Automate Stack 2.0 Demo

User Guide

FPGA-UG-02164-1.0

June 2022

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Contents

Figures

1. Introduction

This document describes the process for running the basic Lattice Automate Stack 2.0 Demo.It supports MQTT broker/client based host application, Python Interface as host control and It will also support PCIe interface as host for high speed applications. It support two chains of nodes which can be connected to one main system board and nodes will be synchronized if number of nodes are same in the both chains. and main board connected to the Raspberry pi.

This basic demo will include:

1. Raspberry pi: Communication between Server and Client end.
2. Two systems: Main System and Node System
3. Main System: for Host Communication, Host to Node communication and PDM.
4. Node System: for motor controlling and PDM data Collection.

2. Hardware Requirements

This demonstration requires the following hardware components:

- PC running Windows 10 Operating System of 1920X1080 resolution, 100% dpi
- Raspberry Pi 4 Model B with microSD card.
- USB Type-C cable with 5V adapter for Power connection in Raspberry Pi.
- Micro USB to HDMI cable for Raspberry pi to Monitor Connection.
- Lattice Certus-NX Versa Evaluation Boards with 12 V power adapters(4 Nodes or more)
- Lattice CertusPro-NX Versa Evaluation Boards with 12 V power adapters(1 Main)
- PCIe Cable for Host PC to CertusPro NX connection
- USB Type-A (UART) cable for programming the bit stream and binary files.
- Ethernet Cables for connecting Main system to Node systems
- Two electrical 1G SFPs (Methode, Finisar etc) for Main System Board (Insert at J15 and J16 ports of CertusPro-NX Versa Board)
- GB-42 BLS 24V 5000 RPM 4 or more motors with Trenz TEP0002 4 or more motor control boards
- 24V-0.5Amp DC Power Supplies for motors
- Monitor with HDMI support.
- Keyboard and Mouse, if required.

3. Software Requirements

The following software programs are available at www.latticesemi.com/en/Products/DesignSoftwareAndIP

The software programs are available for download only if you log in at www.latticesemi.com

- Lattice Radiant 3.0
- Lattice Propel SDK 2.0 or later
- Lattice Propel Builder 2.0 or later
- Lattice Radiant Programmer 3.1 or later
- Total Phase Control center 4.1
- Lattice Automate 2.0 Test Application Software

4. Test Setup

4.1. System Block Diagram

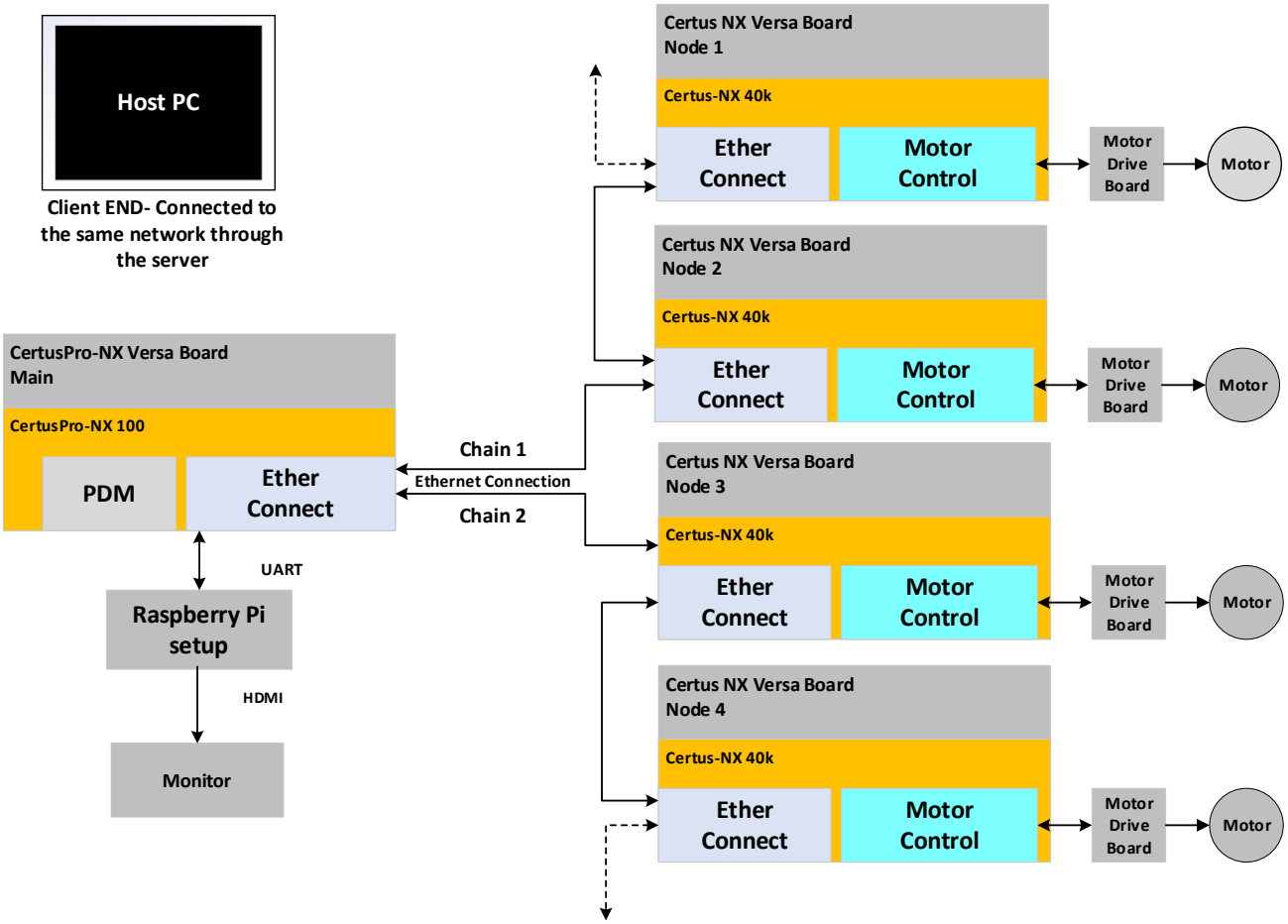


Figure 4.1: Block diagram

4.2. Hardware Setup - Windows Machine

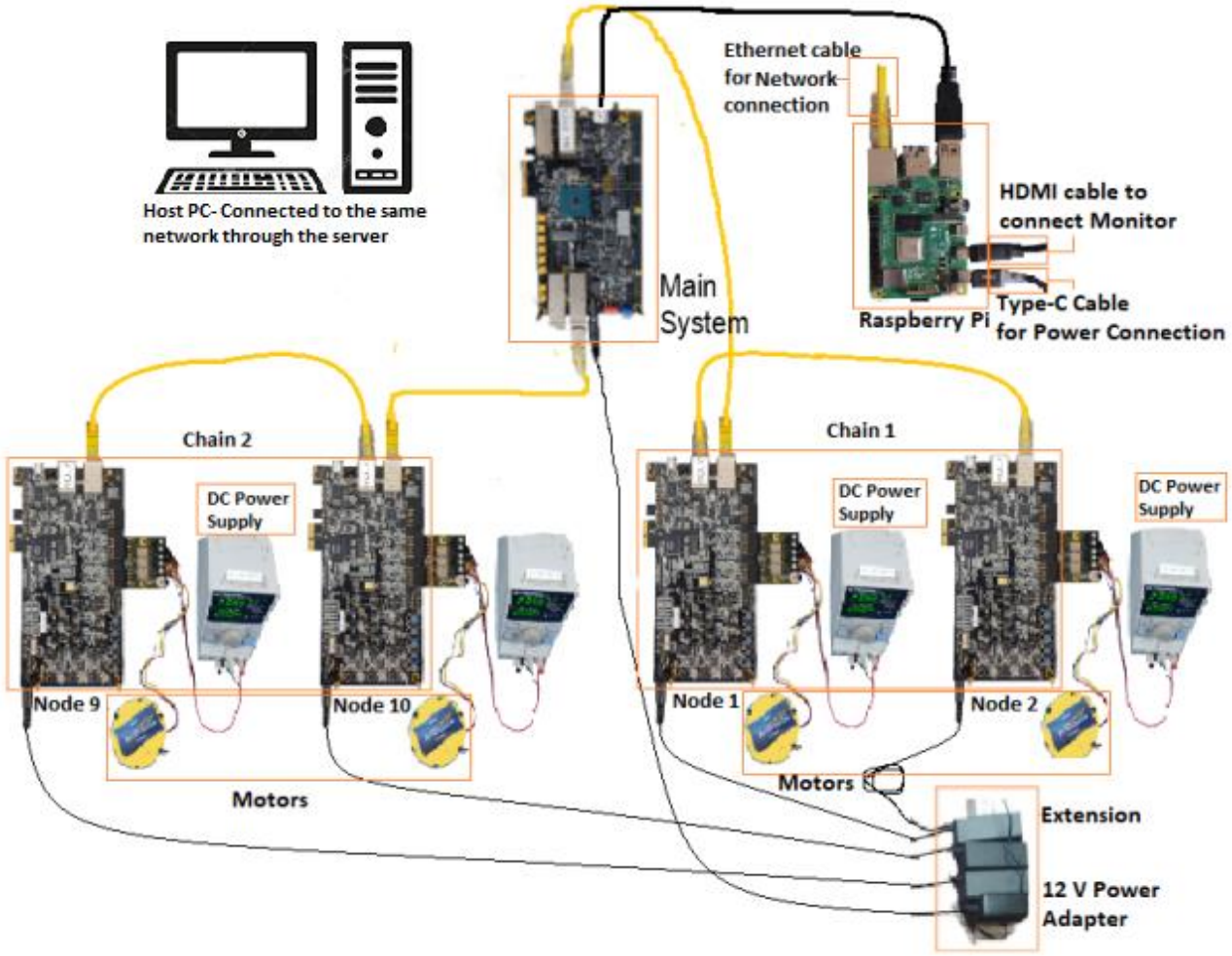


Figure 4.2: System setup

4.2.1. Hardware Connection

1. Host PC (Client End) to run the Lattice Automate 2.0 Application
2. Raspberry pi 4 Model B with micro-SD card.
3. USB Type-C cable with 5V adapter for Power connection in Raspberry Pi.
4. Lattice Certus-NX Versa Evaluation Boards with 12 V power adapters.
5. A Lattice CertusPro-NX Versa Evaluation Board with 12 V power adapter.
6. USB Type-A (UART) cable for Connect the Raspberry pi to Lattice CertusPro NX and CertusNX board.
7. Ethernet cables and two electrical 1G SFPs (Methode, Finisar etc) for main to Node Connection
8. Ethernet or Wi-Fi for Network connection at the client and server end.
9. DC power Supply with 24 V and 0.5 A current of minimum requirement.
10. GB-42 BLS 24V 5000 RPM 4 or more motors with Trenz TEP00-3 4 or more motor control boards.
11. Micro USB to HDMI cable for Raspberry pi to Monitor Connection.

4.3. Hardware Setup - Linux Machine

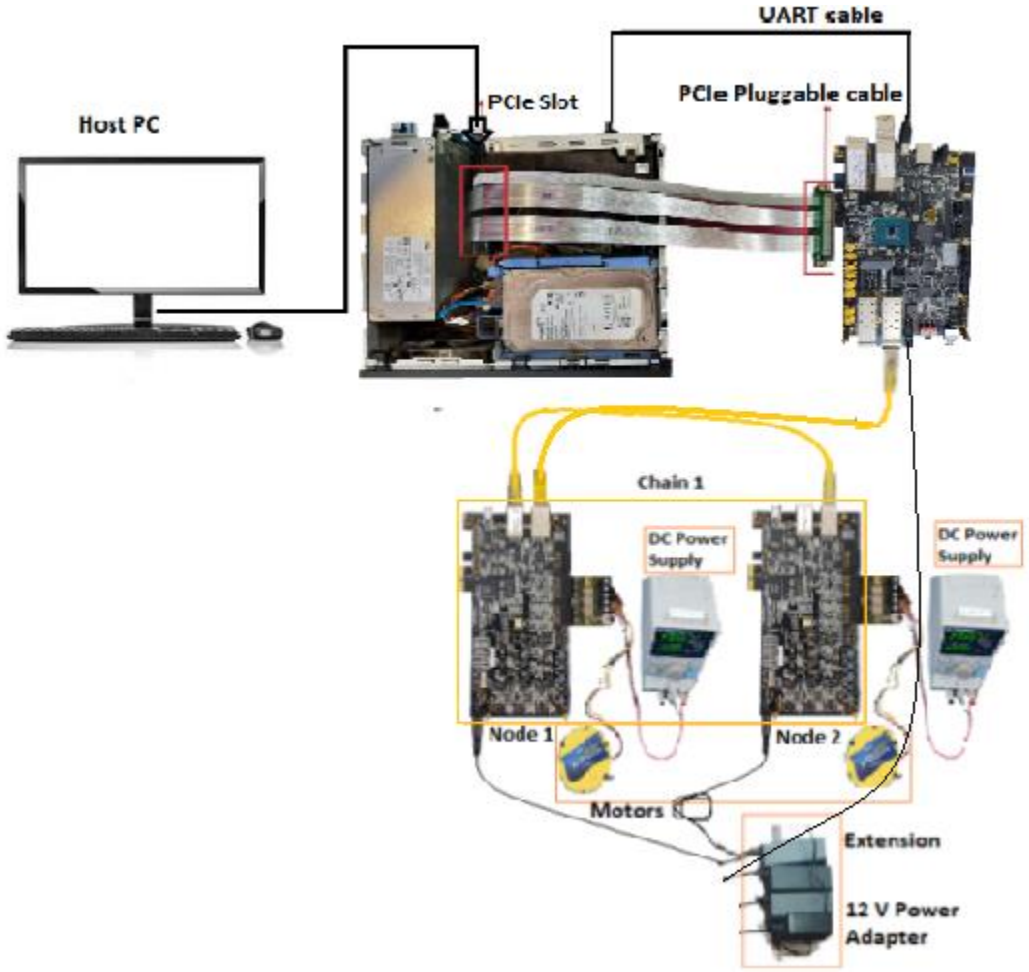


Figure 4.3: PCIe system setup

4.3.1. Hardware Connection

1. Host PC to run the Lattice Automate script.
2. PCIe Cable for Host PC to CertusPro NX connection
3. Lattice Certus-NX Versa Evaluation Boards with 12 V power adapters.
4. Lattice CertusPro-NX Versa Evaluation Board with 12 V power adapter.
5. USB Type-A (UART) cable for Connect the Raspberry pi to Lattice CertusPro NX and CertusNX board.
6. Ethernet cables and two electrical 1G SFPs (Methode, Finisar etc) for main to Node Connection
7. DC power Supply with 24 V and 0.5 A current of minimum requirement.
8. GB-42 BLS 24V 5000 RPM 4 or more motors with Trenz TEP00-3 4 or more motor control boards

Automate Stack Demo Package Directory Structure

The directory structure of the Automate Stack Demo Package is listed below.

4.4. Automate Stack Demonstration

4.4.1. Downloadable Demo Files

4.4.1.1. Documentation

A. Executables
    a. Main System
        i. PDM_DataSection.mem
        ii. PDM_ISRCodeSection.mem
        iii. riscv-pdm.bin
        iv. soc_main_system_impl_1.bit
    b. Node System
        i. NodeSystem_AS2_001.bin
        ii. NodeSystem_AS2_001.bit
B. Executables
    a. Main System

4.4.1.2. Host PC

A. GUI
B. PciScript

4.4.1.3. Raspberrypi

A. Mqtt_Lattice_Automate_2.0.zip
B. Readme.txt

4.4.1.4. Script

A. Lattice_Automate_Stack_2_0_Docklight.ptp

Below is the brief description of the main directories.

- The Automate Stack Demonstration folder will be the parent folder for all the files. It will have 3 sub folders, namely Images, Project and Documentation.
- The Images sub-folder will have the FPGA Images (bit files) and Binary Images(Firmware) for both main system and node.
- The Project sub-folder will contain the whole project package and files for both main system and node. The FPGA project can be accessed in the soc_main_system/soc_node section and firmware project can be accessed in the c_main_system/c_node section.
- The documentation sub-folder will contain the user guide for the project.

