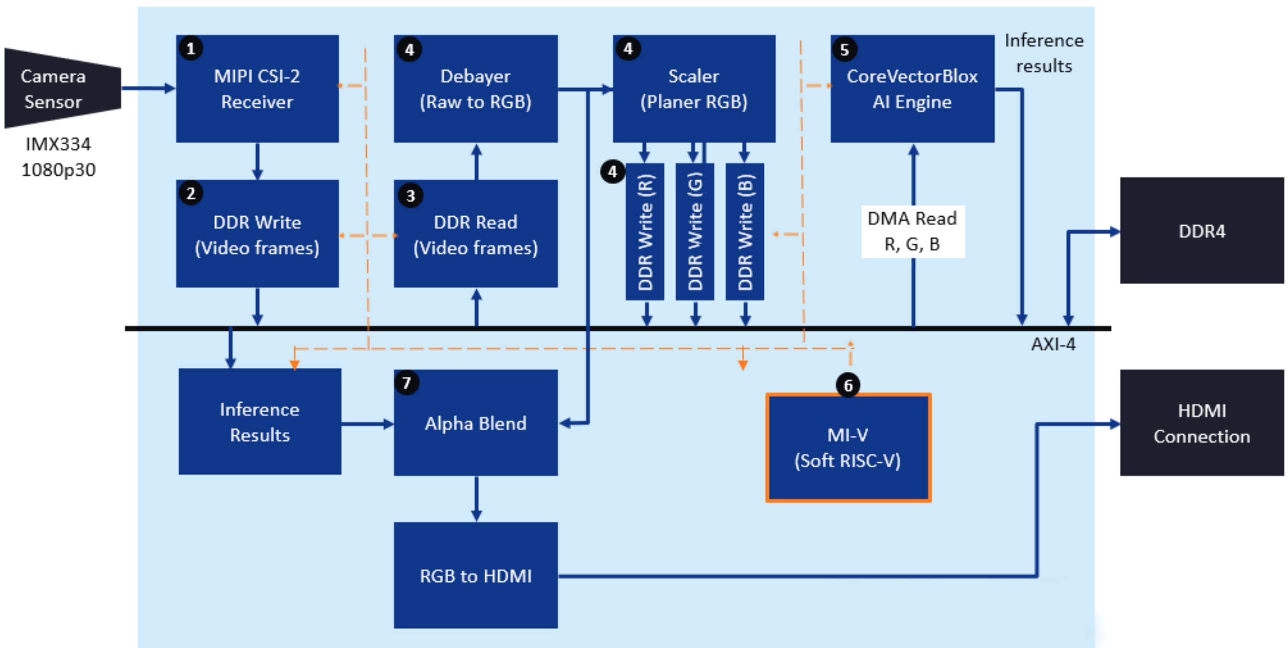
4. Demo Design Description

The following section provides an overview of the dataflow in the demo design.

4.1 System Design

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

Figure 4-1. System Dataflow



Sequence of dataflow shown in the figure above is as follows:

1. Video frame is received through MIPI CSI-2.
2. It is stored in DDR through AXI-4 interconnect.
3. Before inference—the frame is read back from DDR.
4. Converted from RAW to RGB, RGB to planer R, G, B and written back into DDR.
5. CoreVectorBlox engine runs inference on R, G, B arrays and writes results back into DDR.
6. Mi-V sorts probabilities, creates an overlay frame with bounding boxes, classification results, fps etc. and stores the frame in DDR.
7. The original video frame, as read in step 3, is blended with the overlay frame and sent out to an HDMI display.

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 monitor to J2 (HDMI 1.4 TX port) of the video kit using the HDMI cable.
3. Connect the host PC and the video kit 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.

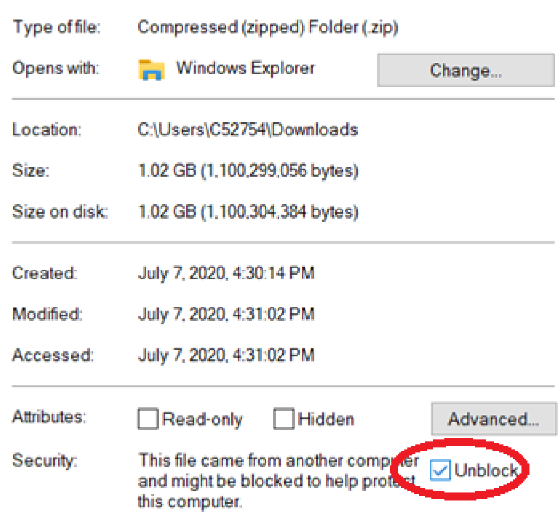
The PolarFire dual camera video and imaging hardware set up is completed.

