OPC UA Industrial Edge Demo

AN4977

Introduction (Ask a Question)

This application note describes the Open Platform Communications Unified Architecture (OPC UA) based Industrial Edge demonstration. This solution runs on PolarFire® SoC, which is configured as an OPC UA server and/or client. The design demonstrates communication over OPC UA between the PolarFire SoC Video Kit, the PolarFire SoC ICICLE Kit, and the Stepper 7 Click using the UAExpert (a full-featured OPC UA client).

Microchip's PolarFire SoC devices combine RISC-V based 5x core Microprocessor Subsystem (MSS), capable of running Linux®, and the PolarFire Fabric in a single device. This combination enables the partitioning of user designs between the MSS (C Source code) and the Fabric (RTL). Microchip's Libero® SoC enables the rapid development of RTL based designs for PolarFire SoC, and many other device families. Libero SoC provides a wide range of IPs for a variety of applications such as video and imaging, signal processing, wired and wireless communications, and networking. Microchip's SoftConsole enables the rapid development of C/C++ source code based applications targeted for all Microchip FPGA and SoC device families.

Stepper 7 Click is a bipolar step motor driver, and features an H-bridge bipolar step motor driver. It supports the Full and Half-Step Control modes. Stepper 7 Click also carries a port expander so that the communication can be done with a minimal number of pins, through the mikroBUS™ SPI bus.

Table of Contents

1. Design Overview (Ask a Question)

The design demonstrates the basic functionality of the PolarFire SoC Video Kit, the PolarFire SoC ICICLE Kit, the Stepper Motor, and their communication with each other over the OPC UA protocol. OPC Unified Architecture (OPC UA) is a machine-to-machine communication protocol used for OPC UA Industrial Edge demo.

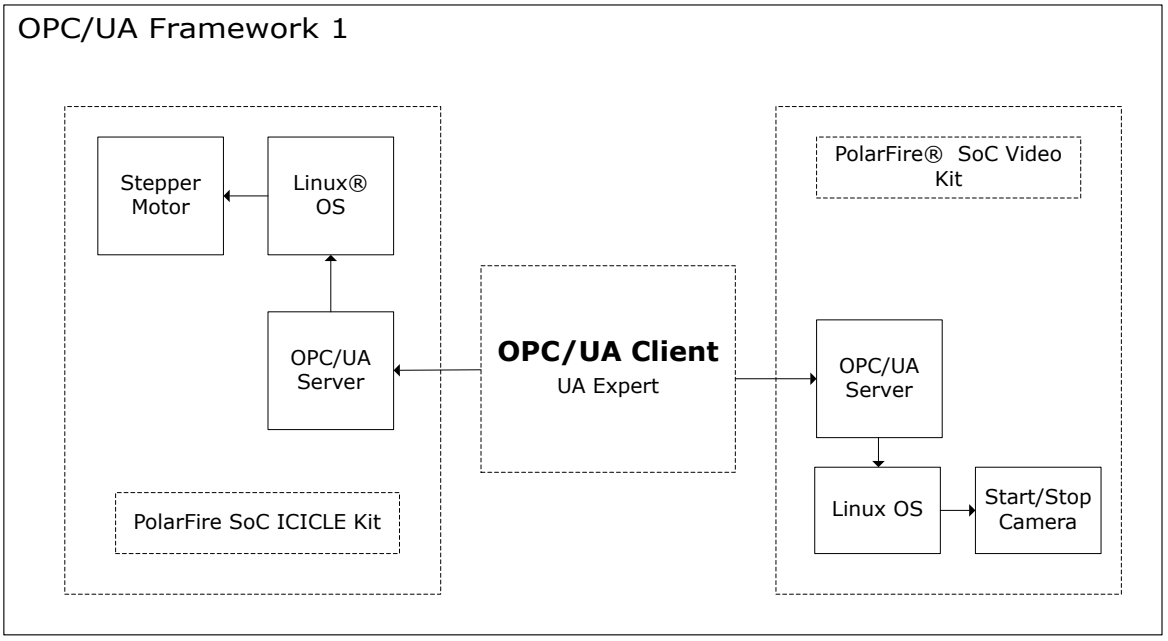
The demo can be run with any of the following scenarios.

- To control Video Kit and ICICLE Kit individually from UAExpert OPC UA client.
- To control Video Kit through ICICLE Kit – OPC UA client.

Scenario 1

In this scenario, OPC UA Client UAExpert acts as the main controller, which controls the PolarFire SoC Video Kit and the Stepper Motor on the ICICLE Kit. Control signals from UAExpert are sent over the OPC UA channel to the PolarFire SoC Video Kit for video streaming and to stepper motor to start or stop the motor in clockwise or anti-clockwise direction.

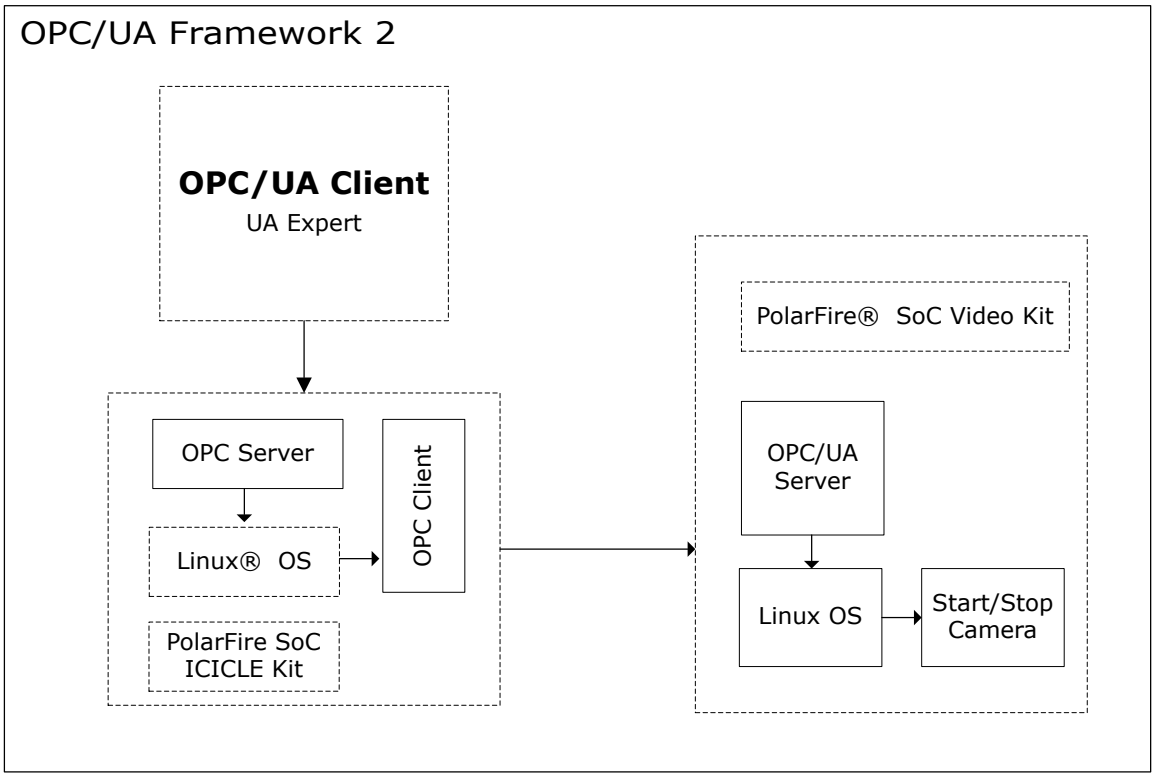
Figure 1-1. Scenario 1 - OPC UA Framework Block Diagram



Scenario 2

In this scenario, OPC UA Client UAExpert communicates with the Video Kit through the ICICLE Kit. The objective here is to demonstrate the ICICLE Kit's capability to act as an OPC UA Client. Control signals from the UAExpert are sent over the OPC UA channel to the ICICLE Kit, which in turn is communicated to the PolarFire SoC Video Kit for video streaming.

Figure 1-2. Scenario 2 - OPC UA Framework Block Diagram



Important: For information about Video Kit and ICICLE Kit, see Video Kit User Guide and ICICLE Kit User Guide.

2. Demo Requirements (Ask a Question)

The following table lists the necessary hardware and software for running this demo.

Table 2-1. Demo Requirements

Requirements	Description
Hardware and Accessories	
PolarFire® SoC Video Kit	MPFS250-VIDEO-KIT Kit Contents: • PolarFire SoC Video Kit Board with (MPFS250TS-1FCG1152I) • 4K30 Dual Camera Sensor with Sony IMX334s • HDMI cable • Micro B USB cable - 2 • RJ45 Ethernet cable • 12V AC adapter, 12V power Cord
PolarFire SoC ICICLE Kit	MPFS-ICICLE-KIT-ES Kit Contents: • PolarFire SoC MPFS250T-FCVG484EES Icicle Board • Ethernet Cable • UART via micro USB (Micro USB Cable) • 12V, 5A AC Power Adapter, and Cord
Host PC	A host PC with USB, Ethernet port, and Windows® 10 OS.
Ethernet cable	To communicate with the PolarFire SoC Video Kit or PolarFire SoC ICICLE Kit, three Ethernet cables are required. CAT5 cable with 1.5 meter length.
Network Switch	Generic Network Switch 5 Ports Fast Ethernet 10/100 Mbps LAN RJ45 with Power Adapter for Desktop PC
Stepper 7 Click	This Click Board™ is equipped with two integrated circuits. The step motor driver IC is the MTS62C19A, a dual full-bridge motor driver from Microchip.
Multi Stepper Motor	Stepper Motor QMot.eu, Part Number QSH 4218-35-10-027 Lot No. 1016062(1.001)A
Utility Software	
Program Debug 2021.2	Executable for installing FlashPro Express 2021.2 that is used to program the FPGA
MobaxTerm, Putty, or TeraTerm	UART receiver-transmitter application on the host PC
CP2108	USB to UART chip to interact with on-board Linux OS
Win32 Disk Imager	Freeware tool for flashing binary images to USB sticks or SD/CF cards. **Note:** You need to have Administrator privileges for flashing Linux `.wic` images through the Win32 Disk Imager tool.
7-zip	Freeware archiving tool for compressing and decompressing files. This tool is needed for extracting `.wic` file from the `.wic.gz` compressed file.
VLC Media Player	• For Windows: 3.0.16 and above • For Ubuntu: 3.0.9.2 and above
Binaries	
Linux wic Image	`Industrial_Edge_Video_Kit_Demo-design-WIC-Image.wic.gz` `Industrial_Edge_ICICLE_Kit_Demo-design-WIC-Image.wic.gz`
Job file	`Industrial_Edge_Video_Kit_H264.job` `Industrial_Edge_ICICLE_Kit_Step_Motor.job`
SDP file	`video.sdp`

Important: The name of the binaries mentioned in the preceding table may vary from the rest of this guide as they often keep changing in each release. However, the flashing and demo procedures remain the same.