5. Hardware System Readyness

1. Hardware should be Connected properly as mentioned in Section 4.2.
2. All Boards Should be programmed
3. Power cycle the each boards After programming all the boards.
4. After Power cycle done, Reset the Main Board.
5. For Raspberry Pi Connections and installation process refer to Appendix A.
6. Application Installation, refer to Appendix C.
7. To start the server, refer the Section 7.
8. To launch the GUI/Application, refer the Section 8.

6. Steps to run the server (Server End)

Note: For Raspberry pi Board bring up, refer the Appendix A.

1. Open the terminal.
2. Go to the Directory
3. Lattice_Automate_Stack_1_1/OPCUA_Server/OPCUA_serverApp/bin
4. Write the command **"./server" to start the server**

```
pi@raspberrypi:~ $ cd Rel18May/Mqtt_Lattice_AutomateStack_2_0/
pi@raspberrypi:~/Rel18May/Mqtt_Lattice_AutomateStack_2_0 $ cd bin/
pi@raspberrypi:~/Rel18May/Mqtt_Lattice_AutomateStack_2_0/bin $ ./server -v5
```

Figure 6.1: server

5. Server will start.

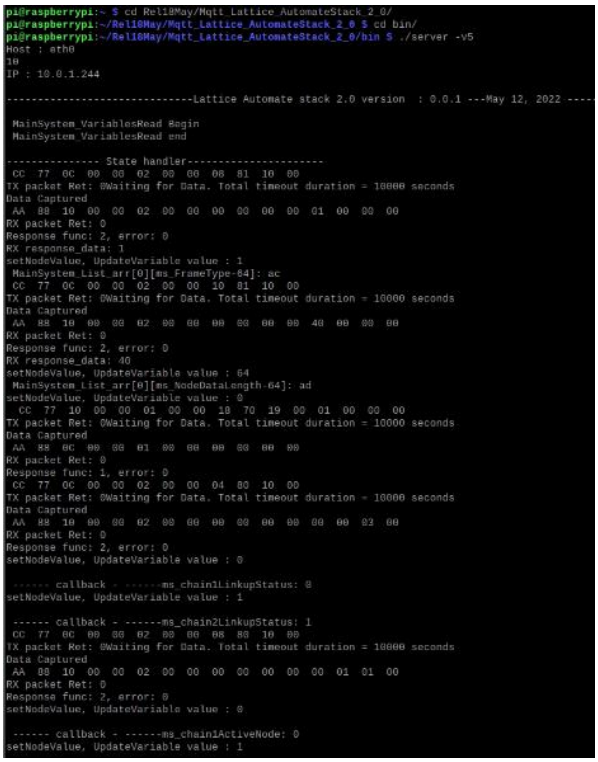


Figure 6.2: running server

7. Running the Motor through Test Application Software (Client Side)

This section provides the procedure for running the motor through Graphical User Interface/Test Application.

Note: For Lattice Automate Stack 2.0 Application Installation, refer to Appendix C.

Note: For generation the Bit and Binary file, refer to Appendix D.

Note : Make sure that Main system and each nodes programmed before running the Lattice Automate Stack 2.0 Complete setup, refer to Appendix E.

7.1. Start the Application in Windows PC

1. Open the Lattice Automate Stack 2.0 Application.
2. GUI will be launch.

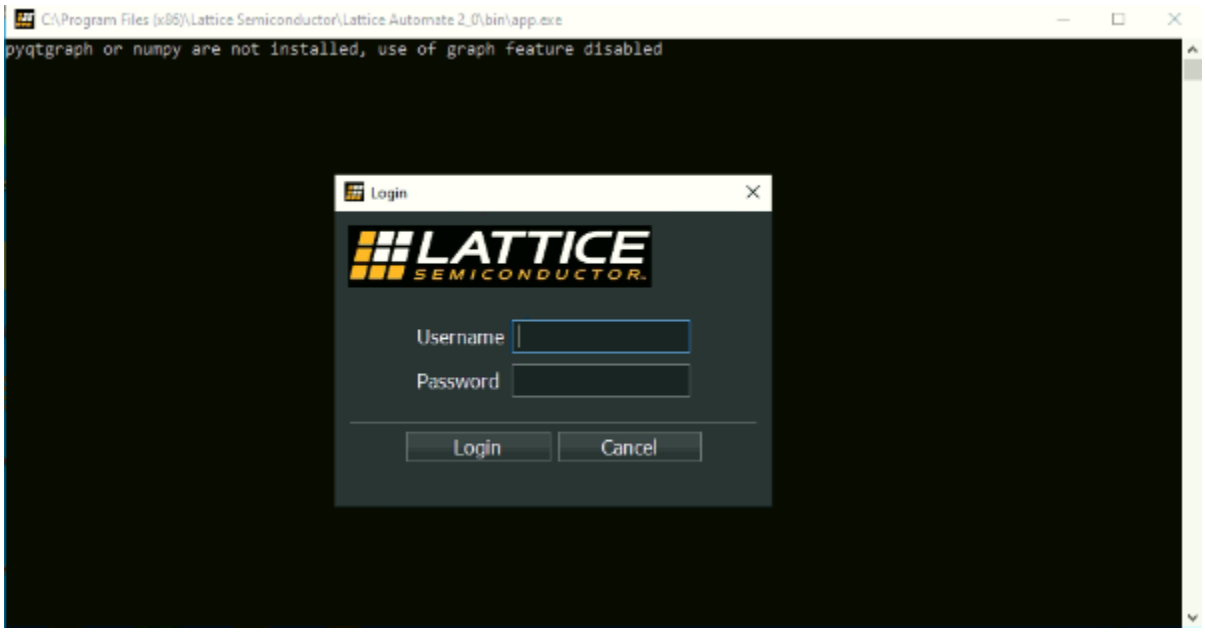


Figure 7.1: Login Page

3. Enter the Username: lattice, Password: lattice
4. Dashboard Page will open.

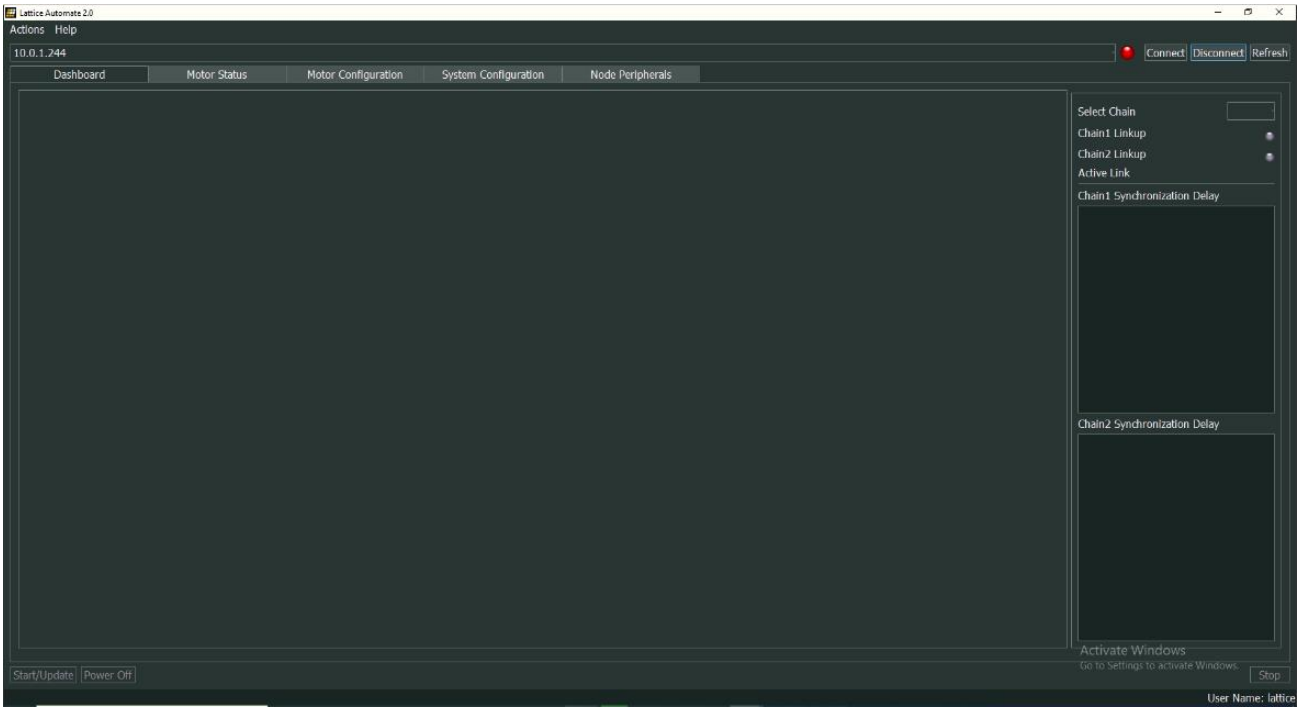


Figure 7.2: Dashboard Page

7.2. Connect to the server

1. Go on the System Configuration page.

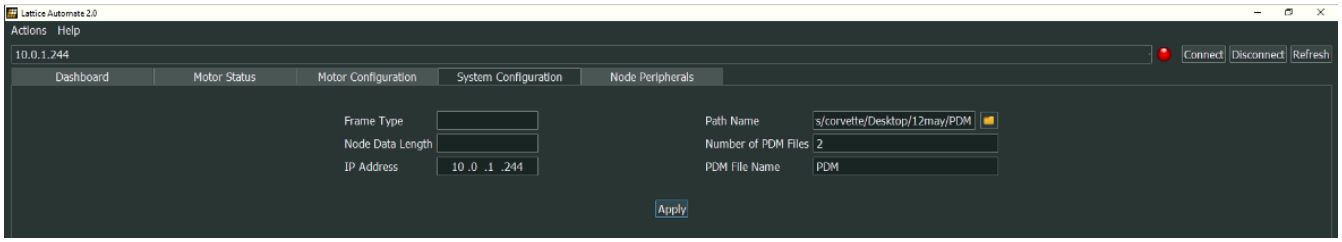


Figure 7.3: System Configuration page

2. Type the correct IP Address on the IP Address bar.

Note: IP Address should be from the raspberry pi setup.

3. Now press the **Apply** button than **Update Successfully** pop up will come.
4. Now click on the **Connect** button.
5. Once IP Address configured, it will update on the top of the Address bar.