5.2 Programming the PolarFire Device

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 v12.5, and open the `.prjx` project file.

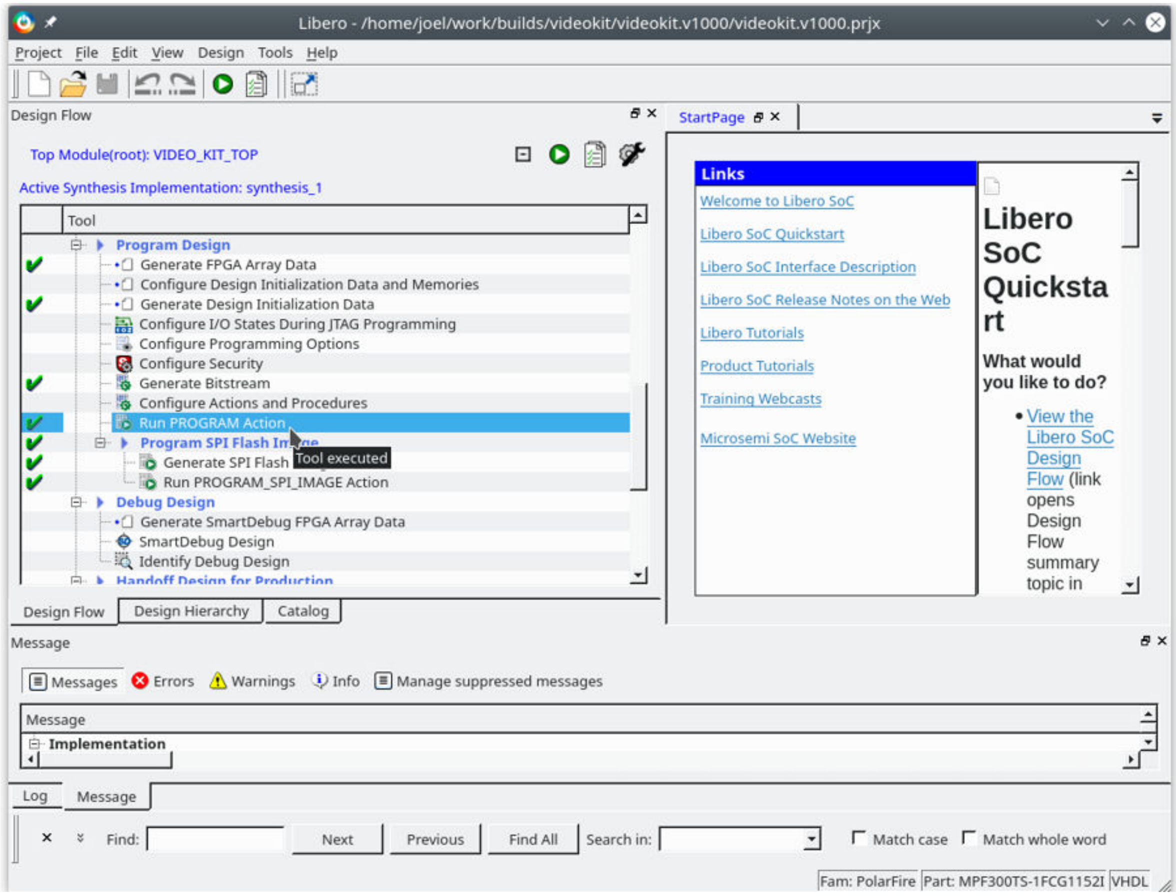
Note: You may be prompted to update Libero SoC or individual IP cores, ignore these prompts.

5.2.2 Programming the Device

Perform the following steps.