3. Demo Prerequisites (Ask a Question)

Before you begin, ensure that the following components are in place:

1. Download the programming job file, Linux `.wic` image, and `video.sdp` file from the following link: www.microchip.com/en-us/application-notes/an4977.
2. Download the free version of UAExpert (OPC UA client) from the following link: www.unified-automation.com/downloads/opc-ua-clients/uaexpert.html.

Important:

- The Linux version of UAExpert (an OPC UA client) is also available and can be used.
- To download the packages, you need to have an active account on the Unified Automation website.

4. OPC Unified Architecture (Ask a Question)

Open Platform Communications Unified Architecture (OPC UA) is a machine-to-machine communication protocol that has become increasingly popular in industrial automation. The protocol is designed to provide a standard and secure way for different machines and systems to communicate with each other, regardless of the manufacturer, platform, or operating system.

The OPC UA protocol is based on a client-server architecture, where the client initiates the communication and the server provides the requested data. The communication is structured around a set of predefined services that define the interaction between clients and servers. These services include browsing, reading, writing, subscribing, and monitoring. OPC UA also provides a range of security mechanisms, including encryption, authentication, and authorization, to ensure secure communication between clients and servers.

The OPC Foundation is the organization behind the standard and with 678 members it has a very broad base. Its members include global players in the automation industry. For example: Siemens, Honeywell, Microsoft, Beckhoff, SAP, Yokogawa, ABB, Rockwell, Schneider Electric, Wago, Iconics. All members of the Foundation can be found in the OPC Foundation member list. The association was founded in 1994 and released the first version of OPC in 1996. Since then, it has been working very successfully and actively on the further development and dissemination of the OPC standard.

The current standard of the OPC specification is OPC UA (OPC Unified Architecture). It is the successor of the old OPC standard, which is called OPC Classic. Many installations of OPC servers are Classic OPC Servers until today. The old standard already very successfully solved the task of realizing data exchange in automation independent of the manufacturer and defined the basic interfaces. The disadvantage of OPC Classic was the lack of platform independence. OPC Classic is based on the Microsoft technologies COM and DCOM and therefore OPC Server and OPC Client installations were limited to Microsoft Windows operating systems and networks. With the increasing success of other platforms such as Linux, Web architectures, Cloud, IoT Devices, and CPS the distribution of OPC was limited.

One of the key advantages of OPC UA is its platform independence. This means that it can be used with different operating systems, programming languages, and hardware platforms. This makes it a popular choice for industrial automation systems, where different machines and systems need to communicate with each other seamlessly.

The OPC UA protocol has several features that make it a powerful and versatile communication protocol for industrial automation. One of these features is its ability to handle complex data types. OPC UA supports a wide range of data types, including numerical data, strings, arrays, structures, and more. It also supports user-defined data types, which allows industrial automation systems to define their own data structures for their specific needs.

Another important feature of OPC UA is its support for time synchronization. In industrial automation, precise time synchronization is critical for ensuring that different machines and systems operate in sync with each other. OPC UA provides a mechanism for time synchronization between clients and servers, which ensures that data is exchanged accurately and on time.

OPC UA also provides built-in diagnostics and error handling capabilities. These capabilities make it easier for industrial automation systems to detect and diagnose errors and faults that occur during communication between clients and servers. This helps to minimize downtime and ensure that the system is operating efficiently.

The security features of OPC UA are also worth highlighting. OPC UA provides several security mechanisms to ensure secure communication between clients and servers. These mechanisms include encryption, authentication, and authorization. Encryption ensures that data is transmitted securely over the network, while authentication ensures that clients and servers are who they claim to be. Authorization ensures that clients and servers have the necessary permissions to access the requested data.

One of the key benefits of OPC UA is its interoperability. Because OPC UA is a standardized protocol, different machines and systems can communicate with each other seamlessly, regardless of the manufacturer, platform, or operating system. This makes it easier for industrial automation systems to integrate different components and systems into a single, cohesive system.

In summary, OPC UA is a standardized, secure, and platform-independent communication protocol for industrial automation. Its versatility, reliability, and security make it a popular choice for a wide range of applications in the industrial automation sector with its support for complex data types, time synchronization, built-in diagnostics and error handling, and security mechanisms.

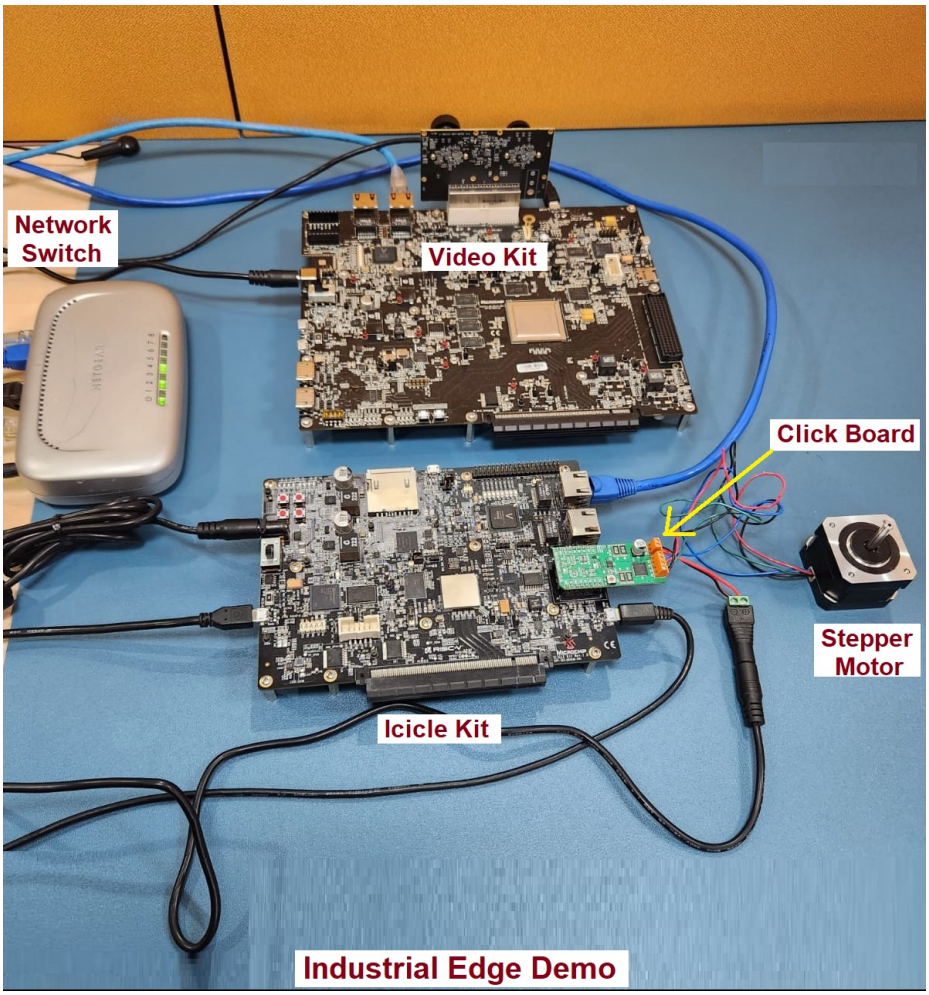
5. Setting Up the Industrial Edge Demo (Ask a Question)

The demonstration involves the following steps:

- Setting up the PolarFire SoC Video and ICICLE Kit
- Setting up the Serial Terminal
- Programming the Device

The following figure shows the board setup.

Figure 5-1. Board Setup of Industrial Edge Demo

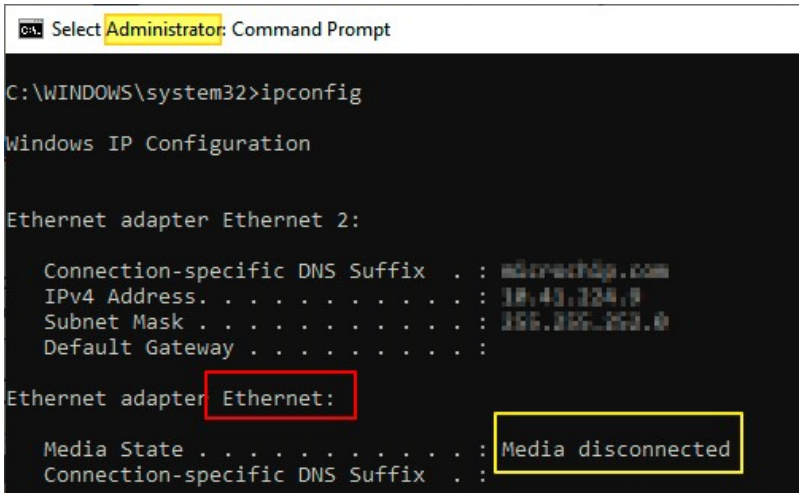


5.1 Setting Up the PolarFire SoC Video and ICICLE Kit (Ask a Question)

Before running the demo, perform the following steps:

1. Do not connect any Ethernet cable from the Windows Host PC to the Video Kit or ICICLE Kit.
2. On the Windows Host PC, open the command prompt in Admin mode, type the `ipconfig` command, and press the **Enter** key. The command prompt window appears displaying the Windows IP configuration details as shown in the following figure.

Figure 5-2. Windows Command Prompt Window in Administrator Mode



3. Note down the name of the Ethernet adapter displayed against the Media disconnected interface. It is **Ethernet** in this case.

Video Kit Setup

To setup the Video Kit board, perform the following steps:

1. Insert the dual-camera sensor module in the **J10** port on the PolarFire SoC Video Kit. Ensure to remove the camera lens cap.
2. Connect the **RJ45** Ethernet cable to any one of the Ethernet ports (connector **J6** or **J7**) of the board and the Windows Host PC.
3. Power on the board and wait for the system boot sequence to complete.
4. Log in as the root user (no password required).
5. Set the IP address of the board to `192.168.2.1` (or choose another address) by executing the following command in the terminal:

```
sudo ifconfig eth0 192.168.2.1 netmask 255.255.255.0 up
```

Important: If your network includes a DHCP server, you may also use the IP address assigned by the DHCP server.