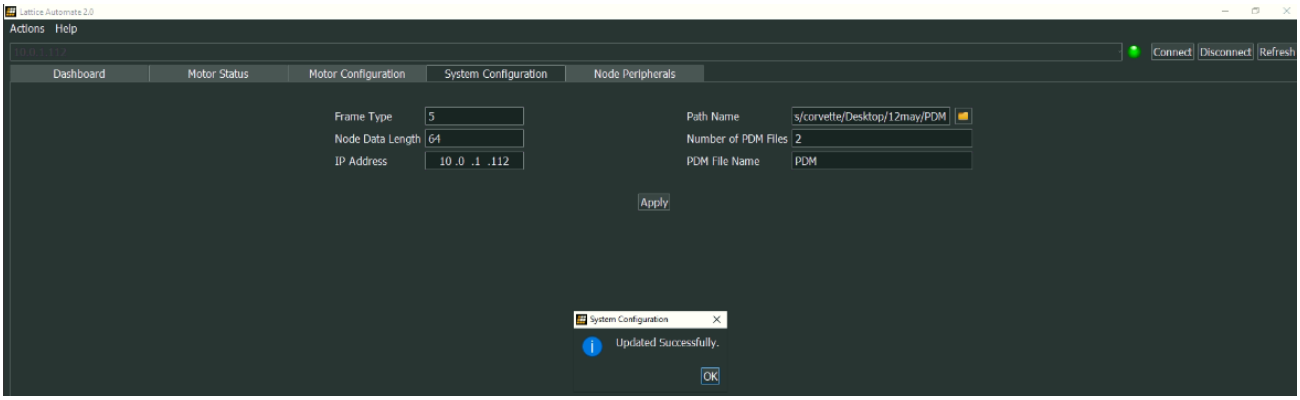


Figure 7.4: IP Address bar

7.3. Select the Chain

1. Select the **Select Chain** option as **Both**.

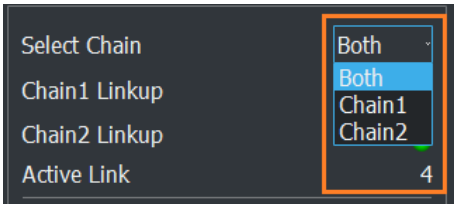


Figure 7.5: select Chain

2. It will display the both chains.

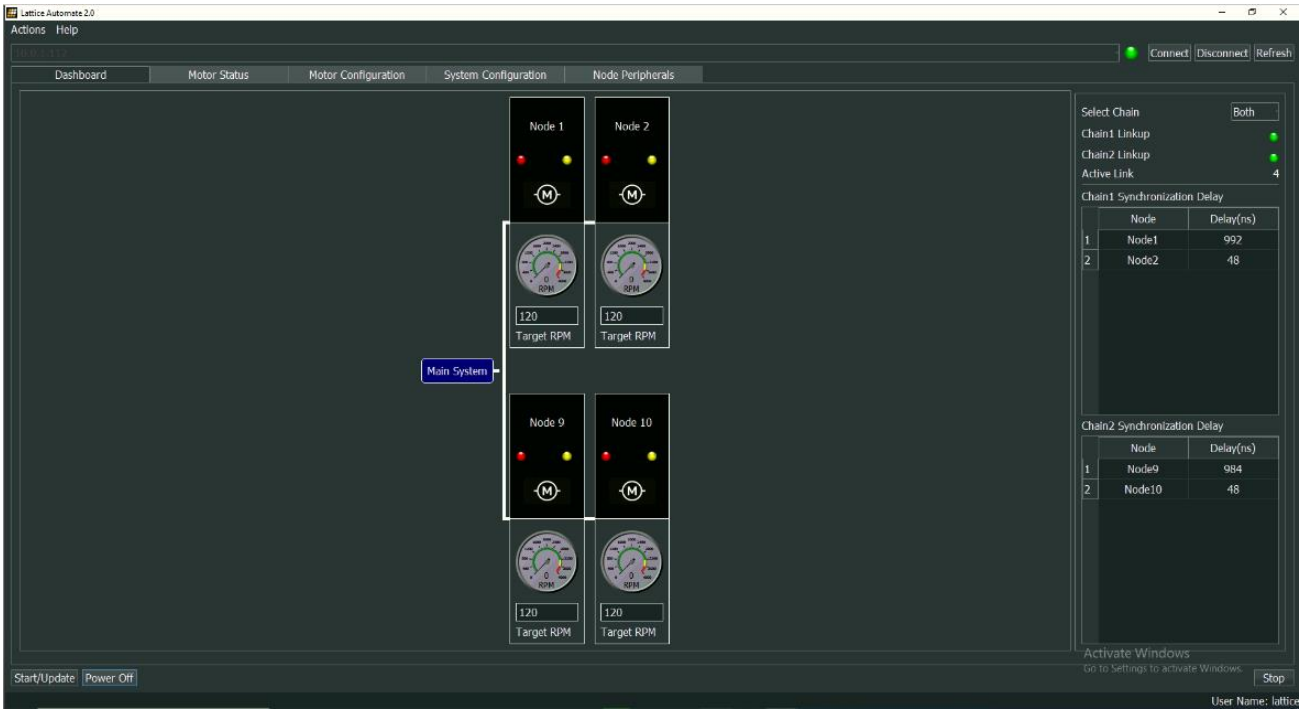


Figure 7.6: Both Chain

3. If Selected the **Select Chain** option as **Chain1** or **Chain 2**

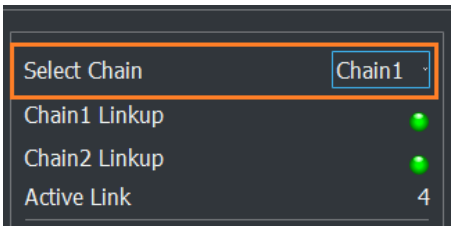


Figure 7.7: Select Chain

4. It will display the only Single Chain.

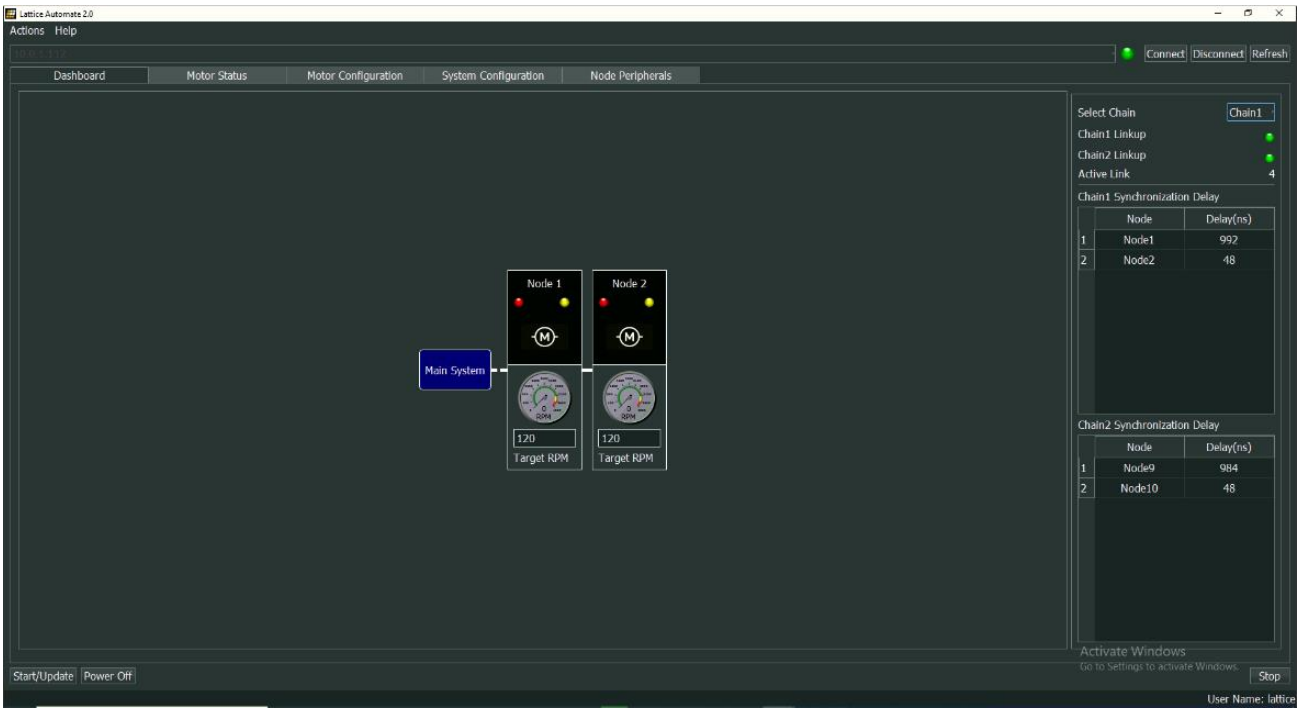


Figure 7.8: Single Chain

7.4. Motor Configurations

1. Now go on the Motor Configuration page
2. Select the number of nodes.

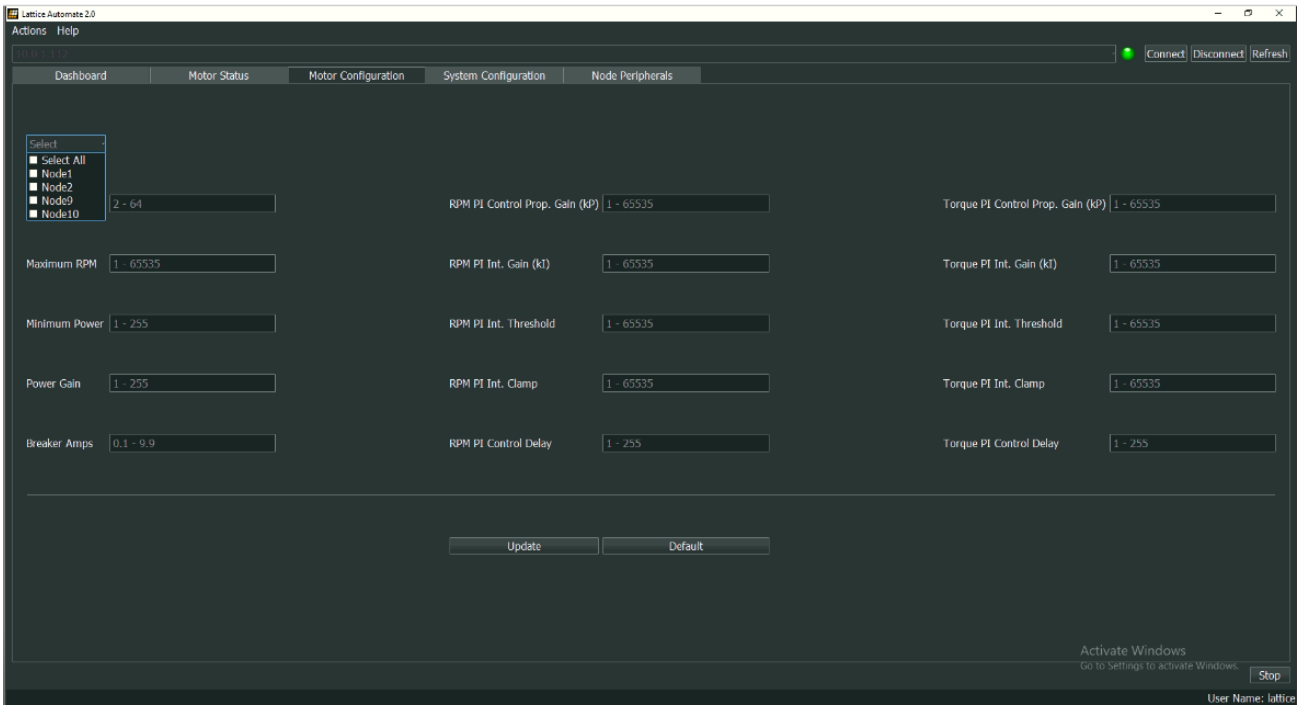


Figure 7.9: Motor Configuration page

3. Click on the default option.
4. Click on Update option.
5. Pop message will come and Confirm the update action by clicking on Yes button.

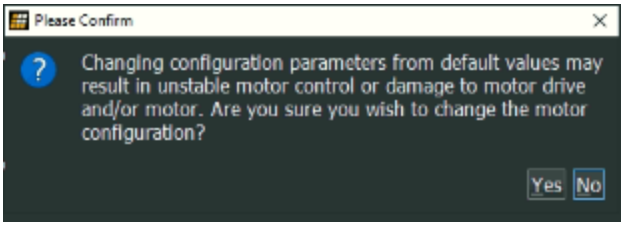


Figure 7.10: Confirmation Pop up

6. Authentication Page will come.
7. Enter the **Username: lattice and Password: lattice**
8. Click on the **Login** button.

Figure 7.11: Authentication page

9. Configuration **Successfully updated the configuration of the selected node** pop will come.

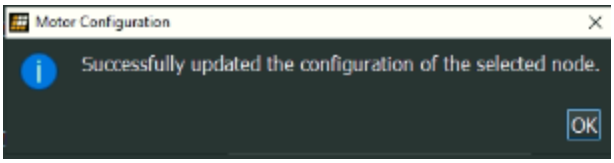


Figure 7.12: Update Configuration

7.5. Set the Target RPM from the Dashboard page.

1. Go on the Dashboard Page.
2. First Enter the Target RPM Value 120.

Note: Targeted RPM value should not be more than the Maximum RPM Value of Motor Configuration Page.

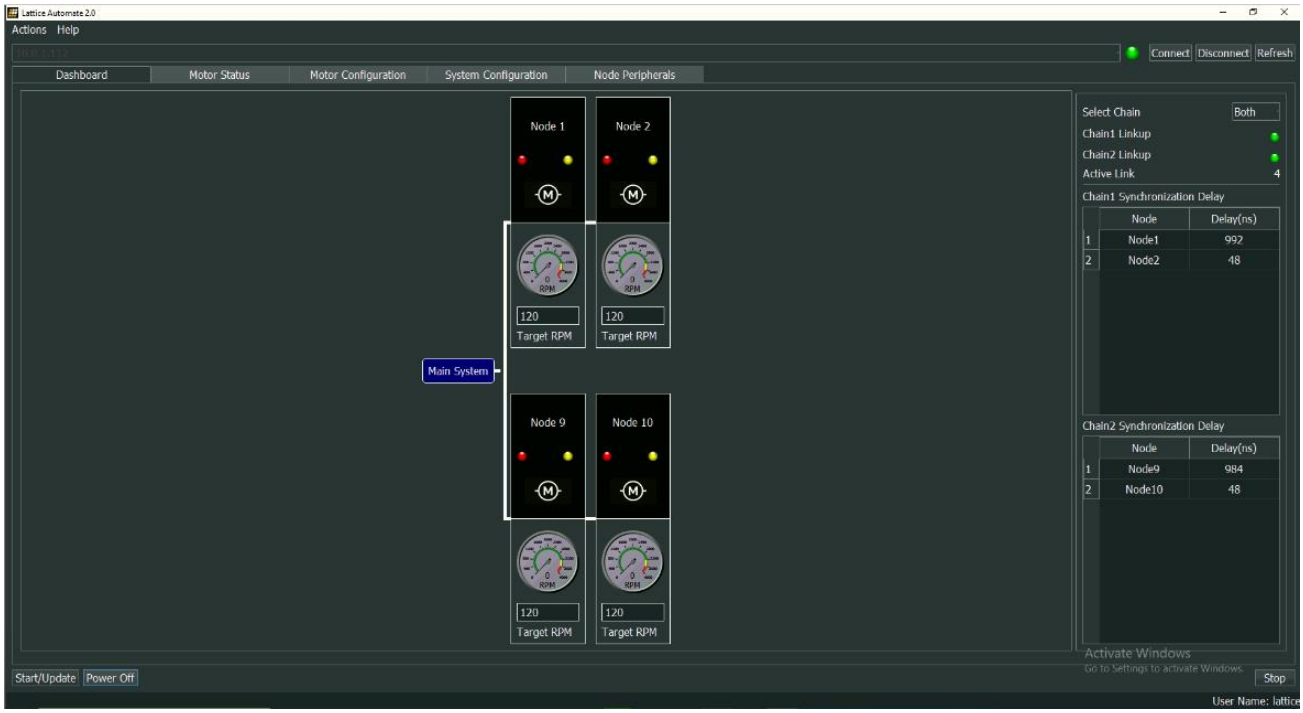


Figure 7.13: Set Target RPM

3. Click on the Start Update Option.
4. After the RPM Lock Achieved the Node LED glow green.

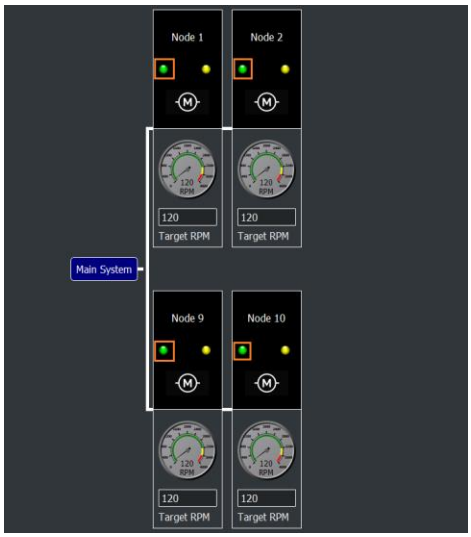


Figure 7.14: RPM Lock Achieved Status

5. Now go on the Motor status page to Check the RPM, Voltage and Current value.
6. Now Select the any Nodes as **Node 1/ Node 2/ Node 3/ Node4** or **Select all**.

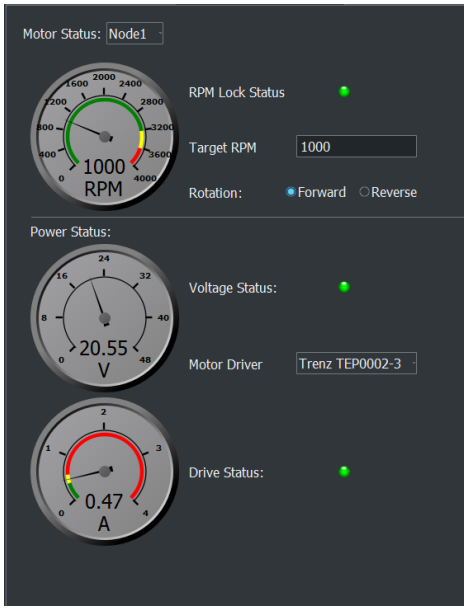


Figure 7.15: Motor status page

7. For Stopping the Motor, Click on the **Stop** from the Motor status page or dashboard.
8. In case of any Emergency or to Withdraw the current in the Motor, Click on the **Power Off** button.

7.6. Motor Status

1. Go on the Motor Status page.
2. Set the Target RPM 120
3. Now click on the **Start/Update** button.

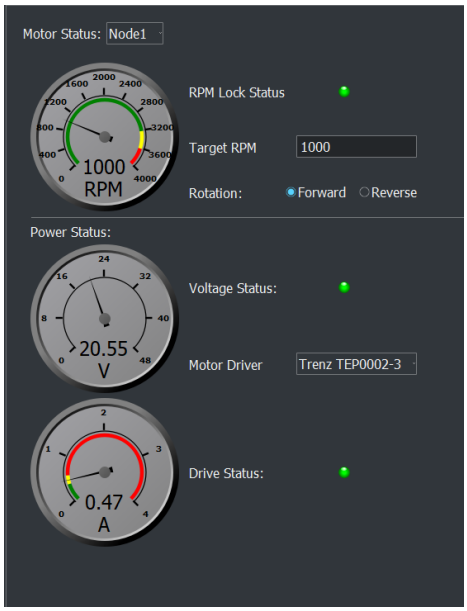


Figure 7.16: Target RPM

4. Meter gauge update to 120RPM and it will update to 120 RPM on the Target RPM bar too.
5. Set the Target RPM 1000 RPM to update the RPM Speed.
6. Meter gauge update to 1000 RPM and it will update to 1000 RPM on the Target RPM bar too.
7. For stopping the Motor, click on the **Stop** button.
8. Click on the **Power Off** button to stop the voltage and current in motor.

7.7. Forward/Reverse rotation

1. Go on the Motor Status page.
2. Select the Forward Rotation and Enter the target RPM 1000.
3. Click on **Start/Update** button.