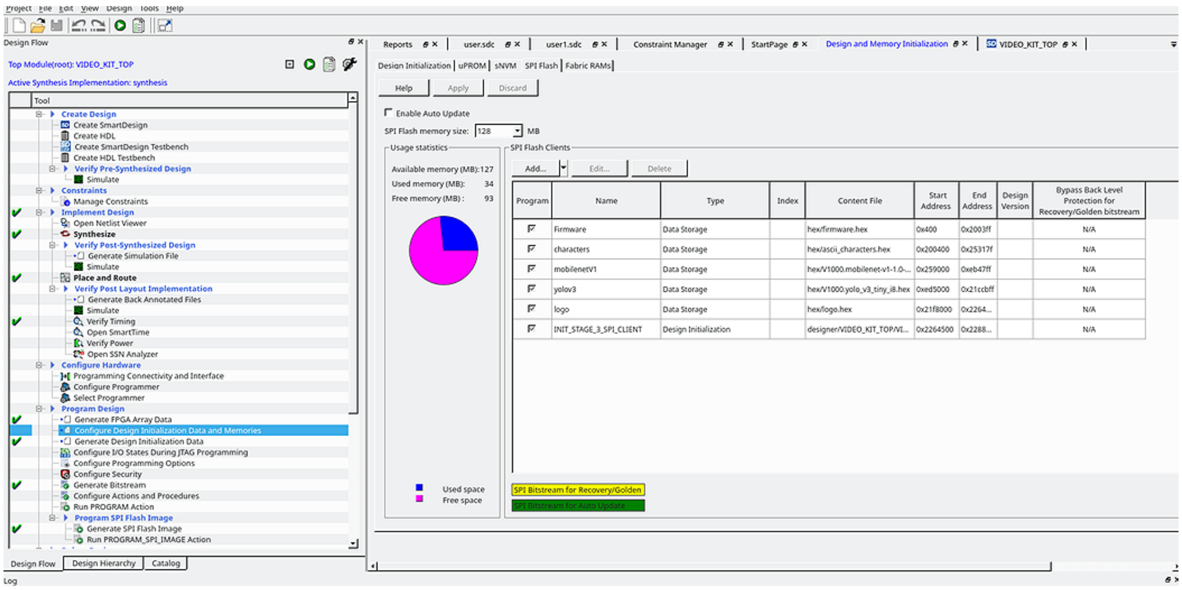
1. In the **Design Flow** window, double click **Run PROGRAM Action**.

Figure 5-1. Run PROGRAM ACTION



2. To program the SPI Flash, double click **Configure Design Initialization Data and Memories**.
   Note: The model and firmware files are configured to be programmed into the SPI Flash chip. There are other files listed (`ascii_characters.hex` and `logo.hex`) that are used for drawing the results of the models onto the HDMI connected screen.

   Figure 5-2. Configure Design Initialization Data and Memories

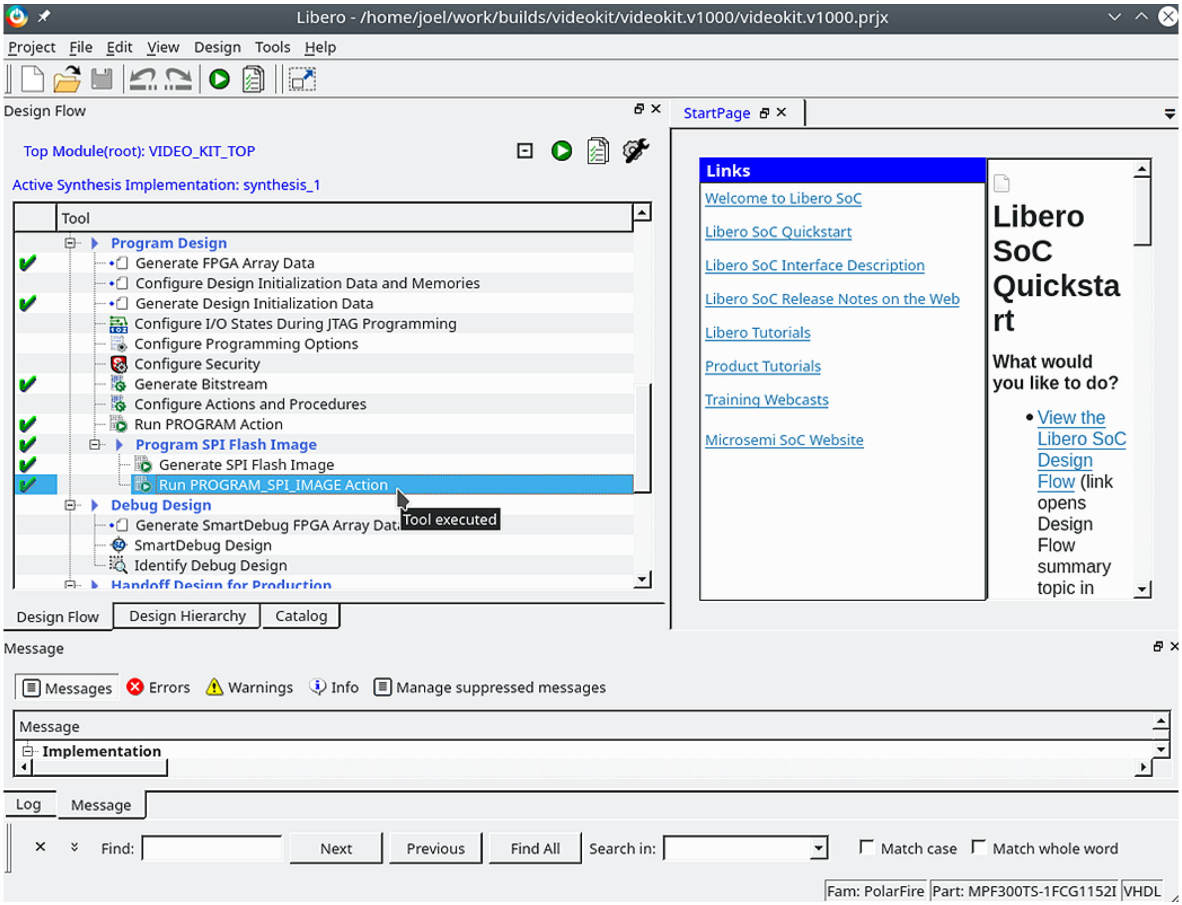
   Refer to the following table for contents in the SPI Flash Hex file.