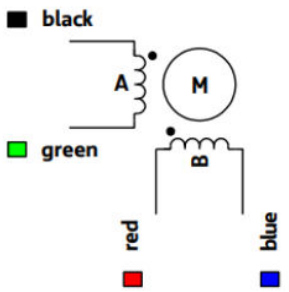
ICICLE Kit Setup

To setup the ICICLE Kit board, perform the following steps:

1. Insert the Stepper Motor Click Board in the Mikro Bus connector of ICICLE Kit. Make the required wire connections from Stepper Motor to the Click Board, as shown in the following figure.

Figure 5-3. Lead Wire Configuration

Cable type	Coil	Function
Black	1B	Motor coil A pin 1
Green	1A	Motor coil A pin 2
Red	2B	Motor coil B pin 1
Blue	2A	Motor coil B pin 2



2. Connect the power adapter to the click board GND and VM points. For more information on Stepper Motor, See the QMOT QSH4218 MANUAL.
3. Connect the **RJ45** Ethernet cable to any one of the Ethernet ports (**J1** or **J2**) of the board and the Windows Host PC.
4. Power on the board and wait for the system boot sequence to complete.
5. Log in as the root user (no password required).
6. Set the IP address of the board to `192.168.2.1` (or choose another address) by executing the following command in the terminal:

```
sudo ifconfig eth0 192.168.2.1 netmask 255.255.255.0 up
```

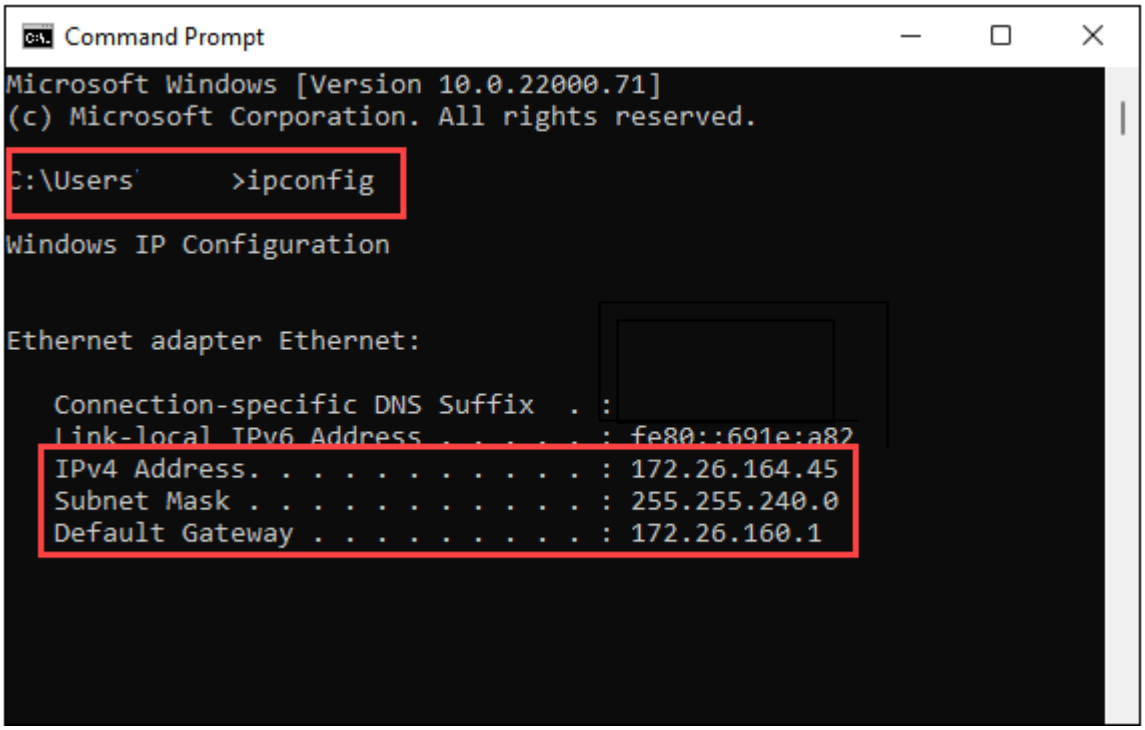
Important: If your network includes a DHCP server, you may also use the IP address assigned by the DHCP server.

Verifying Network Connection between the Windows Host PC and the Kits

To verify the network connection, perform the following steps:

1. Ensure that the Windows Host PC is in the same network.
2. In the command prompt of the Windows Host PC, type the `ipconfig` command, and press the **Enter** key.
3. If your computer is connected to a network with a DHCP server, note the IP address assigned to your PC, as illustrated in the following figure.

Figure 5-4. Fetching the Ethernet Port Status

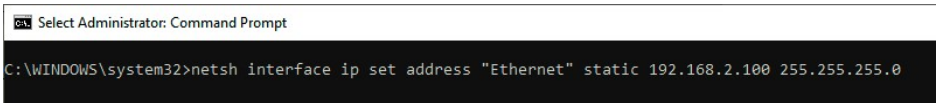


4. If you prefer to manually set the IP address, ensure to set the following as listed:
   - Configure the IP address of the Windows Host PC to `192.168.2.X`, where `X` is any integer between 2 and 254.
   - Set the Subnet mask to `255.255.255.0`.

   Use the following command to apply these settings:

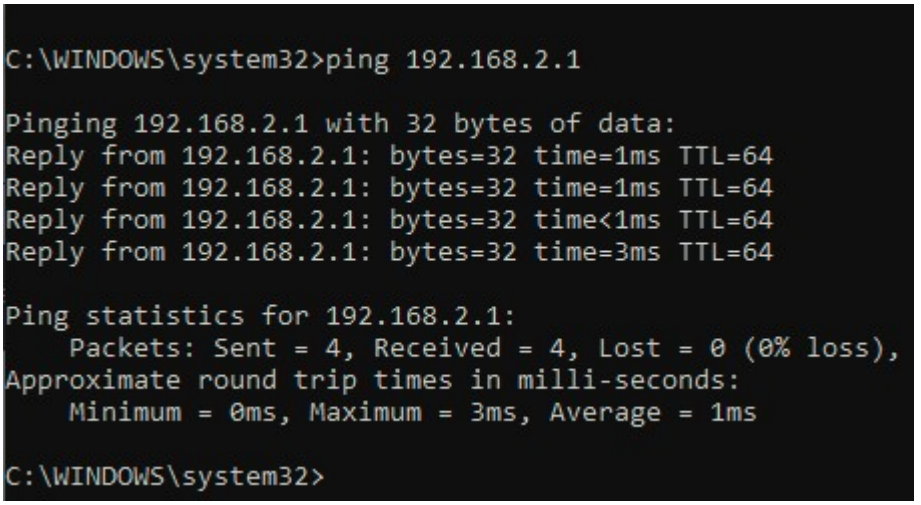
```
netsh interface ip set address "Ethernet" static 192.168.2.100 255.255.255.0
```

Figure 5-5. Setting the Windows Host PC IP Address



5. Ping the Video Kit or ICICLE Kit from the Windows Host PC to verify successful connection as shown in the following figure:

Figure 5-6. PolarFire SoC Video Kit or ICICLE Kit Ping Result



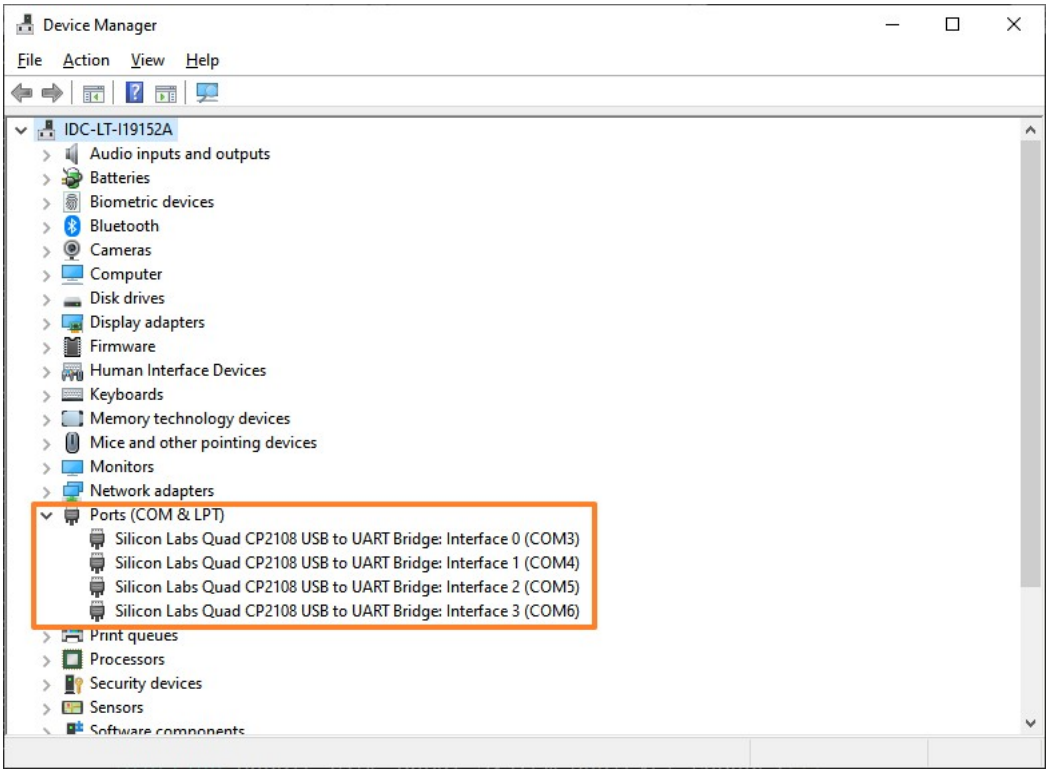
Important: For more information about connectors, jumper settings, and other demo details, see Video Kit User Guide and ICICLE Kit User Guide.

5.2 Setting Up the Serial Terminal (Ask a Question)

The PolarFire SoC Video Kit includes the CP2108 USB to UART chip to interact with on-board Linux OS. After installing the CP2018 driver, perform the following steps:

1. Connect the USB cable at the **J12** port on the PolarFire SoC Video Kit board to the host PC (connect to J11 port for ICICLE Kit).
2. After connecting the power adapter to the board at **J39** port (**J29** for ICICLE Kit), switch ON the board's power supply using the SW5 switch (use SW6 switch for ICICLE Kit). This detects the USB UART chip on the board at the host PC.
   You can verify the detection of the USB UART chip in the **Device Manager** window of the host PC as shown in the following figure.