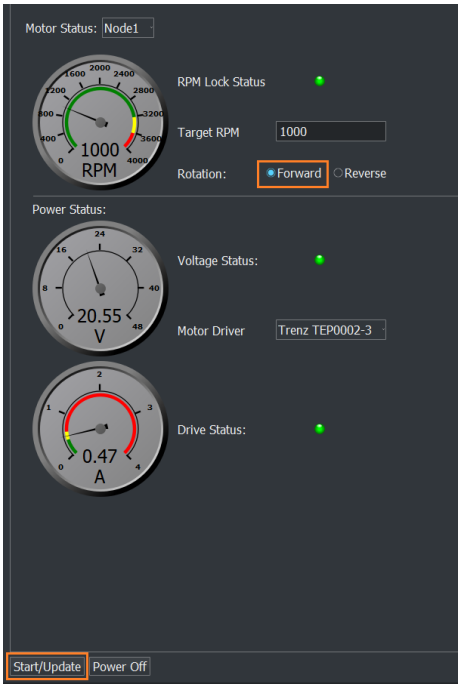


Figure 7.17: Reverse Rotation Selection

4. Motor will Start rotating in an Clockwise direction.
5. Now select the Reverse rotation.

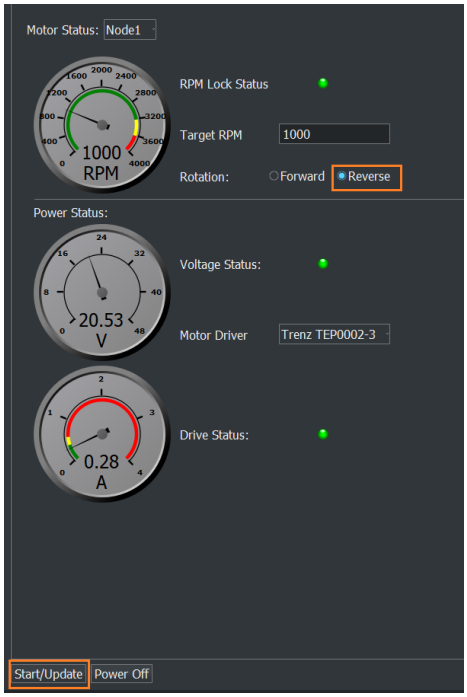


Figure 7.18: Start Update

6. Click on **Start/Update** button.
7. Motor will Start rotating in an Anti-Clockwise direction.

8. In case of Emergency, power off the motor by clicking on **Power off** button.

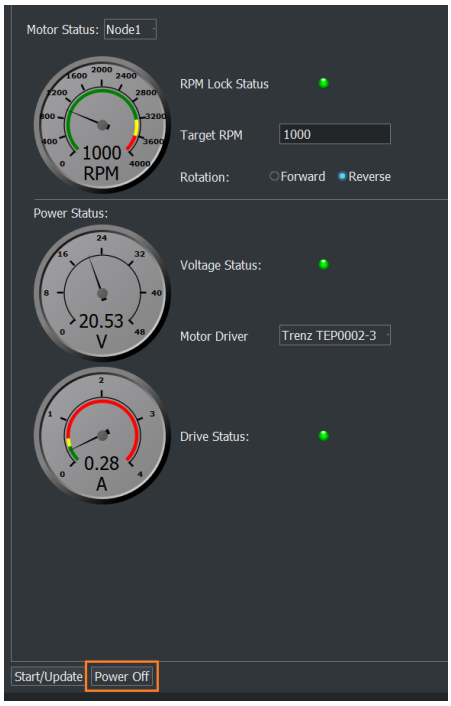


Figure 7.19: Motor Power OFF

7.8. Capture PDM data

7.8.1. Collect PDM Data

1. Go on the Motor status page.
2. Set the target RPM between 1400 and 1800.
3. Now click on the **Start/Update** button, wait until the RPM lock.
4. Now click on the **Collect PDM data**, wait for the PDM data process will complete.
5. It will show the **Analyzing PDM Data from Node** and **Collecting PDM Data from Node** while capturing the image.

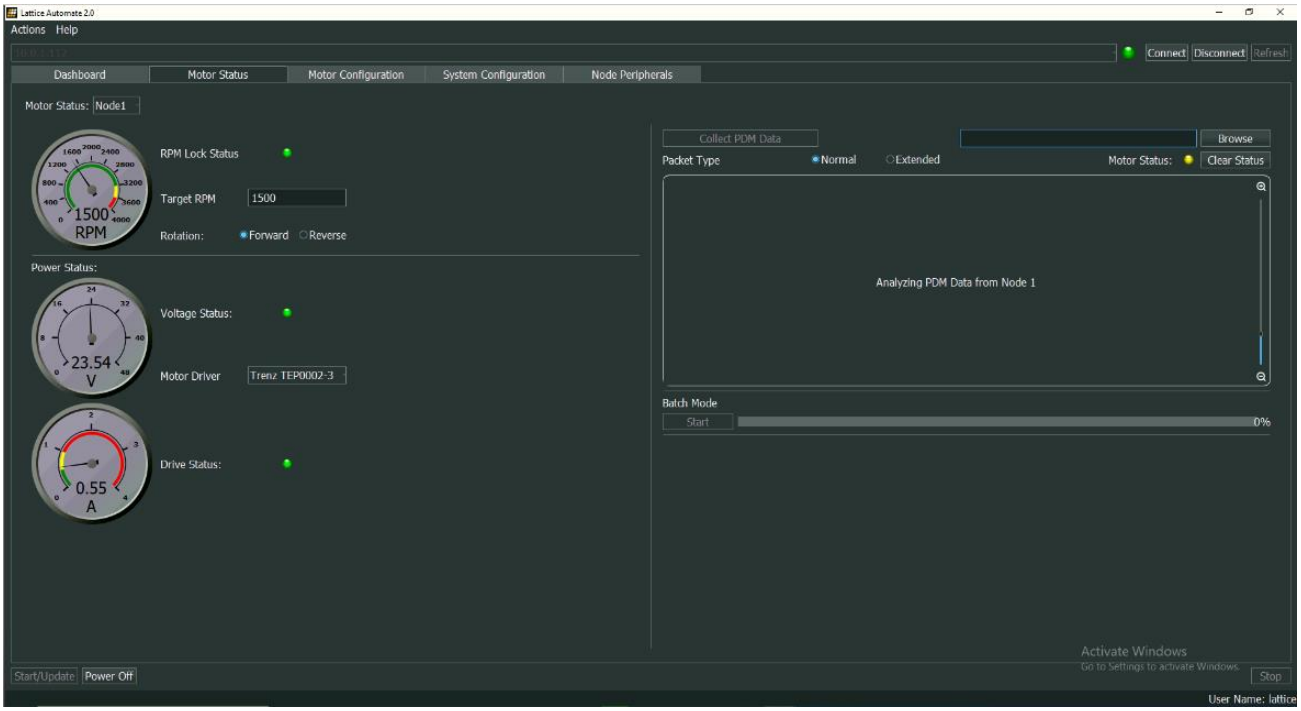


Figure 7.20: Analyzing PDM Data

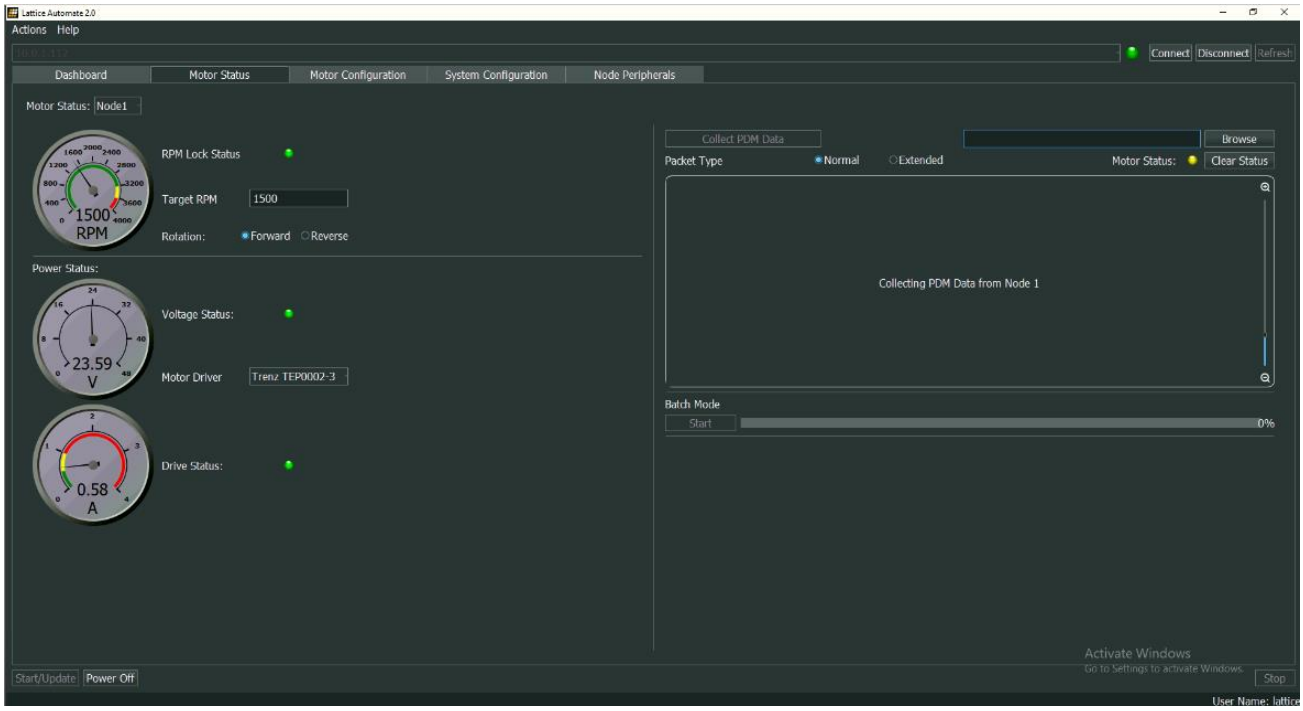


Figure 7.21: Collecting PDM Data

6. Check the PDM image, it will display on the Screen.
7. If collected data is red then click on the **Clear status** button to clear the status.
8. To fetch the previous images, click on the **Browse** button.

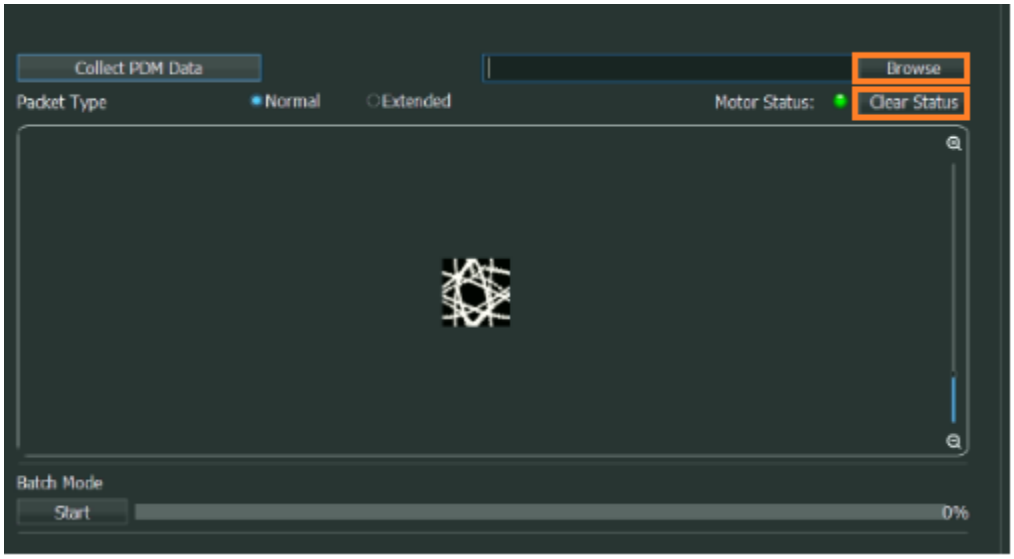


Figure 7.22: Collect PDM data

9. To Zoom-in or Zoom-out the size of PDM image, move the cursor on the blue line from the black line.

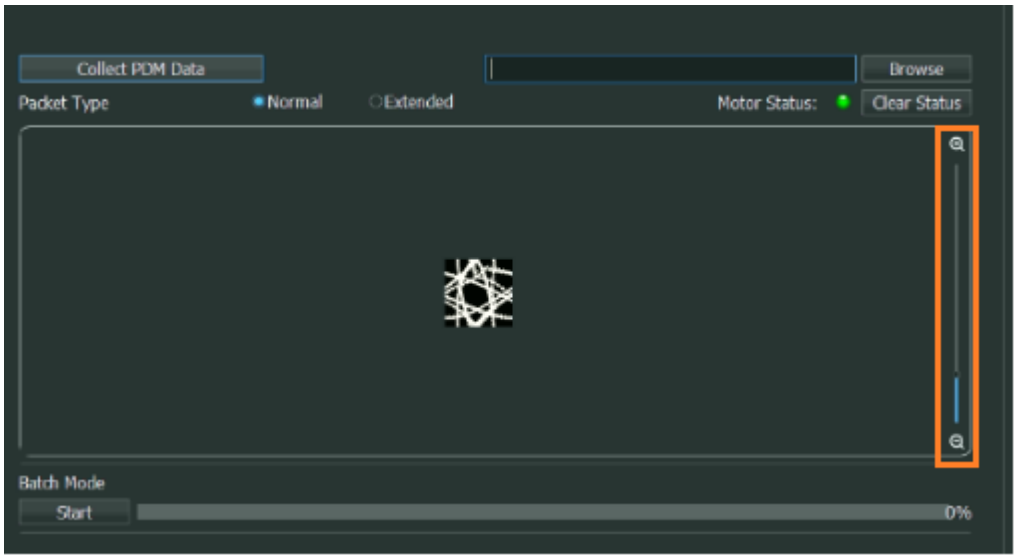


Figure 7.23: Zoom In and Zoom Out

7.8.2. Batch Mode

1. Follow the same process of Collect PDM Data process after that Batch Mode.
2. Go on the system configuration and set the Number of PDM files 5 .