Table 5-1. SPI Flash Contents

Name	Description
Firmware	CoreVectorBlox firmware BLOB
characters	Character set for overlay display
mobilenetV1	MobileNetV1 model BLOB
yolov3	Tiny YOLOv3 model BLOB
logo	Microchip logo for overlay display
INIT_STAGE_3_SPI_CLIENT	Mi-V demo code

3. Double click **Run PROGRAM_SPI_IMAGE Action** and wait. This will take some time.
Note: In Windows, you might be prompted with a firewall popup.

Figure 5-3. Run PROGRAM_SPI_IMAGE Action



5.2.3 Running the Demo

Power cycle the board with SW4 to start the demo.

The startup might take 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, and the models are tested with the test data.

After the startup is completed, the demo will switch every 5 seconds between MobileNet V1 and YOLOv3.

6. Running Alternate Models

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.

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 (available separately). 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. To change the file pointed to by the YOLO data client to the generated file, highlight the `TinyYoloV3.hex`, click the **Edit** button, and 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.
2. Click **Apply**.
3. In the **Design Flow** window, double click **Run PROGRAM_SPI_FLASH Action** (see Step 3 in the Programming the Device section).
4. After the SPI programming is complete, power cycle the board using SW4.

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/videokit.v1000/softconsole`. Open that directory as a workspace with SoftConsole 6.2.

In the VideoKit project locate and open `main.c`. The following code can be seen in or on line 289.

```
struct model_descr_t models[] = {
        {"MobileNet V1",0x259000,224,IMAGENET,10,0xf203f880,30},
        {"Tiny Yolo V3 COCO",0xed5000,416,YOLOV3,30,0x8d989534,30},
              };
```

Change the code to the following.

```
struct model_descr_t models[] = {
        {"MobileNet V1",0x259000,224,IMAGENET,10,0xf203f880,30 view},
        {"Tiny Yolo V2 VOC",0xed5000,416,YOLOV2,30,0,0},
              };
```

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.), YOLOv2, and YOLOv3 are implemented.

- The maximum number of frames per second to run at. Used to reduce the rate of change of displayed labels to make the network output readable.
- The last two parameters are for verification at boot time.
  - The first is the correct checksum of the network running the built in test input.
  - The second is the number of self test runs to perform. If the correct checksum is unknown for a network, set them both to 0 to disable the boot time verification.

After these modifications are performed, the software will run and models can be executed.

6.4 Running the Mi-V Program

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
B	11/2020	Updated to 1.0 Release
A	08/2020	Initial Revision

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