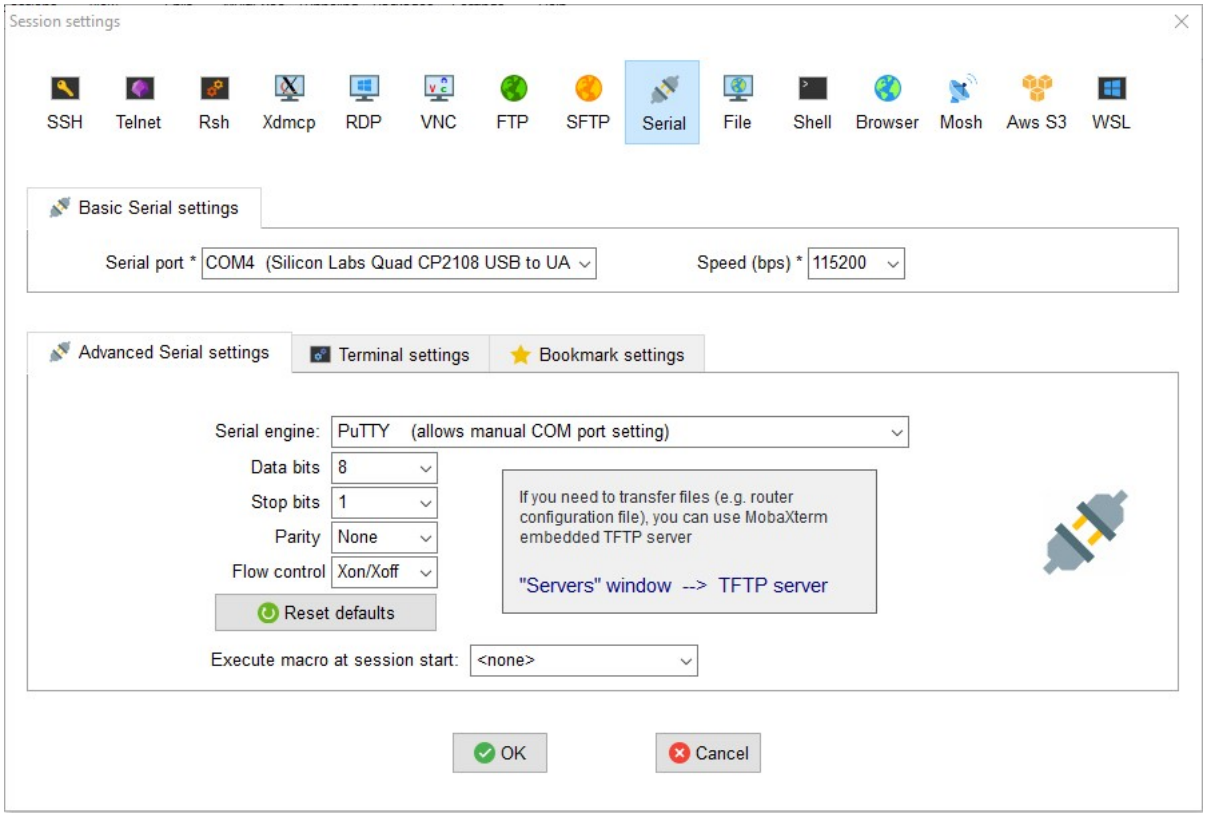
Figure 5-7. Host PC Device Manager Window



The interfaces in the **Device Manager** window on the host PC are active in the current demo project and displays the messages when appropriately configured.

An application like MobaXterm/TeraTerm at the host PC is required to a establish serial communication with the Video Kit board to interact with the PolarFire SoC Video Kit board. The baud rate for such connections must be 115200 bps, as shown in the following figure.

Figure 5-8. Serial Port Settings Dialog Box



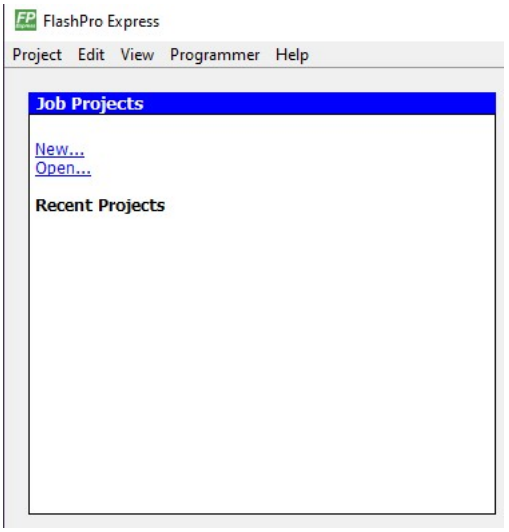
Important: The data-rate must be configured for all interfaces to establish successful communication with the Video Kit.

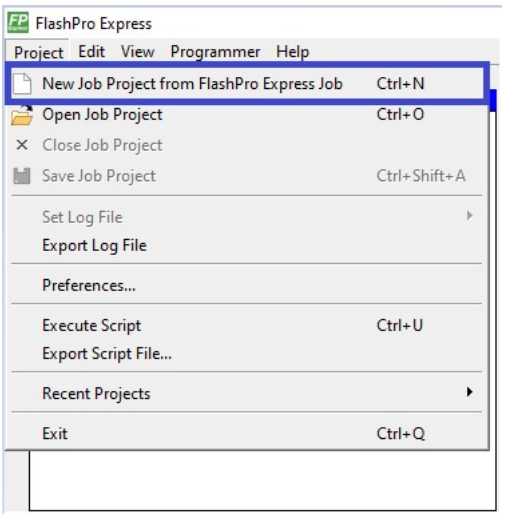
5.3 Programming the Device (Ask a Question)

To program the PolarFire SoC device with the job file using FlashPro Express, perform the following steps.

1. Connect a micro-USB to the ICICLE Kit (J33) or Video Kit (J5) from the host PC and launch the FlashPro Express tool from the installation directory. Also, ensure that the jumper **J9** is closed on the ICICLE Kit, and **J28** is closed on the Video Kit.
2. To create a new job, click **New** on the FlashPro Express landing pageV or select **Project** and click **New Job Project from FlashPro Express Job** from the menu, as shown in the following figure.

Table 5-1. FlashPro Express





3. In the **New Job Project from FlashPro Express Job** dialog box, enter the following details:
   - Programming job file: Click **Browse** and navigate to the location where the job file is located and select the file.
   - FlashPro Express job project location: Select **Browse** and navigate to the location where you want to save the project.
4. Click **Open**. The required programming file is selected and is ready to be programmed in the device. The FlashPro Express window appears. Confirm that a programmer number appears in the **Programmer** field. If it does not appear, check the board connections, and click **Refresh/ Rescan Programmers**.
5. Click **RUN** to program the device. When the device is programmed successfully, a `RUN PASSED` status is displayed.
6. To close the FlashPro Express tool, select **Project** and **Exit** from menu.
7. Power-cycle the board.

5.4 Flashing Linux .wic Image in eMMC Mode (Ask a Question)

The Linux `.wic` image is packaged with all demo applications. Extract the contents of the `.wic` file to a folder of your choice. The extracted wic image can be flashed either in an eMMC or a SD card. Irrespective of the flashing device, running the demo user applications remain the same.

Important: If the Linux image has multi-compression extensions such as `wic.gz.zip`, continue extracting the file until you obtain the `.wic` file.

This section describes the steps to place the HSS in CLI mode, program the Linux images into eMMC using the Win32 Disk Imager tool, and initiate the Linux boot.

1. Do not insert the SD card in the board. If an SD card already exists in the board, the SD card takes the first priority in the bootup sequence.
2. Connect the micro USB cable to the board (on Video Kit - **J19** port or on ICICLE Kit - **J16** port).
3. Power ON the board and press the **Enter** key while booting.
4. Execute the `usbdmsc` command at the HSS prompt as shown in the following figure.

Figure 5-9. Executing the usbdmsc Command

```
[7.462372] HSS_TinyCLI_Parser(): Type HELP for list of commands
[7.469663] HSS_TinyCLI_Parser(): >> usbdmsc
[207.689983] HSS_MMCInit(): Attempting to select SDCARD ... [208.699423] mmc_init_common(): MSS_MMC_init() returned unexpected 0
Failed
[208.708190] HSS_MMCInit(): Attempting to select eMMC ... Passed
Waiting for USB Host to connect... (CTRL-C to quit)
USB Host connected. Waiting for disconnect... (CTRL-C to quit)
 0 bytes written, 10863616 bytes read
```

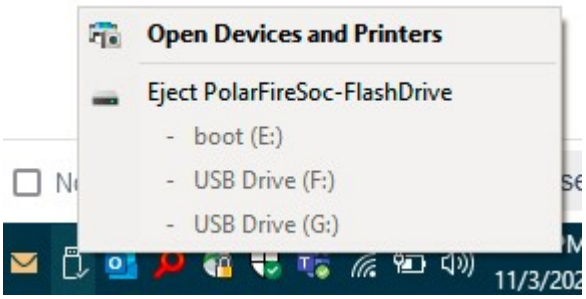
Important: Ensure to execute the `emmc` command before executing the `usbdmsc` command in case of ICICLE Kit.

The board switches to eMMC mode once the eMMC is passed.

5. Open the **Win32 Disk Imager** tool with administrative privileges and browse for the `.wic` file to flash the Linux `.wic` image.

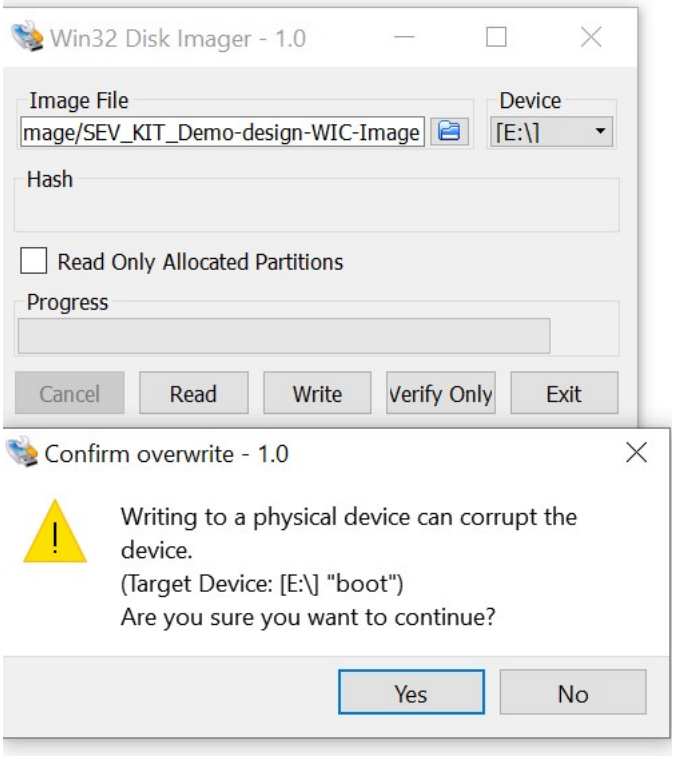
Important: To confirm if the eMMC drive is active, from the taskbar select **Safely Remove Hardware and Eject Media**. You will notice that the drive letter **boot (E:)** appears in list of connected devices, as shown in the following figure.