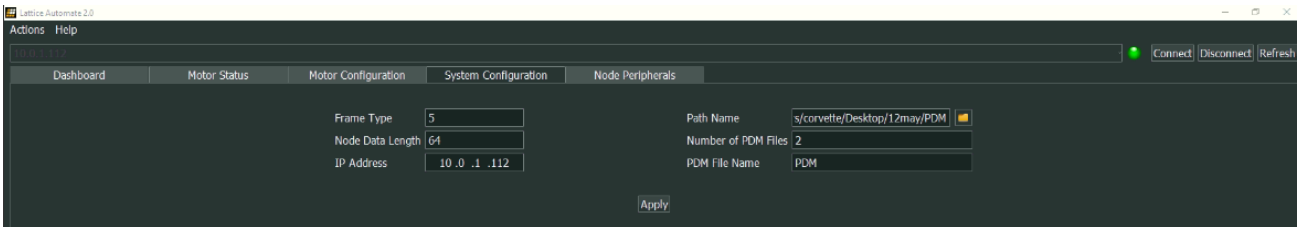


Figure 7.24: Number of PDM file Name

3. Now go back to the Motor status page.
4. For collecting the Multiple images, Click on the Batch Mode.

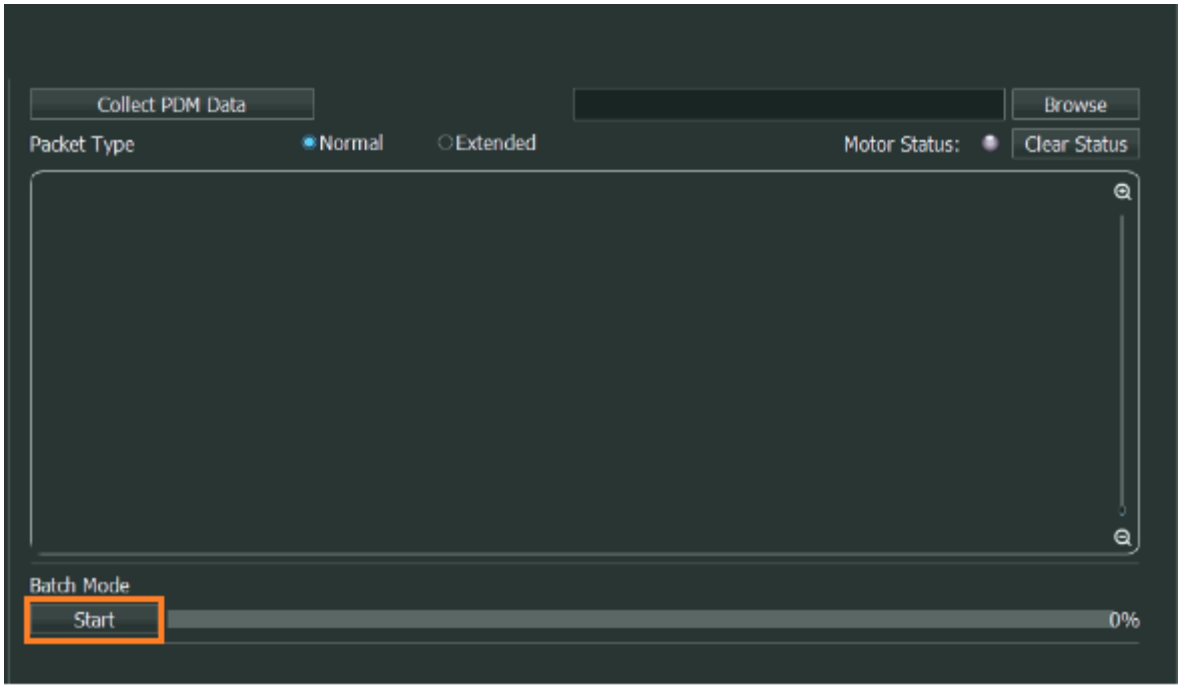


Figure 7.25: Start Batch Mode

5. Wait for the some time to collect the multiple images till 100% .

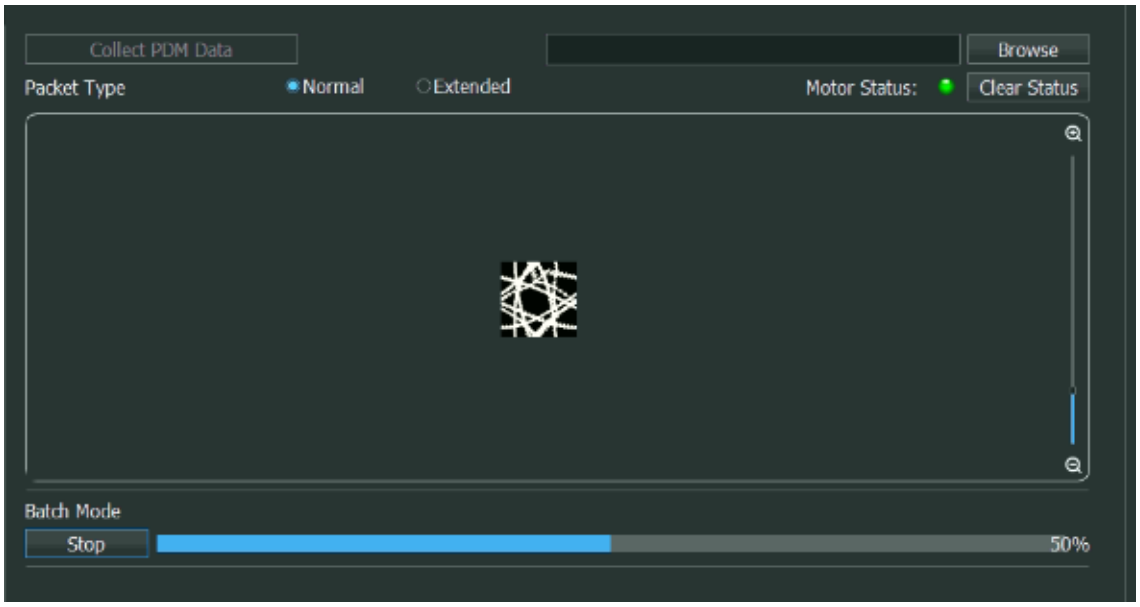


Figure 7.26: Collecting Multiple images

6. After Collecting the Multiple images, Click the **Stop** button.

7.9. Node Peripherals

7.9.1. I2C

1. Select any of the node.
2. Select the protocol: I2C
3. Select the option: Write
4. Enter the slave Address one byte: for eg 4A
5. Enter the Register Address one byte: for eg. 01
6. Enter the Data 4 bytes: for eg. 14527
7. Now Click on the write button.

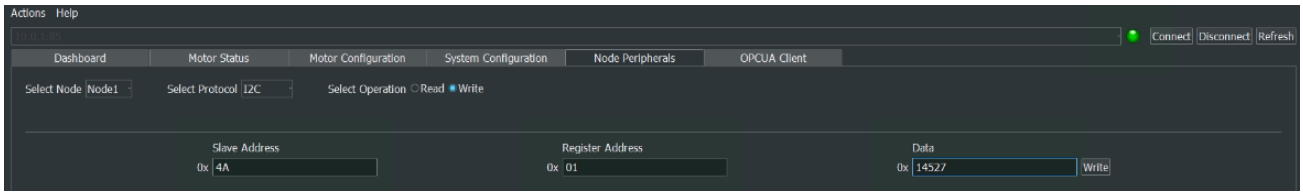


Figure 7.27: 12C

8. Now open the Total Phase Control Center tool
9. Go to the Adapter option
10. Now go to the connect option as shown in below fig.

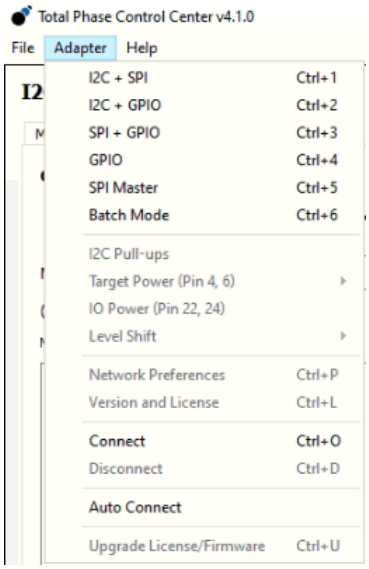
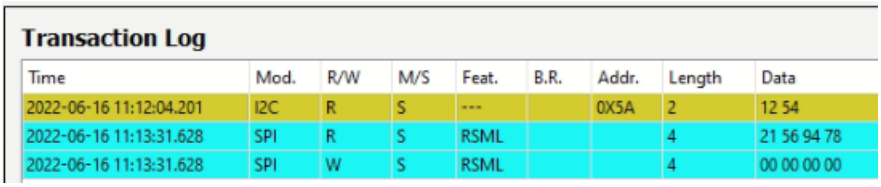


Figure 7.28: Connect option

11. Select the configuration as I2C/SPI
12. Click on the OK button
13. Click on the enable button
14. Check the transaction log

Note: Make sure that UART cable should be connected properly.



Transaction Log

Time	Mod.	R/W	M/S	Feat.	B.R.	Addr.	Length	Data
2022-06-16 11:12:04.201	I2C	R	S	---		0X5A	2	12 54
2022-06-16 11:13:31.628	SPI	R	S	RSML			4	21 56 94 78
2022-06-16 11:13:31.628	SPI	W	S	RSML			4	00 00 00 00

Figure 7.29. Transaction log

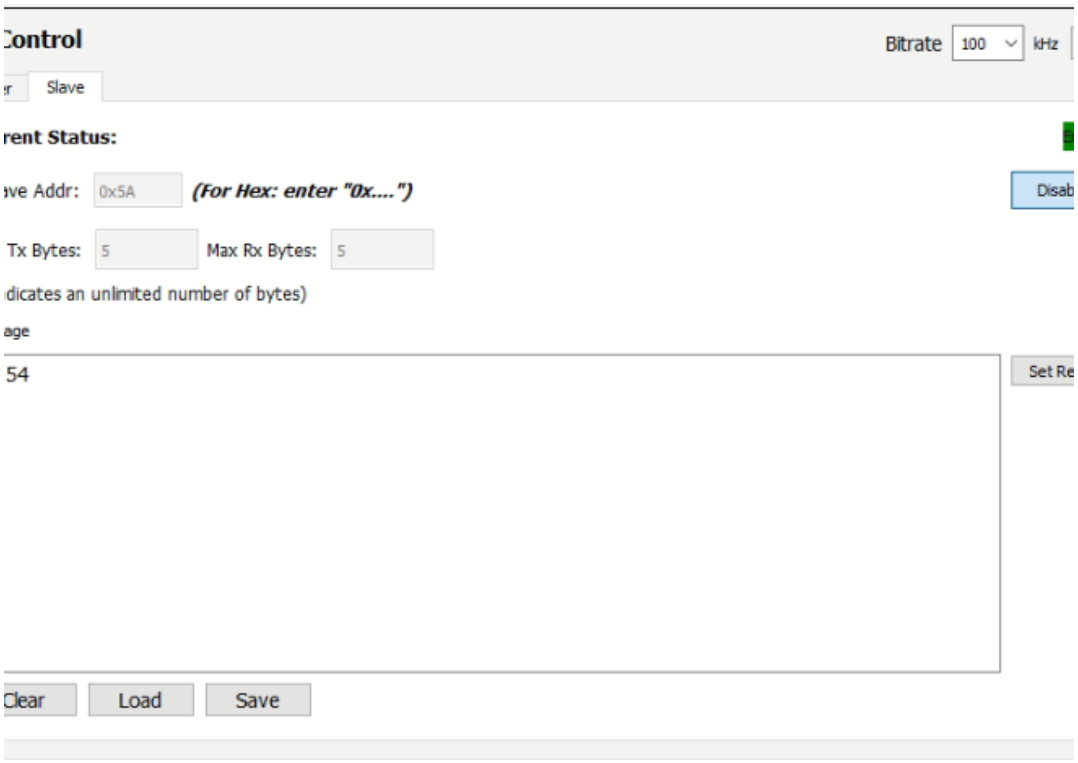


Figure 7.30: I2C control

7.9.2. SPI

1. Select any of the node.
2. Select the protocol: SPI
3. Select the option: Write
4. Enter the slave Address one byte: for eg 9F
5. Enter the Register Address one byte: for eg. 05
6. Enter the Data 4 bytes: for eg. 25784
7. Now Click on the write button.

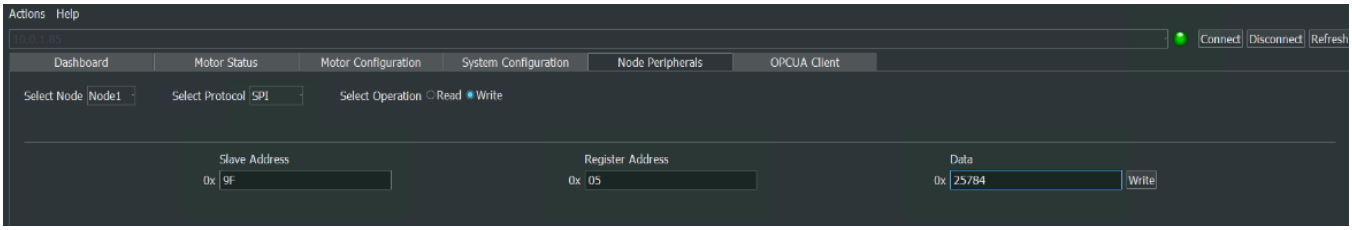


Figure 7.31: SPI

8. Now open the Total Phase Control Center tool
9. Go to the Adapter option
10. Now go to the connect option as shown in below fig.

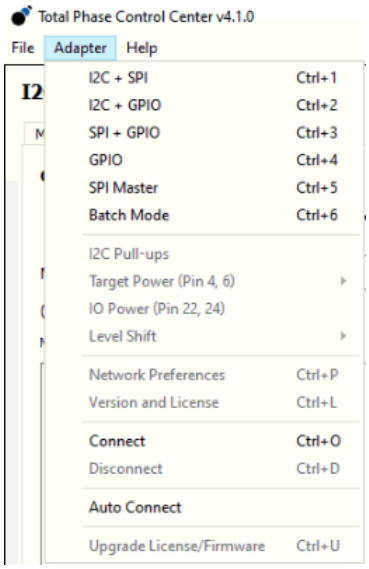


Figure 7.32: Connect option

11. Select the configuration as I2C/SPI
12. Click on the OK button
13. Click on the enable button.
14. Check the transaction log

Note: Make sure that UART cable should be connected properly

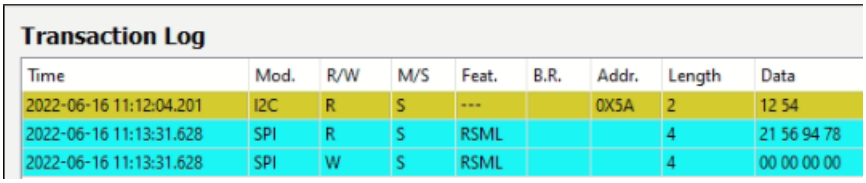


Figure 7.33. Transaction log

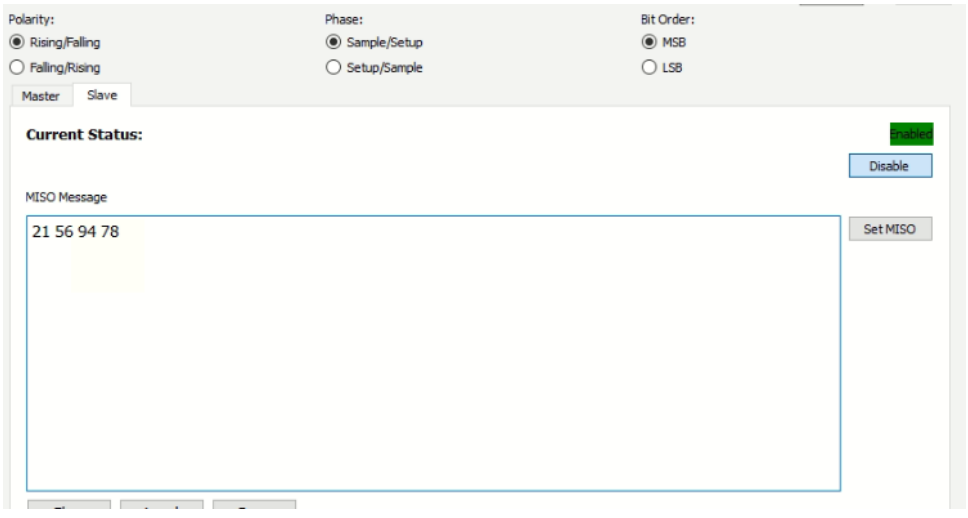


Figure 7.34: SPI Control

7.9.3. Modbus

1. For holding register, Enter the register no. : 0x6
2. Enter the Data 2 bytes: 12547

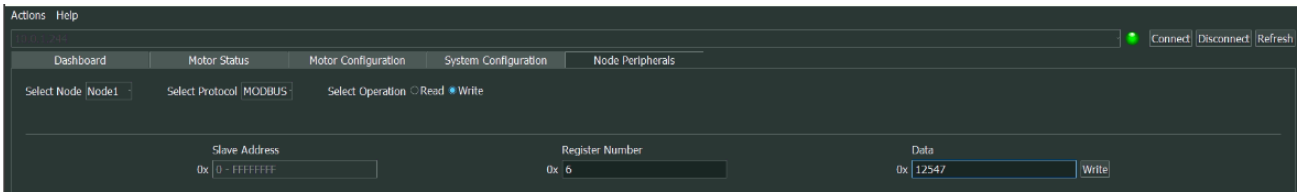


Figure 7.35: Modbus

8. Running the Motor through the Script (PCIe connection)

8.1. The following steps of Readme.txt:

1. Python packages required: pybind11, invoke
2. Python package installation commands:

```
pip3 install pybind11
pip3 install invoke
```

3. In Source_Code/wrapper/build_wrapper.py file on line 7 replace the python version if you have a different python version than 3.7
    a. For instance if the installed python verion is 3.6 then update the verison from 3.7 to 3.6, as shown below
        a. "-o {1}`python3.6-config --extension-suffix` "
    b. Python version can be found by running this command:
        a. python3 -V
4. Before running the demo run the following command:

    python3 Source_Code/wrapper/build_wrapper.py

This command will create the python binding over c shared library "libmem_rw.so". This is a one time step

Kindly note that this step is not required when the python script is run using script.sh. The shell script is written to handle this step.

5. Execute the following commands (One time step)

    chmod 777 script.sh console_app.sh

6. To run the python script run this command. This script builds the driver, library, inserts the driver, builds the python wrapper (if required) and then runs the python script.

    sudo script.sh

7. To run the C++ console application run this command. This script builds the driver, library, inserts the driver and then runs the console application.

    sudo console_app.sh

Check whether the board has linkup with PC , run the command: lspci - xxx

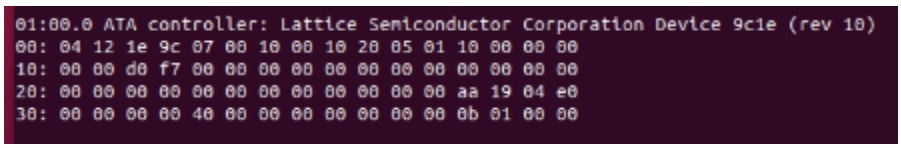


Figure 8.1: Check Device

8.2. The following steps to run the motor through the commands.

1. Go to the trunk directory.
2. Now run the following command: **sudo ./script.sh**

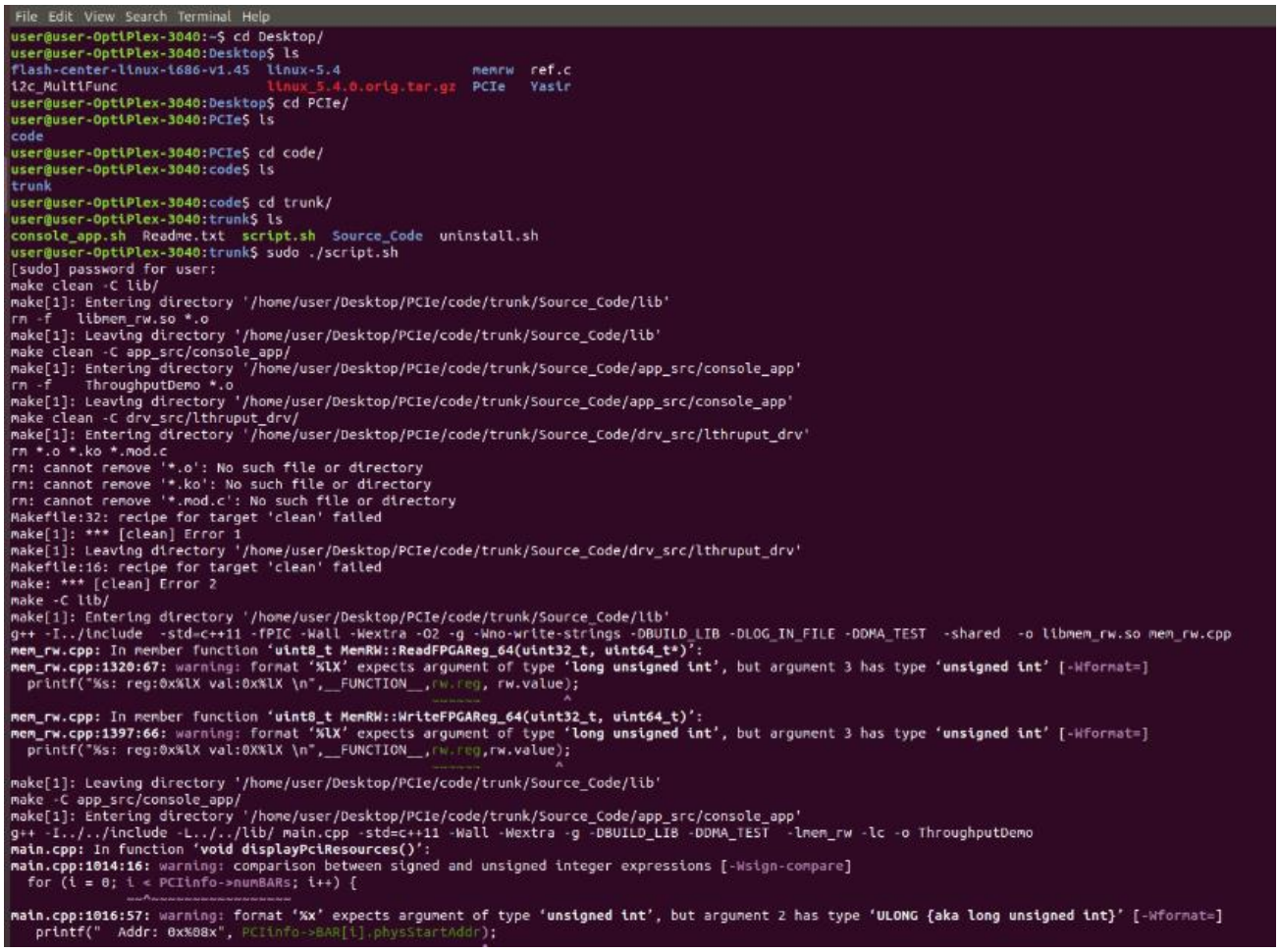


Figure 8.2: run the script

3. For run the motor initialization object will appear as mentioned in below figure.

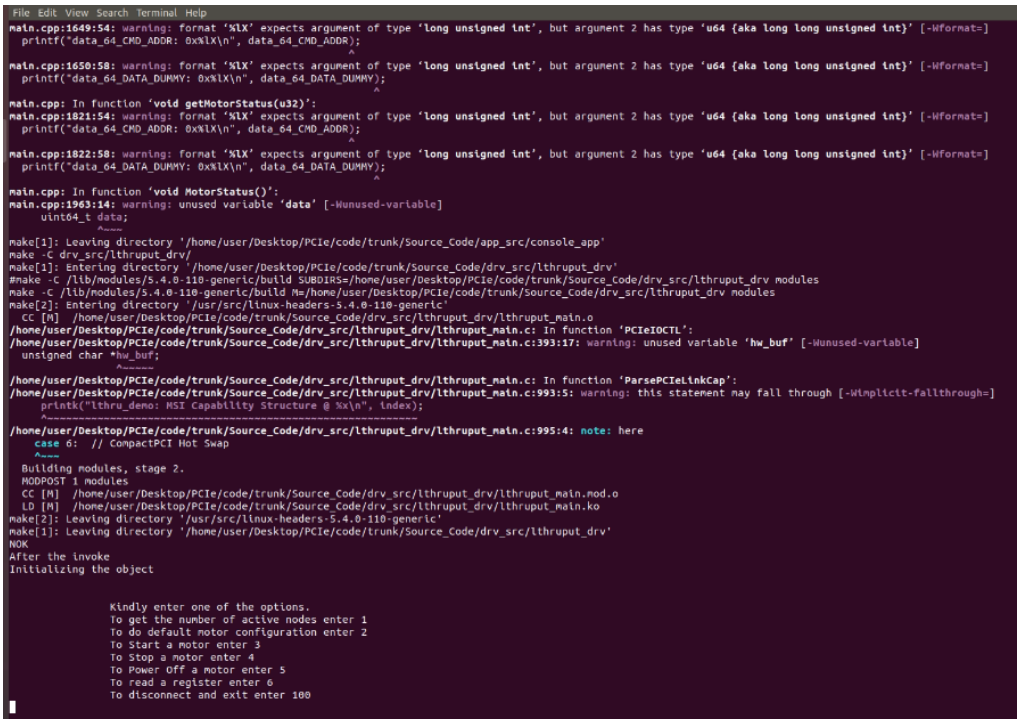


Figure 8.3: initializing the object

4. To get the number of active nodes: Enter 1
5. To do default motor configuration: Enter 2
6. After that enter the node between 1 to 16
7. Then Motor configuration will appear as mentioned in below figure.