Figure 5-10. Drive Eject Options



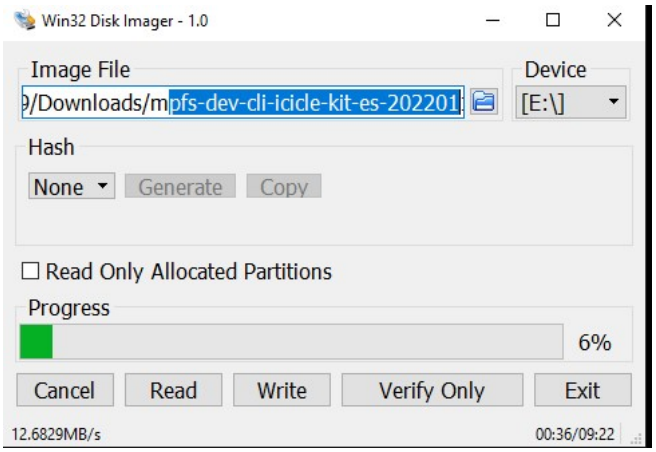
6. In the **Win32 Disk Imager** tool, select the boot device, and click **Write**. A **Confirm overwrite** dialog box appears, as shown in the following figure.

Figure 5-11. Confirm Overwrite Dialog Box



7. Click **Yes** to confirm. After the image gets written, click **Exit**.

Figure 5-12. Win32 Disk Imager—Image Writing in Progress



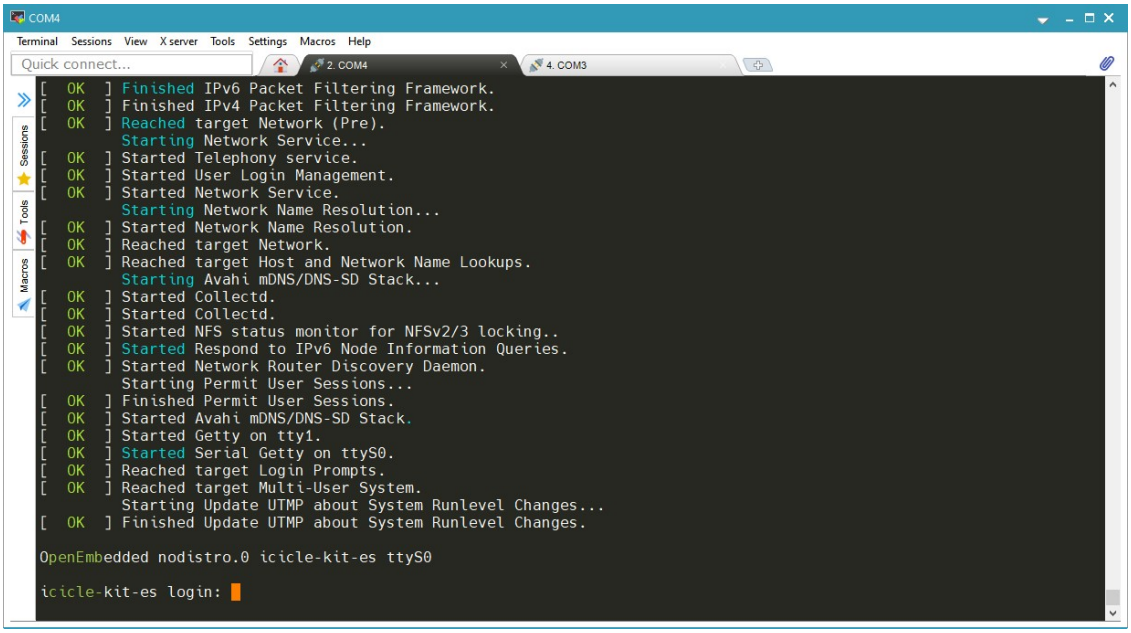
8. Disconnect the USB cable from the USB-UART connector on the Kit. Observe the USB host disconnected message.
9. At the HSS CLI prompt, execute the `boot` command. Linux starts-up and enters the user login mode.

Figure 5-13. Executing the Boot Command and Entering into User Login Mode

```
[208.708190] HSS_MMCInit(): Attempting to select eMMC ... Passed
Waiting for USB Host to connect... (CTRL-C to quit)
USB Host connected. Waiting for disconnect... (CTRL-C to quit)
 5854579712 bytes written, 54118400 bytes read
USB Host disconnected...

[1799.793281] HSS_TinyCLI_Parser(): >> boot
```

Figure 5-14. User Login Mode



6. Starting the OPC UA Server (Ask a Question)

Follow the steps outlined, to ensure the proper utilization of the kits provided.

- Video Kit
- ICICLE Kit

6.1 Video Kit (Ask a Question)

To start the OPC UA server on the Video Kit, perform the following steps:

1. Program the job file on the Video Kit. For more information on installing the job file, see 5.3. Programming the Device.
2. Install the wic image on the Video Kit. For more information on installing the wic image, see 5.4. Flashing Linux .wic Image in eMMC Mode.
3. Reboot and login as root.
4. Check the IP address of the machine. Note and keep the IP address handy.
5. Navigate to the `/opt/microchip/opcua/video-kit/` folder, execute the `./video-kit-server.py &` or `python3 video-kit-server.py &` command, and wait for the terminal to display the following logs.

   ```
   Video Kit OPC-UA Server Started
   ```

   The server starts and runs in the background at port 4840.
6. Connect to this server using the UAExpert OPC UA client. For information on connecting to the server, see 7. Establishing a Connection Between OPC UA and Client/Server.

6.2 ICICLE Kit (Ask a Question)

To start the OPC UA server on the ICICLE Kit, perform the following steps:

1. Program the job file on the ICICLE Kit. For more information on installing the job file, see 5.3. Programming the Device.
2. Install the wic image on the ICICLE Kit. For more information on installing the wic image, see 5.4. Flashing Linux .wic Image in eMMC Mode.
3. Reboot and login as root.
4. Check the IP address of the machine. Note and keep the IP address handy.
5. Connect the Stepper Motor to the Stepper 7 Click Board.
6. Connect the Stepper 7 Click Board to the Mikro Bus Connector.
7. Navigate to the `/opt/microchip/opcua/icicle-kit/` folder.
8. Execute the `./icicle-motor-server.py &` or `python3 icicle-motor-server.py &` command. It displays the following message:

   ```
   Attempting to load the MCP23S08 SPI device
   MCP23S08 SPI device loaded successfully
   ```

   Wait for the terminal to display the following log:

   ```
   Stepper Motor - OPC-UA Server Started
   ```

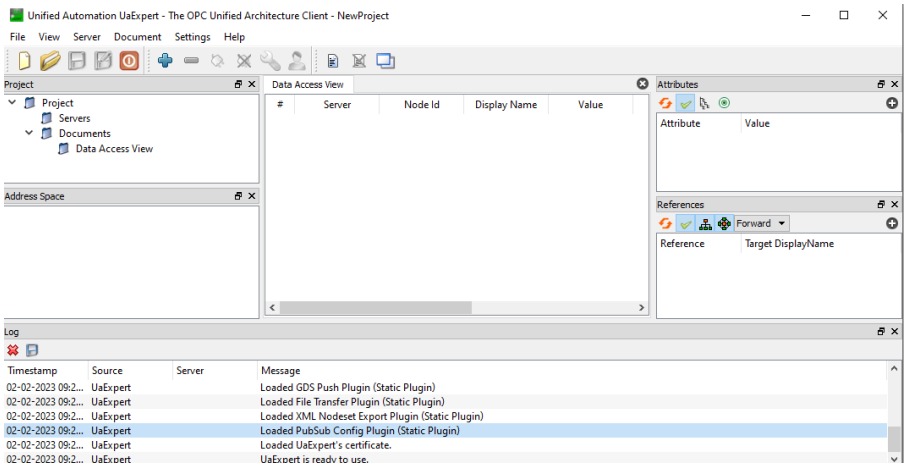
   The server starts and runs in the background at port `4840`.
9. Connect to the OPC UA server using the UAExpert OPC UA client. For information on connecting to the server, see 7. Establishing a Connection Between OPC UA and Client/Server.

7. Establishing a Connection Between OPC UA and Client/Server (Ask a Question)

The following steps establishes a connection between the OPC UA and Client/Server.

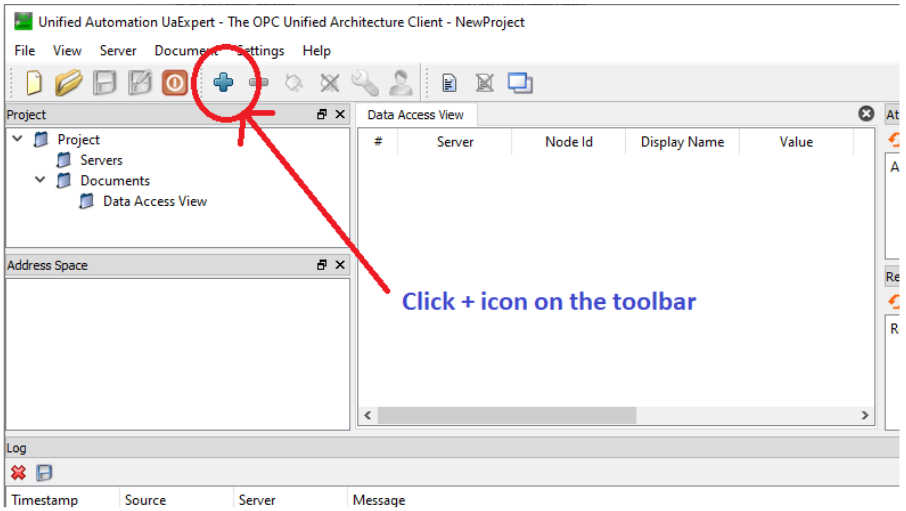
1. Launch the UAExpert OPC UA client.

Figure 7-1. UAExpert OPC UA Client Window



2. Connect to the ICICLE or Video Kit using the IP address.

Figure 7-2. Adding a Server IP Address



3. In the **Add Server** dialog box, click the **Advanced** tab, enter the **Configuration Name**, specify the **Endpoint Url**, and then click **OK** as shown in Figure 7-3.