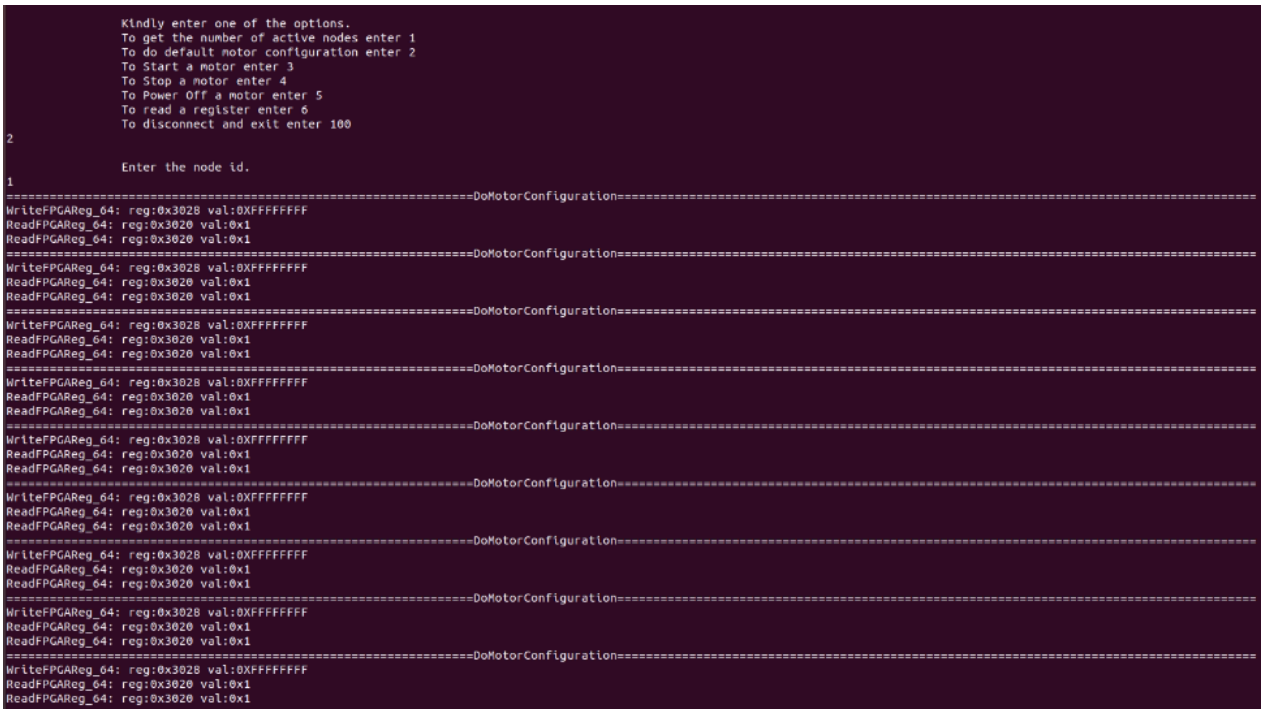


Figure 8.4: Motor Configuration

8. To Start a Motor: Enter 3
9. Then enterthe node id between 1 to 16 and Target RPM 120 to 1800 RPM

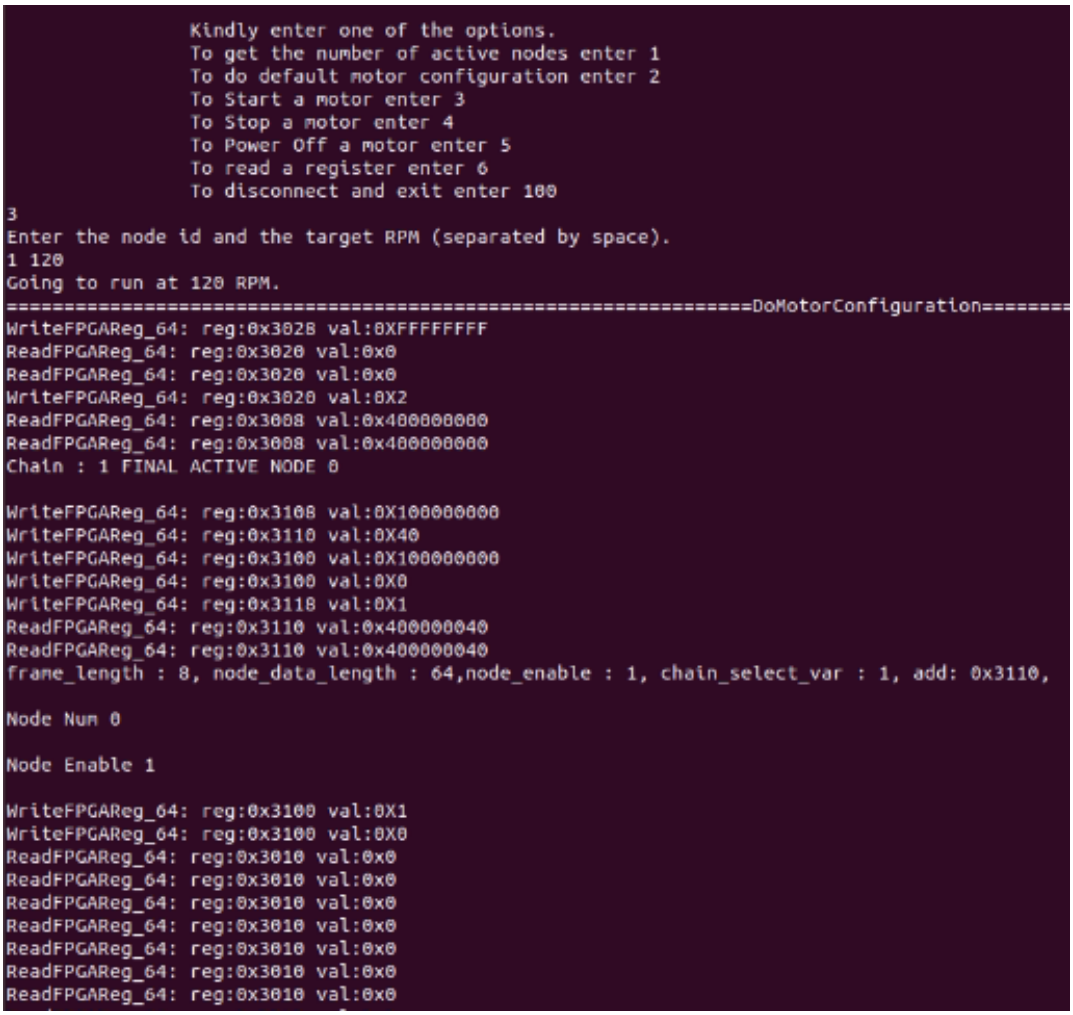


Figure 8.5: Start motor Node id and target RPM

10. To Stop a Motor: Enter 4
11. Then enter the node id same as selected before.

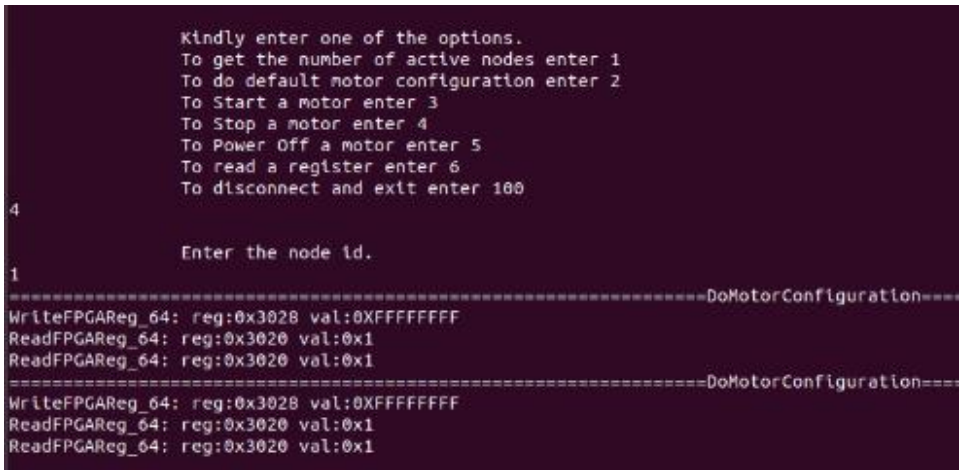


Figure 8.6: Stop motor node id

12. To Power Off a Motor: Enter 5
13. Enter the Node id same as entered before

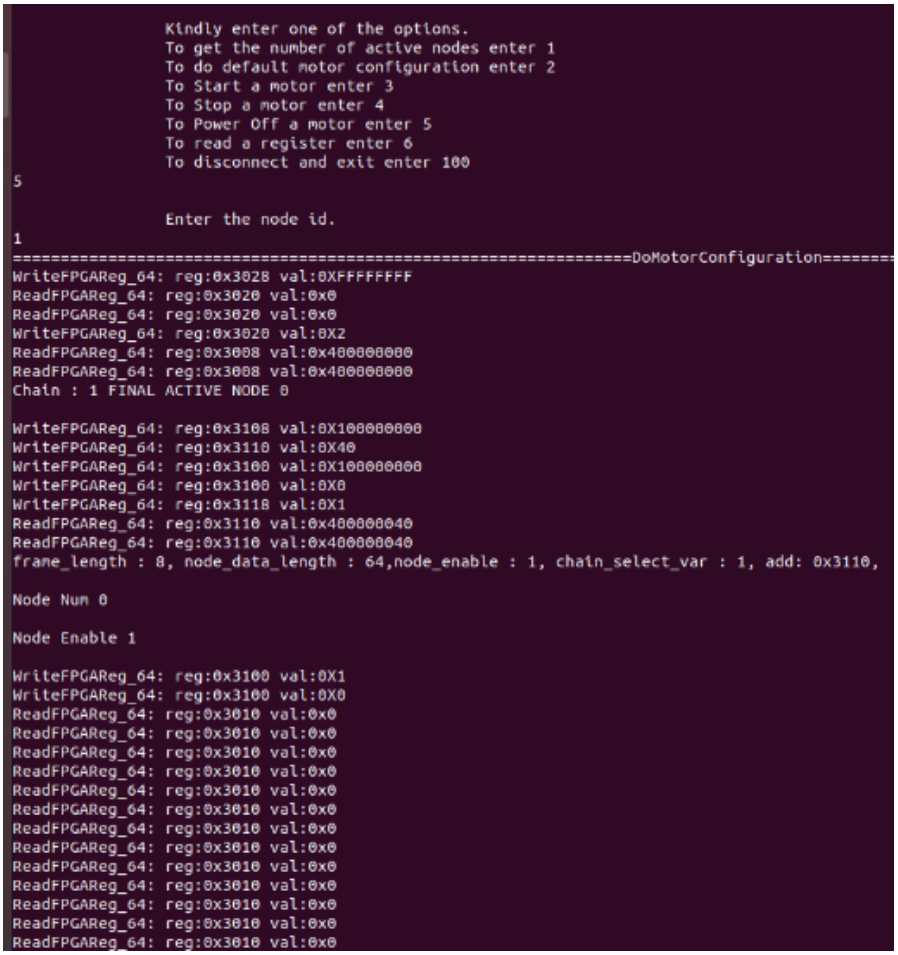


Figure 8.7: Power off node id

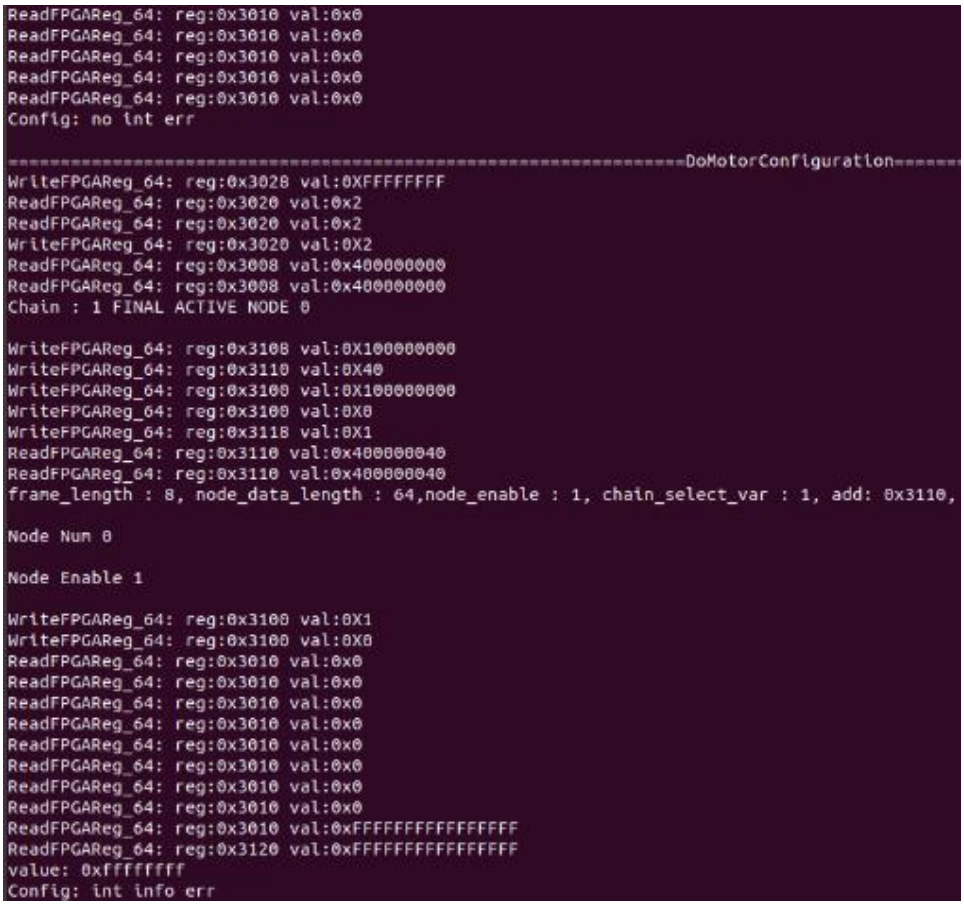


Figure 8.8: Power off node id prints

14. To read a register: Enter 6
15. Enter Reg for read: 1

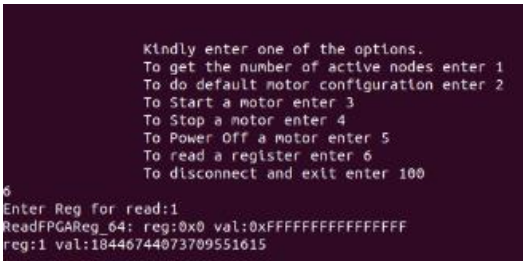


Figure 8.9: read a register

16. To disconnect and exit: Enter 100

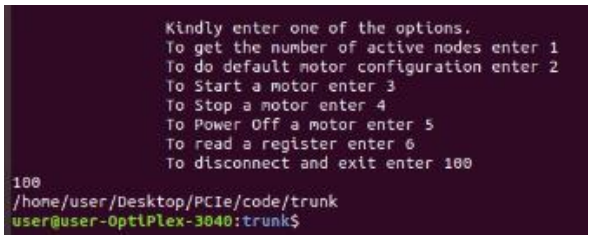


Figure 8.10: Disconnect and exit

Appendix A. Raspberry pi Setup

A.1 SD card Format

1. Insert your **microSD card** into the USB card reader and plug into the PC or laptop.
2. Download the SD card formatter from the given link https://www.sdcard.org/downloads/formatter/sd-memory-card-formatter-for-windows-download/.

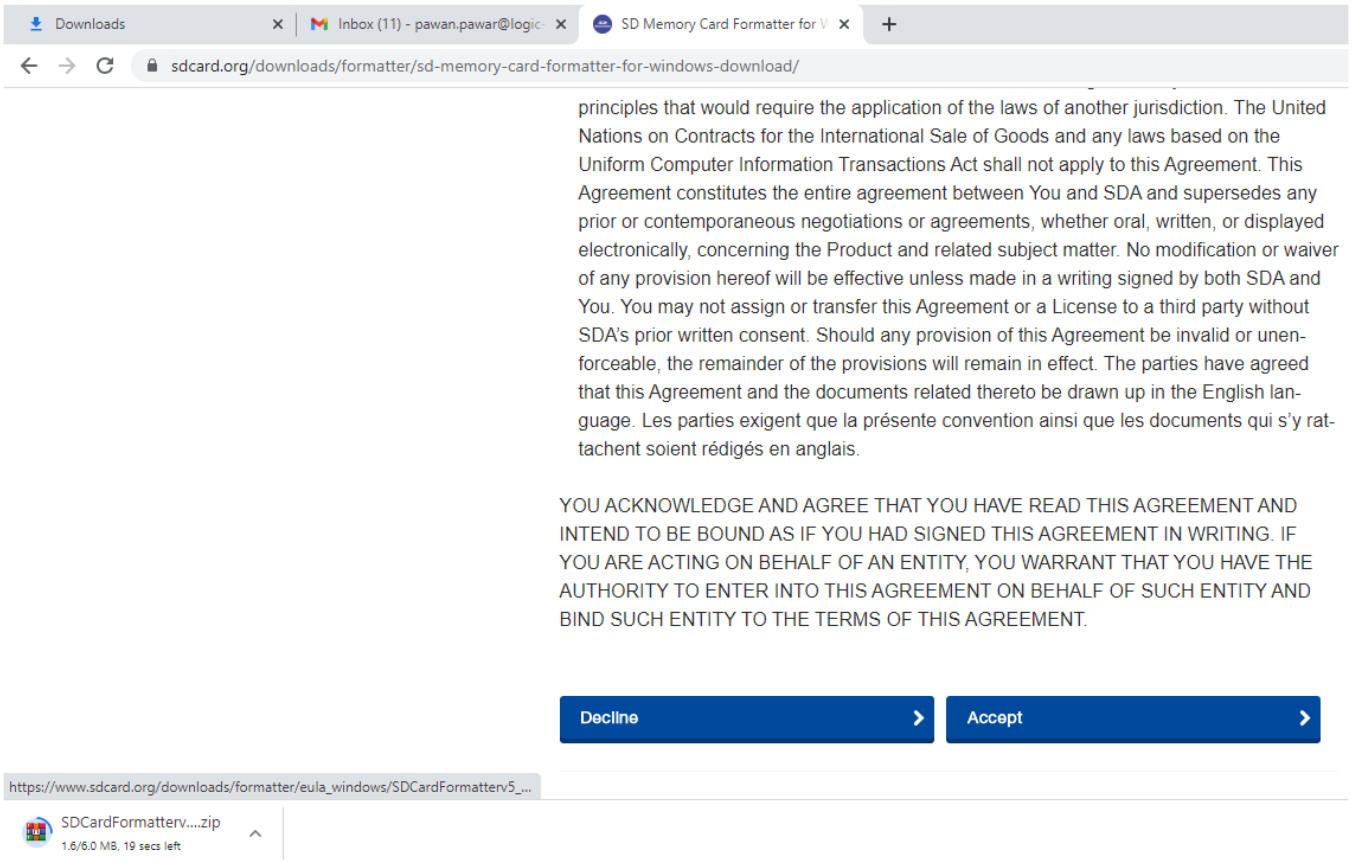


Figure 8.11: SD card installation

3. Click on the Accept and file will be download.
4. Unzip the Downloaded file and install the SD card format Application.
5. Now Open the SD card Formatter 5.0.1 setup.
6. Now choose the **Quick format** and click on **Format** option.

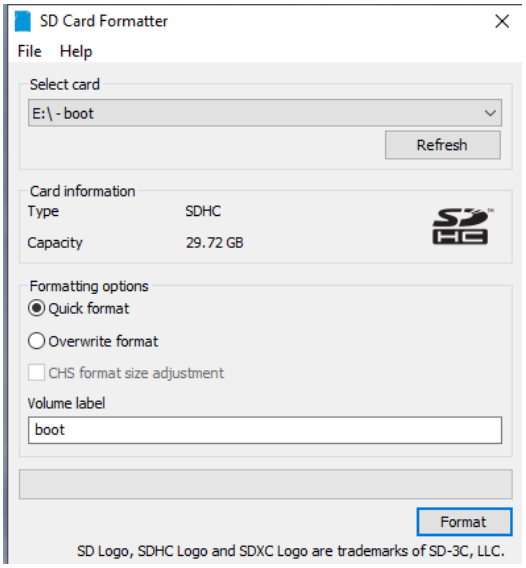


Figure 8.12: SD card Formatter

A.2 Raspberry Pi Imager Setup

1. Download the Imager 1.6.2 Application for raspberry pi from the given link https://www.raspberrypi.com/software/.
2. Now Open the downloaded imager_1.6.2.exe file.

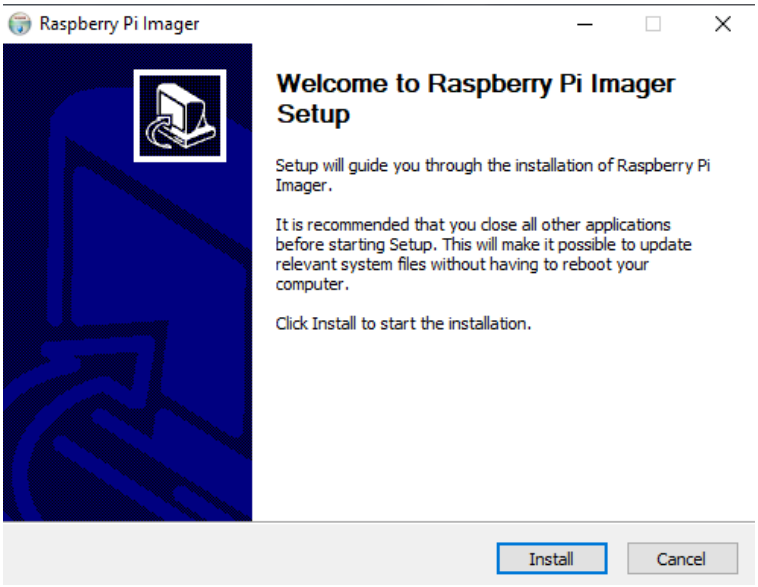


Figure 8.13: Imager Installation

3. Now click on the **Install** button.
4. Once it will completed then click on **Finish** button.
5. In the Raspberry Pi Imager, select the OS that you want to install and the SD card you would like to install it on.
6. Now select the **Raspberry PI OS (32 bit)** option.