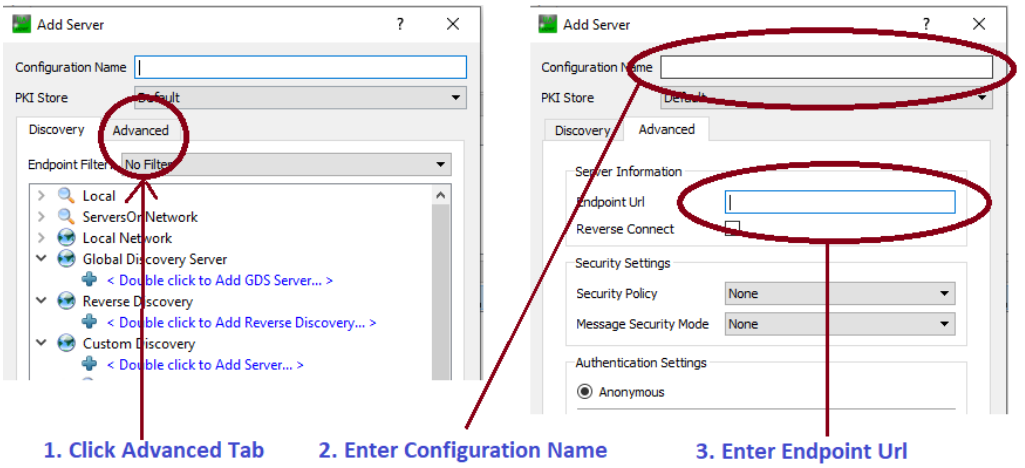
Important: You can choose to enter any name in the **Configuration Name** field, but the IP address must be that of the PolarFire SoC Video Kit or ICICLE Kit. For example, `opc.tcp://192.168.2.1:4840`.

The following table lists the Add Server details.

Table 7-1. Adding Server Details

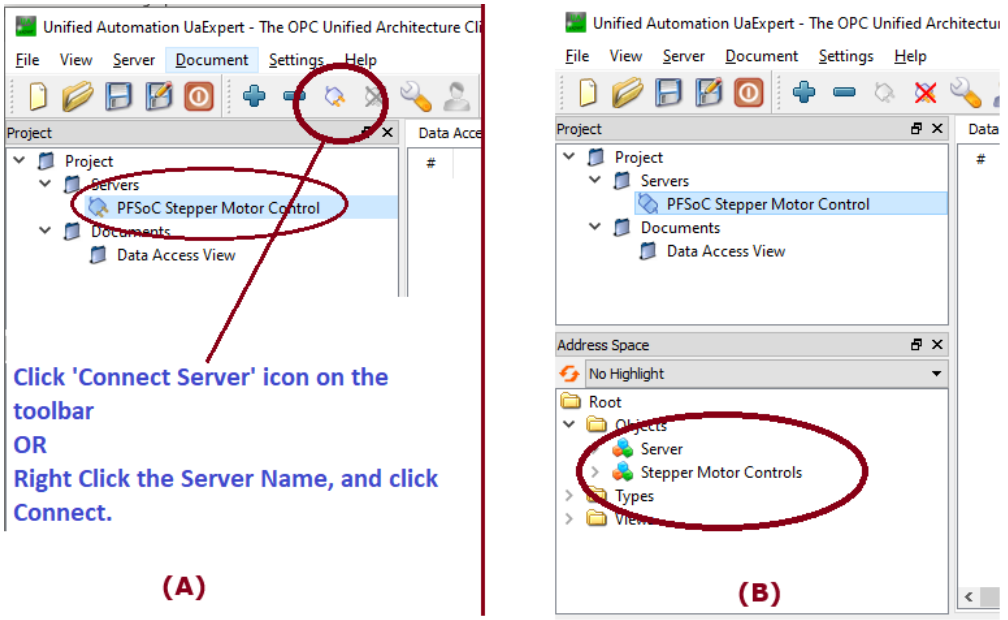
Field	Value
Configuration Name	PolarFire SoC Stepper Motor Control
Endpoint Url	`opc.tcp://<IP Address>:4840`

Figure 7-3. Add Server Dialog Box



4. The server name is displayed in the **Servers** tab. Right-click the server name and click **connect**. Alternatively, you can click the **Connect Server** icon from the toolbar as shown in Figure 7-4 (A). A connection is established with the OPC server based on the specified IP address as shown in Figure 7-4 (B).

Figure 7-4. Connecting to the Server



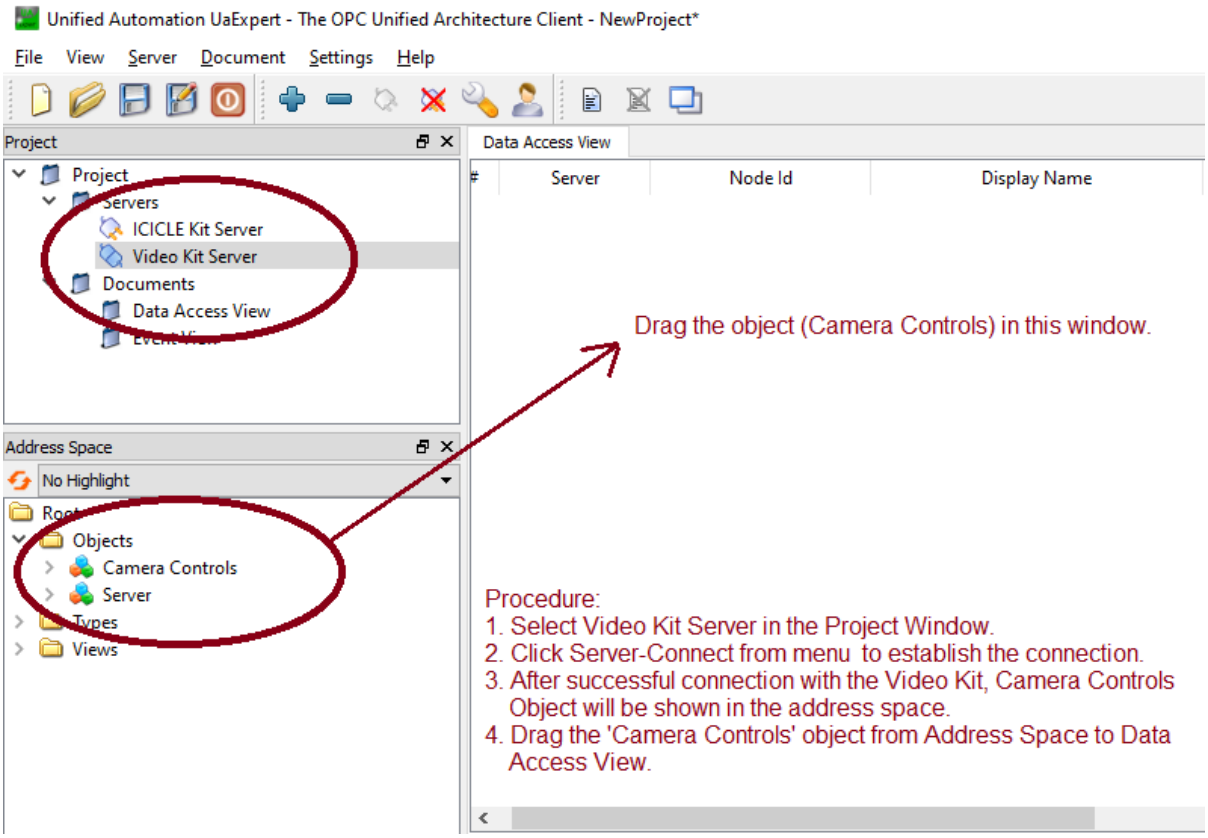
Similarly, you can connect the video board by repeating the steps from 1 to 4.

8. Sending OPC Commands to PolarFire SoC Video Kit (Ask a Question)

After establishing the connection between the client and server through the OPC UA channel, perform the following steps to start or stop the streaming on the Video Kit.

1. From the **Address Space** pane, drag and drop the **Camera Controls** object into the **Data Access View** pane as shown in the following figure.

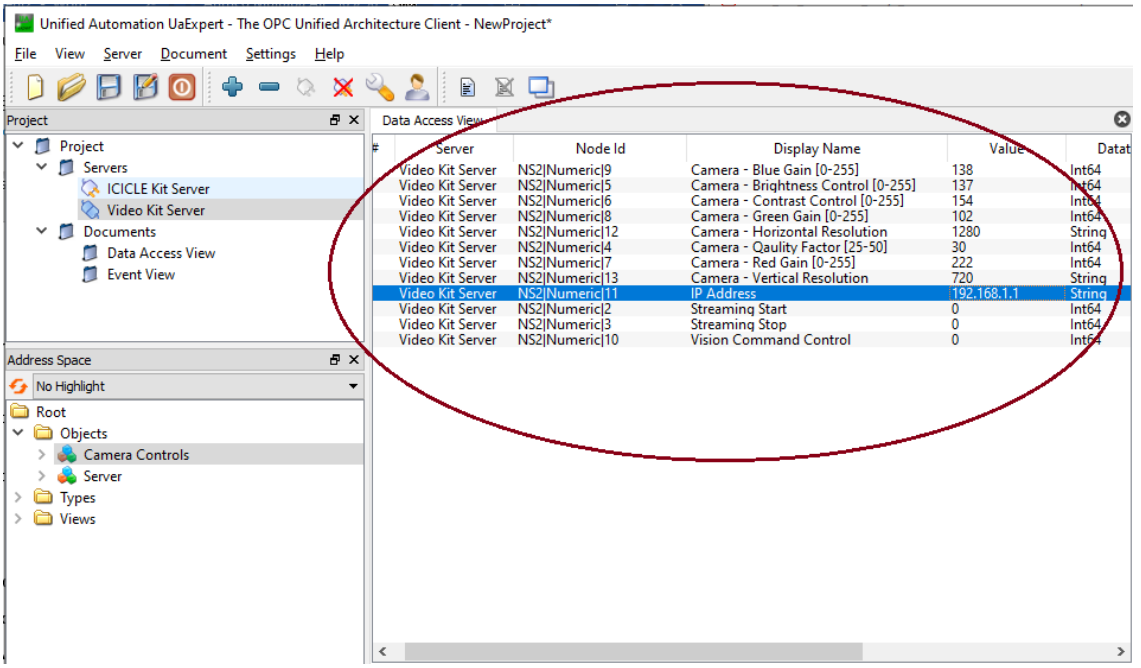
Figure 8-1. UAExpert Window



Important: A **Recursive Add Notes** dialog appears. Click **Yes** and continue with the next steps.

2. All the functionality exported by the Video Kit such as video streaming start, video streaming stop, and so on are made visible in the **Data Access View** pane as shown in the following figure.

Figure 8-2. Data Access View



The following table lists the Video OPC UA exported APIs and features.

Table 8-1. OPC UA Exported APIs and Features

Display Name	Valid Values
Streaming Start	Set the **Streaming Start** value to `1111` to start the streaming. The default is `0`.
Streaming Stop	Set the **Streaming Stop** to `1111` to stop the streaming. The default is `0`.
Vision Command Control	Set the **Vision Command Control** to `1111` to update everything else. The default is `0`.
Camera - Green Gain [0-255]	Any value between `0-255`. The default is `102`.
Camera - Red Gain [0-255]	Any value between `0-255`. The default is `122`.
Camera - Blue Gain [0-255]	Any value between `0-255`. The default is `138`.
Camera - Contrast Control [0-255]	Any value between `0-255`. The default is `154`.
Camera - Brightness Control [0-255]	Any value between `0-255`. The default value is `137`.
Camera Gain - Horizontal Resolution	The valid possible screen resolutions are: `432, 640, 960, 1280 or 1920`
Camera - Vertical Resolution	The valid possible screen resolutions are: `240, 480, 544, 720 or 1072`
Camera - Quality Factor	Any value between `25-50`. The default is `30`.

Examples

1. To start the streaming in the VLC media player running on a machine with the IP address `192.168.2.100`.
   a. Change the IP address in the **Data Access View** pane to `192.168.2.100`.
   b. Change the **Stream Start** value from `0` to `1111`. Streaming starts on the Video Kit for the IP Address `192.168.2.100`.
   c. Open the VLC media player and load the `video.sdp` file. For more information on downloading the files, see 3. Demo Prerequisites. The live video stream is displayed in the VLC media player.

2. To stop the live stream, change the **Stream Stop** value from `0` to `1111`. The video stream from the Video Kit is stopped.
3. To change the **Red Gain** value from `122` to `222` and the **Contrast** value from `154` to `254`.
   a. Ensure that the live stream is running.
   b. Change the **Contrast Control** value to `254`.
   c. Change the **Red Gain** value to `222`.
   d. Change the **Vision Command Control** value to `1111`. The contrast and red gain values are restored in the live video steam and is displayed in the VLC media player.
4. To restore the **Red Gain** value from `222` to `122` and the **Contrast** value from `254` to `154`.
   a. Change the **Contrast Control** value to `154`.
   b. Change the **Red Gain** value to `122`.
   c. Change the **Vision Command Control** value to `1111`. The new contrast and red gain changes are applied in the live stream and is displayed in the VLC media player.
5. To change the video **Resolution** to `640x480`.
   a. Ensure that the live stream is running.
   b. Change the **Horizontal Resolution** value to `640`.
   c. Change the **Vertical Resolution** value to `480`.
   d. Change the **Vision Command Control** to `1111`. The new video resolution changes are applied to the live stream and is displayed in the VLC media player.

Important:

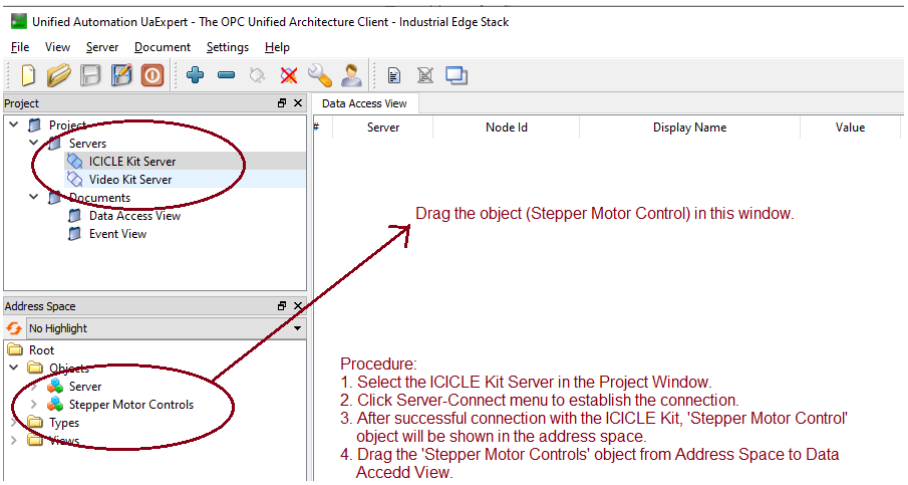
- The VLC media player `video.sdp` file can be downloaded from the website.
- Ensure to change the IP Address mentioned in the SDP file with the local computer's IP address where the VLC media player is installed.

9. Sending OPC Commands to Stepper Motor (ICICLE Kit) (Ask a Question)

After establishing the connection between client and server through the OPC UA channel, perform the following steps to start or stop the stepper motor that is connected to the ICICLE Kit Mikrobus connector.

1. From the **Address Space** pane, drag-and-drop the **Stepper Motor Controls** object into the **Data Access View** pane as shown in the following figure.

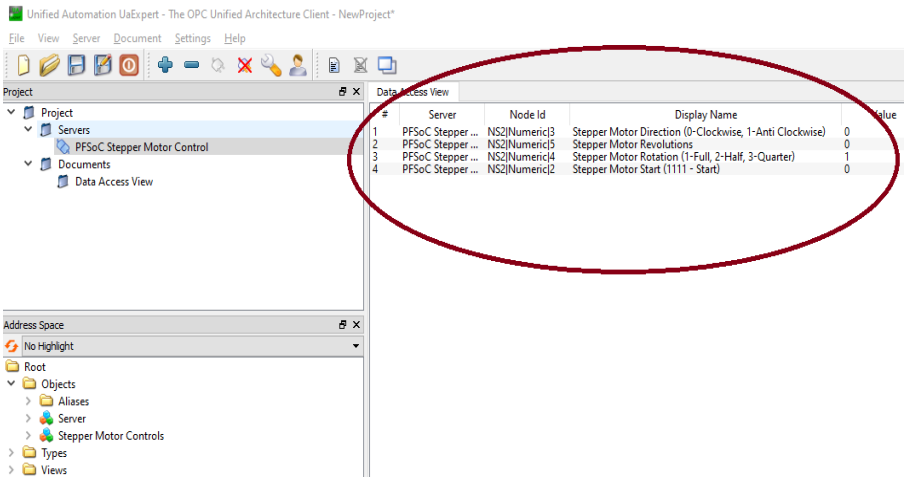
Figure 9-1. UAExpert Window - Stepper Motor Controls



Important: A **Recursive Add Notes** dialog appears. Click **Yes** and continue with the next steps.

2. All the functionality exported by Motor Control Board such as motor start, motor stop, and so on are made visible in the **Data Access View** pane as shown in the following figure.

Figure 9-2. UAExpert - Data Access View



The following table lists the Stepper Motor OPC UA exported APIs and features.

Table 9-1. Stepper Motor OPC UA Exported APIs and Features

Display Name	Valid Values
Stepper Motor Start (1111-Start)	Set the **Motor Start** value to `1111` to start the motor. The default is `0`.
Stepper Motor Revolutions	Set the number of revolutions as follows: • **Default Value**: The default number of revolutions for the motor is set to 0. • **Maximum Limit**: The motor revolutions are limited to a maximum of 100. Attempting to set the number of revolutions beyond this limit will not increase the actual number of revolutions performed by the motor.
Stepper Motor Direction (0-Clockwise, 1-Anti-clockwise)	Set the **Motor Direction** value to `1` to run the motor in anti-clockwise direction. The default is `0` (Clockwise direction).
Stepper Motor Rotation (1-Full, 2-Half, and 3-Quarter)	Set the **Motor Rotation** value to `1|2|3` as required. By default, the stepper motor rotation is set to `1`. • 1: Full (default) • 2: Half • 3: Quarter

Important: The following example demonstrates the procedure for sending OPC commands to the Stepper Motor:

1. To start the stepper motor with default values (Clockwise, Full Rotation), change the **Stepper Motor Start** value from `0` to `1111`. The stepper motor starts running in clockwise direction with the configured values.
2. To change the stepper motor direction from clockwise to anti-clockwise direction, change the **Stepper Motor Direction** value from `0` to `1`.
3. To initiate 10 revolutions of the stepper motor.
   a. Change the Stepper Motor Revolutions value from `0` to `10`.
   b. Change the Stepper Motor Start value from `0` to `1111`. The stepper motor will start spinning in clockwise direction and should stop after 10 revolutions.

10. Running OPC UA Demo Application (Ask a Question)

The demo can be run with any of the following scenarios:

- To control Video Kit and ICICLE Kit individually from UAExpert OPC UA client.
- To control Video Kit through ICICLE Kit – OPC UA client.

10.1 Scenario 1: OPC Client UAExpert Connecting Directly to Video Kit OPC Server and ICICLE Kit (Stepper Motor) OPC Server (Ask a Question)

Objective: Demonstrate the server capabilities for the ICICLE Kit and the Video Kit.

In this scenario, the UAExpert software which acts as an OPC UA client, connects directly to the OPC server running on the Video Kit, and the stepper motor OPC server running on the ICICLE Kit. Once the connection is established, data can be sent over OPC UA channel to give or read commands.

Starting the Stepper Motor Server on the ICICLE Kit

To start the stepper motor server on the ICICLE Kit, perform the following steps:

1. Start the OPC server by executing the following commands at the command prompt:
   a. Execute the `cd /opt/microchip/opcua/icicle-kit` command to change to this directory.
   b. Execute the `./icicle-motor-server.py &` or `python3 icicle-motor-server.py &` command to start the server.
   c. Wait until the OPC-UA server starts.
2. Note down the IP address of the OPC server. To note down the IP address of the OPC server, execute the `ifconfig` command.
3. Connect the UAExpert client from PC to the OPC server by using the IP address you obtained by executing the command in the preceding step. For more information, see 7. Establishing a Connection Between OPC UA and Client/Server.
4. Start the stepper motor in clockwise direction. To start the stepper monitor in clockwise direction, in the UAExpert window, set the values as follows:
   a. Set the **Stepper Motor Start** value to `1111`.

   The stepper motor starts spinning in clockwise direction.
5. Start the stepper motor in anti-clockwise direction. To start the stepper motor in anti-clockwise direction, in the UAExpert window, set the values as follows:
   a. Set the **Stepper Motor Direction** value to `1`.
   b. Set the **Stepper Motor Start** value to `1111`. The stepper motor starts spinning in anti-clockwise direction.

Starting the OPC Server on the Video Kit

To start the OPC server on the Video Kit, perform the following steps:

1. Start the OPC server by executing the following commands at the command prompt:
   a. Execute the `cd /opt/microchip/opcua/video-kit` command to change to this directory.
   b. Execute the `./video-kit-server.py &` or `python3 video-kit-server.py &` script to start the server.
2. Note down the IP address of the OPC server. To note down the IP address of the OPC server, execute the `ifconfig` command.
3. Connect the UAExpert client from PC to the OPC server by using the IP address you obtained by executing the command in the preceding step. For more information, see 7. Establishing a Connection Between OPC UA and Client/Server.

4. Start the video streaming. To start the video streaming, set the values as follows:
   a. Set the **IP Address** value to the Windows machine IP address.
   b. Set the **Streaming Start** value to `1111`.
5. Update the video streaming. To update the video streaming, set the following values in the UAExpert window.
   a. Set the **Camera Red Gain** value to `222`.
   b. Set the **Vision Command Control** value to `1111`.
6. Stop the video streaming. To stop the video streaming, set the **Streaming Stop** value to `1111` in the UAExpert window. The Video Kit video streaming stops immediately.

10.2 Scenario 2: OPC Client UAExpert Connecting to Video Kit OPC Server through ICICLE Kit OPC Client (Ask a Question)

Objective : Demonstrate the client and server capabilities for the ICICLE Kit.

In this scenario, the UAExpert software which acts as an OPC UA client connects to the OPC server running on the ICICLE Kit. This kit also has a OPC UA client running, which in turn connects to the OPC server running on the Video Kit. Once both connections are established, commands can be sent to and from the UAExpert and Video Kit through the ICICLE Kit.

1. Start the **Video Kit OPC Server** by executing the following commands at the command prompt:
   a. Execute the `cd /opt/microchip/opcua/video-kit/` command to change to this directory.
   b. Execute the `./video-kit-server.py &` or `python3 video-kit-server.py &` command to start the Video Kit Server.
   c. On successful execution, the following message is displayed:

```
Video Kit OPC-UA Server Started
```

2. Note down the IP address of the Video Kit OPC server. To note down the IP address of the OPC server, execute the `ifconfig` command.
3. Start the **ICICLE Video Proxy Server** by executing the following commands at the command prompt:
   a. Execute the `cd /opt/microchip/opcua/icicle-kit/` command to change to this directory.
   b. Edit the `./icicle-video-proxy-server.py` script to change the IP address at line number 74 to the IP address of the Video Kit noted down in the second step.
   c. Save the script.
   d. Execute the `./icicle-video-proxy-server.py &` or `python3 icicle-video-proxy-server.py &` command to start the OPC Proxy Server.

Important: Ensure that the Video Kit Server is up and running before executing this command.

   e. On successful connection, the following message is displayed on the console:

```
Video Proxy OPC-UA Server Started
OPC Client connected to Video Kit - OPC Server
```

   f. Note down the IP address of the ICICLE Video Proxy Server. To note down the IP address of the Proxy Server, execute the `ifconfig` command.

4. Connect the UAExpert client from PC to the ICICLE Video Proxy Server using the above IP address.
5. To start streaming the video, set the following values in the UAExpert window:
   a. Set the **IP Address** value to the Windows machine IP address.
   b. Set the **Streaming Start** value to `1111`.

11. Revision History (Ask a Question)

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

Table 11-1. Revision History

Revision	Date	Description
C	03/2024	The following is the list of changes in the revision C of the document: • Updated Introduction section • Updated 2. Demo Requirements section • Updated weblink of the UAExpert in the 3. Demo Prerequisites section • Updated Figure 5-3 and 5.1. Setting Up the PolarFire SoC Video and ICICLE Kit section • Updated 6.2. ICICLE Kit section • Updated the note in the 7. Establishing a Connection Between OPC UA and Client/Server section • Updated the Figure 9-2 and Table 9-1 in the 9. Sending OPC Commands to Stepper Motor (ICICLE Kit) section • Updated scenario 1 and scenario 2 in the 10. Running OPC UA Demo Application section
B	07/2023	The following is the list of changes in the revision B of the document: • Changed the `.wic` image names in the 2. Demo Requirements section to make them consistent. • Updated the procedures in scenario 1 and scenario 2 in the 5.4. Flashing Linux .wic Image in eMMC Mode section. • Updated the Video Kit and ICICLE Kit path locations in the 6. Starting the OPC UA Server section. • Updated the images, added a new note, and updated the table in the 8. Sending OPC Commands to PolarFire SoC Video Kit section. • Updated the images, added a new note, and updated the table in the 9. Sending OPC Commands to Stepper Motor (ICICLE Kit) section.
A	04/2023	Initial Revision

Microchip FPGA Support

Microchip FPGA products group backs its products with various support services, including Customer Service, Customer Technical Support Center, a website, and worldwide sales offices. Customers are suggested to visit Microchip online resources prior to contacting support as it is very likely that their queries have been already answered.

Contact Technical Support Center through the website at www.microchip.com/support. Mention the FPGA Device Part number, select appropriate case category, and upload design files while creating a technical support case.

Contact Customer Service for non-technical product support, such as product pricing, product upgrades, update information, order status, and authorization.

- From North America, call **800.262.1060**
- From the rest of the world, call **650.318.4460**
- Fax, from anywhere in the world, **650.318.8044**

Microchip Information

The Microchip Website

Microchip provides online support via our website at www.microchip.com/. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip design partner program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Product Change Notification Service

Microchip's product change notification service helps keep customers current on Microchip products. Subscribers will receive email notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, go to www.microchip.com/pcn and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Embedded Solutions Engineer (ESE)
- Technical Support

Customers should contact their distributor, representative or ESE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in this document.

Technical support is available through the website at: www.microchip.com/support

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is “unbreakable”. Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.

Legal Notice

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. Contact your local Microchip sales office for additional support or, obtain additional support at www.microchip.com/en-us/support/design-help/client-support-services.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL, OR CONSEQUENTIAL LOSS, DAMAGE, COST, OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION.

Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, CryptoMemory, CryptoRF, dsPIC, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Kleer, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AgileSwitch, ClockWorks, The Embedded Control Solutions Company, EtherSynch, Flashtec, Hyper Speed Control, HyperLight Load, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, TimeCesium, TimeHub, TimePictra, TimeProvider, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, Augmented Switching, BlueSky, BodyCom, Clockstudio, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic

ISBN: 978-1-6683-4267-1

Quality Management System

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 Fax: 480-792-7277 Technical Support: www.microchip.com/support Web Address: www.microchip.com **Atlanta** Duluth, GA Tel: 678-957-9614 Fax: 678-957-1455 **Austin, TX** Tel: 512-257-3370 **Boston** Westborough, MA Tel: 774-760-0087 Fax: 774-760-0088 **Chicago** Itasca, IL Tel: 630-285-0071 Fax: 630-285-0075 **Dallas** Addison, TX Tel: 972-818-7423 Fax: 972-818-2924 **Detroit** Novi, MI Tel: 248-848-4000 **Houston, TX** Tel: 281-894-5983 **Indianapolis** Noblesville, IN Tel: 317-773-8323 Fax: 317-773-5453 Tel: 317-536-2380 **Los Angeles** Mission Viejo, CA Tel: 949-462-9523 Fax: 949-462-9608 Tel: 951-273-7800 **Raleigh, NC** Tel: 919-844-7510 **New York, NY** Tel: 631-435-6000 **San Jose, CA** Tel: 408-735-9110 Tel: 408-436-4270 **Canada - Toronto** Tel: 905-695-1980 Fax: 905-695-2078	**Australia - Sydney** Tel: 61-2-9868-6733 **China - Beijing** Tel: 86-10-8569-7000 **China - Chengdu** Tel: 86-28-8665-5511 **China - Chongqing** Tel: 86-23-8980-9588 **China - Dongguan** Tel: 86-769-8702-9880 **China - Guangzhou** Tel: 86-20-8755-8029 **China - Hangzhou** Tel: 86-571-8792-8115 **China - Hong Kong SAR** Tel: 852-2943-5100 **China - Nanjing** Tel: 86-25-8473-2460 **China - Qingdao** Tel: 86-532-8502-7355 **China - Shanghai** Tel: 86-21-3326-8000 **China - Shenyang** Tel: 86-24-2334-2829 **China - Shenzhen** Tel: 86-755-8864-2200 **China - Suzhou** Tel: 86-186-6233-1526 **China - Wuhan** Tel: 86-27-5980-5300 **China - Xian** Tel: 86-29-8833-7252 **China - Xiamen** Tel: 86-592-2388138 **China - Zhuhai** Tel: 86-756-3210040	**India - Bangalore** Tel: 91-80-3090-4444 **India - New Delhi** Tel: 91-11-4160-8631 **India - Pune** Tel: 91-20-4121-0141 **Japan - Osaka** Tel: 81-6-6152-7160 **Japan - Tokyo** Tel: 81-3-6880- 3770 **Korea - Daegu** Tel: 82-53-744-4301 **Korea - Seoul** Tel: 82-2-554-7200 **Malaysia - Kuala Lumpur** Tel: 60-3-7651-7906 **Malaysia - Penang** Tel: 60-4-227-8870 **Philippines - Manila** Tel: 63-2-634-9065 **Singapore** Tel: 65-6334-8870 **Taiwan - Hsin Chu** Tel: 886-3-577-8366 **Taiwan - Kaohsiung** Tel: 886-7-213-7830 **Taiwan - Taipei** Tel: 886-2-2508-8600 **Thailand - Bangkok** Tel: 66-2-694-1351 **Vietnam - Ho Chi Minh** Tel: 84-28-5448-2100	**Austria - Wels** Tel: 43-7242-2244-39 Fax: 43-7242-2244-393 **Denmark - Copenhagen** Tel: 45-4485-5910 Fax: 45-4485-2829 **Finland - Espoo** Tel: 358-9-4520-820 **France - Paris** Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79 **Germany - Garching** Tel: 49-8931-9700 **Germany - Haan** Tel: 49-2129-3766400 **Germany - Heilbronn** Tel: 49-7131-72400 **Germany - Karlsruhe** Tel: 49-721-625370 **Germany - Munich** Tel: 49-89-627-144-0 Fax: 49-89-627-144-44 **Germany - Rosenheim** Tel: 49-8031-354-560 **Israel - Ra'anana** Tel: 972-9-744-7705 **Italy - Milan** Tel: 39-0331-742611 Fax: 39-0331-466781 **Italy - Padova** Tel: 39-049-7625286 **Netherlands - Drunen** Tel: 31-416-690399 Fax: 31-416-690340 **Norway - Trondheim** Tel: 47-72884388 **Poland - Warsaw** Tel: 48-22-3325737 **Romania - Bucharest** Tel: 40-21-407-87-50 **Spain - Madrid** Tel: 34-91-708-08-90 Fax: 34-91-708-08-91 **Sweden - Gothenberg** Tel: 46-31-704-60-40 **Sweden - Stockholm** Tel: 46-8-5090-4654 **UK - Wokingham** Tel: 44-118-921-5800 Fax: 44-118-921-5820