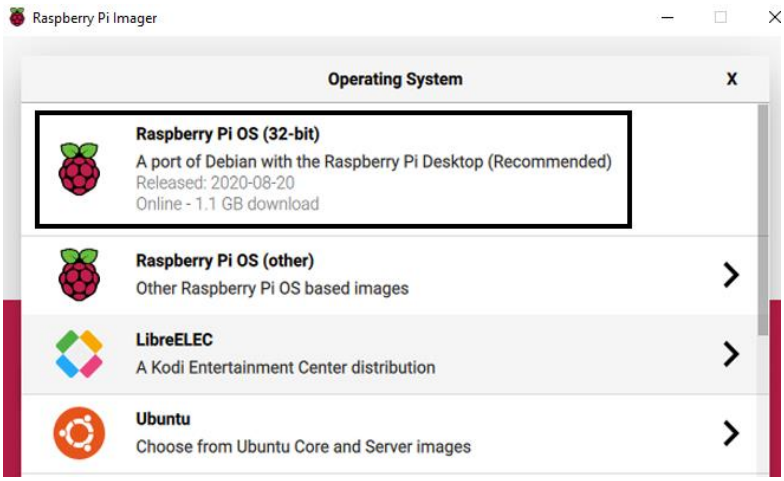


Figure 8.14: OS selection

7. Now select the **Mass Storage device Media** option.

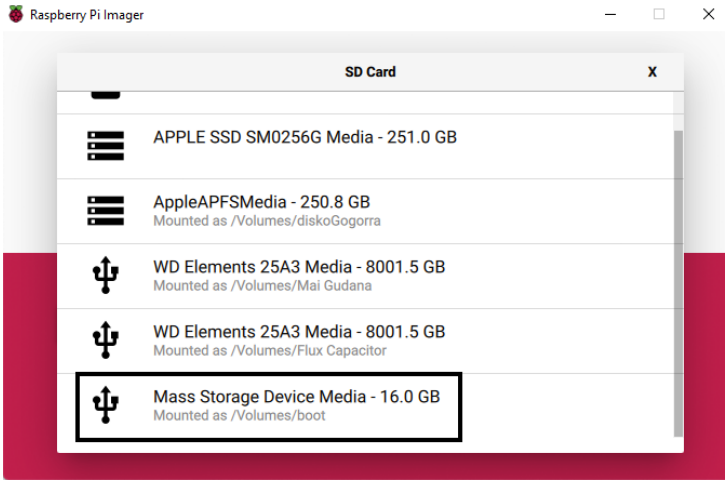


Figure 8.15: SD card selection

8. Now simply click on the **Write** Button.

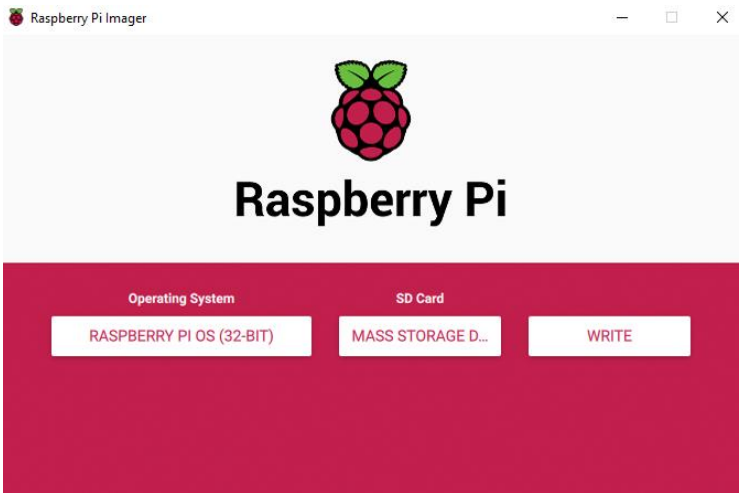


Figure 8.16: Write the SD card

9. Wait for the Raspberry Pi Imager to finish writing
10. Once you get the following message, you can eject your SD card

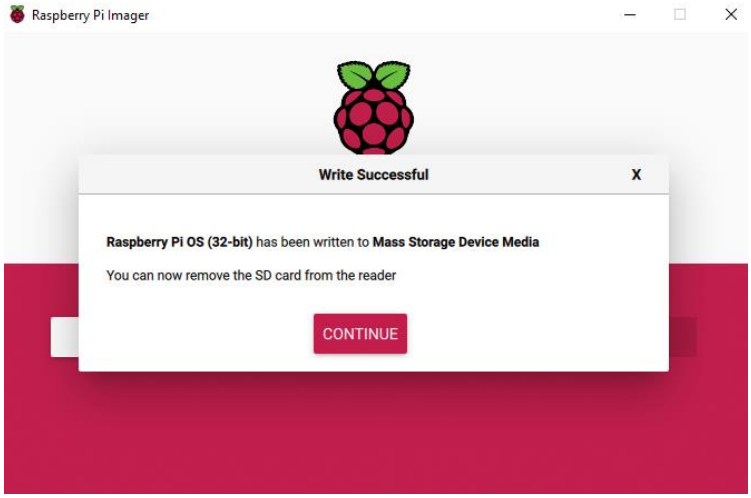


Figure 8.17: SD Card write successful

A.3 Start up the Raspberry Pi (Server End)

1. Insert the SD card into the Raspberry Pi slot.
2. Connect the Ethernet cable into the Ethernet port.
3. Connect the Micro USB cable into the Raspberry Pi and HDMI side cable into the Monitor.
4. Connect the Type-C Power cable into the Type-C port.
5. Connect the Mouse and Key-Board into the USB 3.0 port, if required.

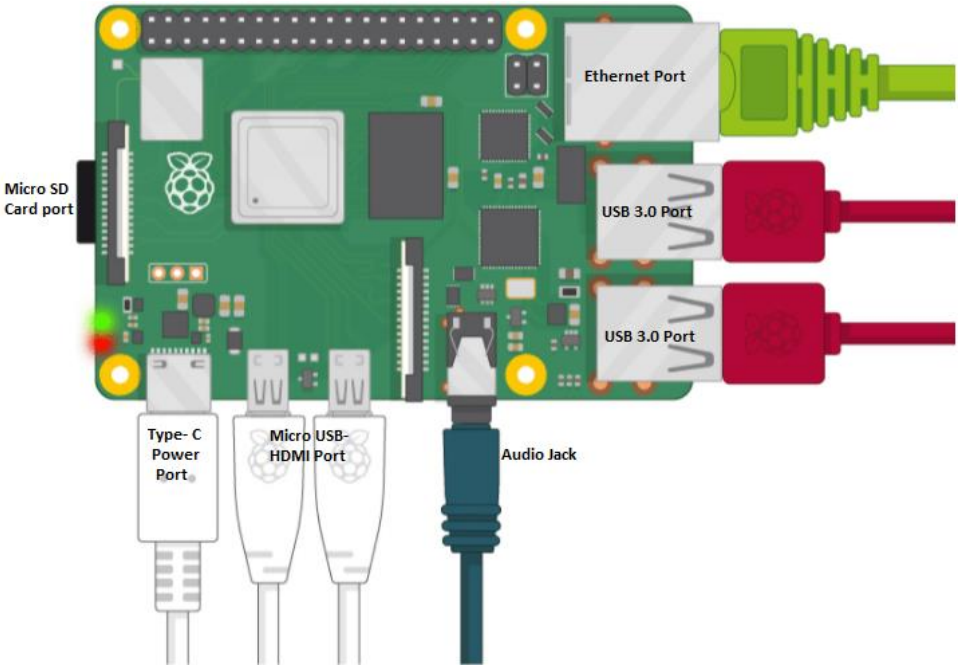


Figure 8.18: Raspberry pi setup image

6. Now turn ON the Power of Monitor and raspberry pi.
7. After a few seconds the Raspberry Pi OS desktop will appear.

Figure 8.19: Raspberry pi OS desktop

8. When you start your Raspberry Pi for the first time, the **Welcome to Raspberry Pi** application will pop up and guide you through the initial setup.

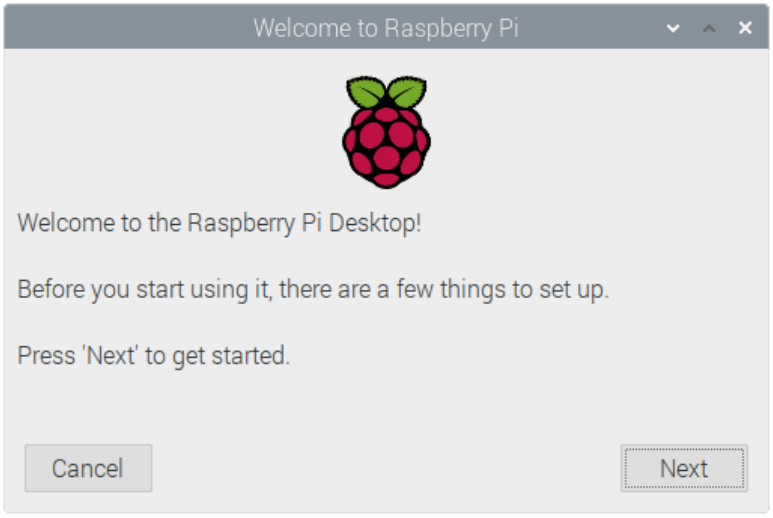


Figure 8.20: Initial step

9. Click on the **Next** Button.
10. Set your **Country, Language,** and **Timezone**, then click on **Next** again.

Figure 8.21: Country, Language and Timezone selection

11. Enter a new password for your Raspberry Pi and click on **Next**.

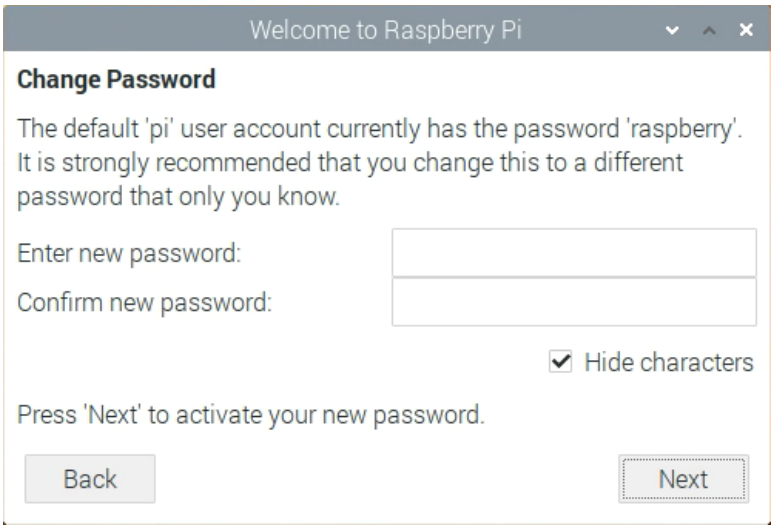


Figure 8.22: change password

12. Click on **Next**, and let the wizard check for updates to Raspberry Pi OS and install them.

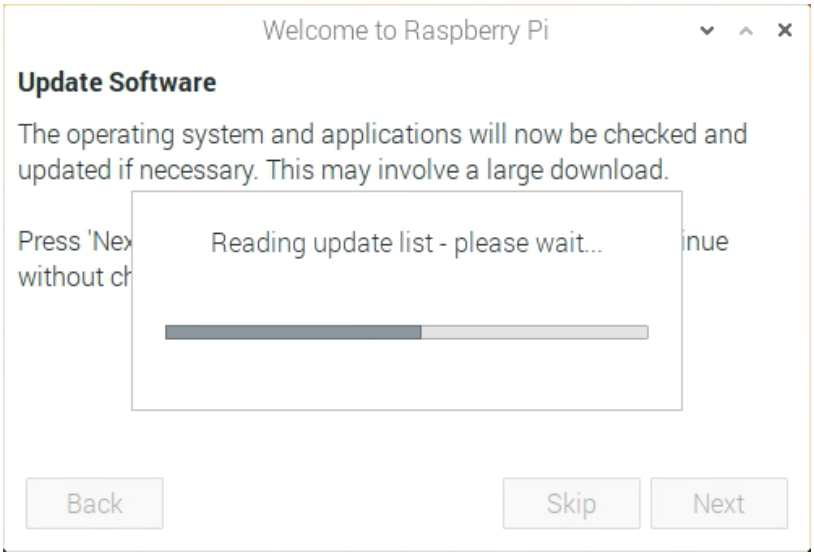


Figure 8.23: update software

13. Click on **Restart** to finish the setup.

Figure 8.24: setup complete

Appendix B. Compile the complete code

B.1 Make file (OPCUA)

1. Open the terminal.
2. Unzip the bundle
3. Write the command: **unzip OPCUA_ServerApp_v0_1_2.zip**
4. Write the command: **cd OPCUA_ServerApp_v0_1_2/**
5. Go to the Scripts directory
6. Write the command: **cd Scripts/**
7. Now Write the command for compilation: **make -j4**

Figure 8.25: Compilation

8. For removing the all objects and binary files, if necessary
9. Write the command: **make clean**

Figure 8.26: Make clean

B.2 To run the server (OPCUA)

1. After make clean or make -j4, Go to the OPCUA_Server/Scripts directory.
2. Go to the bin directory.
3. Write the command: **cd ../bin/**
4. to start the server, write the command: **./server**
5. Server will start.

Figure 8.27: run server

B.3 Make file (Mqtt)

1. Open the terminal.

2. Unzip the bundle
3. Write the command: **unzip Mqtt_Lattice_AutomateStack_2_0.zip**
4. Write the command: **cd Mqtt_Lattice_AutomateStack_2_0/**
5. Go to the Scripts directory
6. Write the command: **cd Scripts/**
7. Now Write the command for compilation: **make**

Figure 8.28: Compilation

8. For removing the all objects and binary files, if necessary
9. Write the command: **make clean**

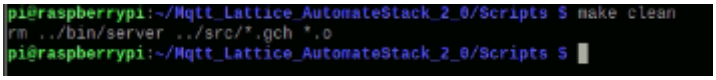


Figure 8.29: Make clean

B.4 To run the server (Mqtt)

1. After make clean or make -j4, Go to the OPCUA_Server/Scripts directory.
2. Go to the bin directory.
3. Write the command: **cd ../bin/**
4. to start the server, write the command: **./server**
5. Server will start.

Figure 8.30: run server

Appendix C. Application Installation (Client End)

Note: All this Installation process will be done on a separate Desktop or Laptop, not in Raspberry pi system.

1. Check the Installer folder, where file is located.
2. Now Click on the Installer to install the application.

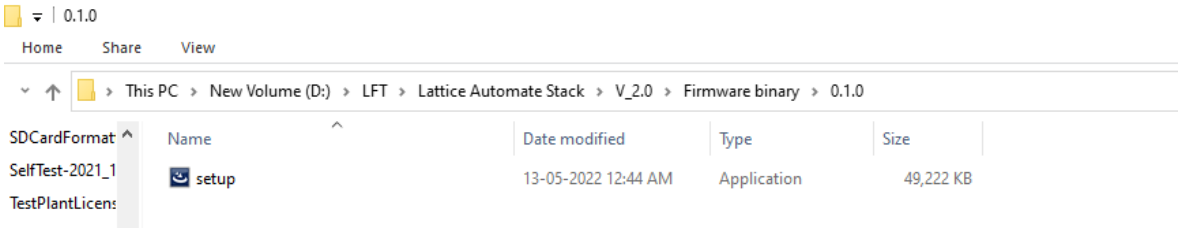


Figure 8.31: Installer directory

3. Wait for the Next.

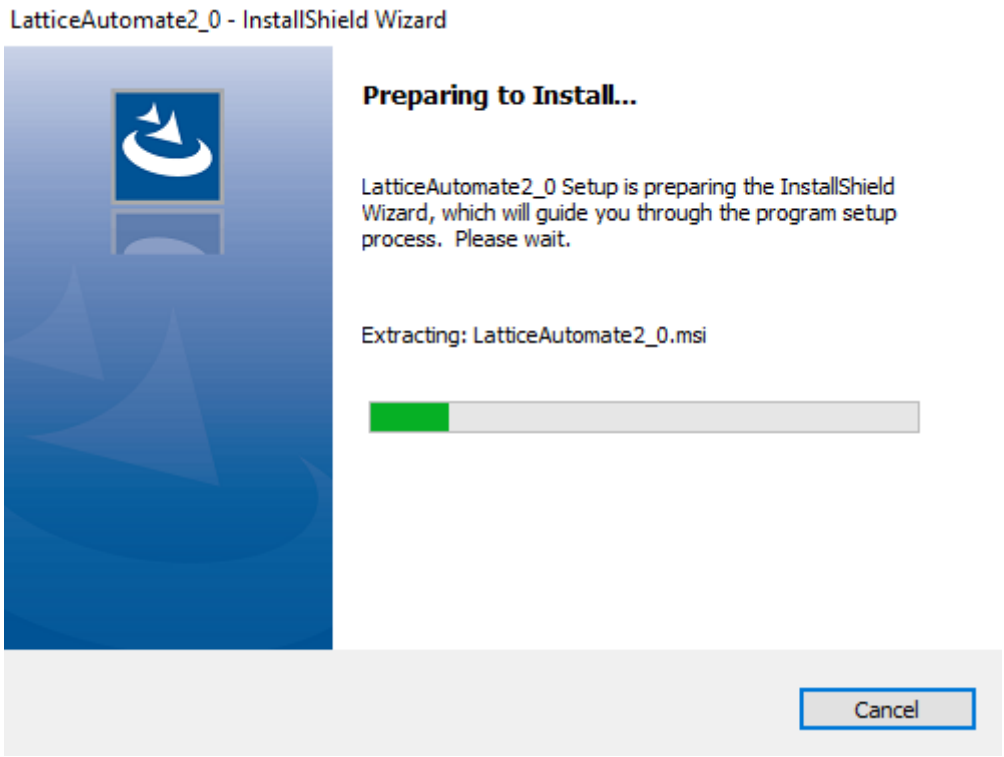


Figure 8.32: Initial Install step

4. Now again click on the **Next** Button.

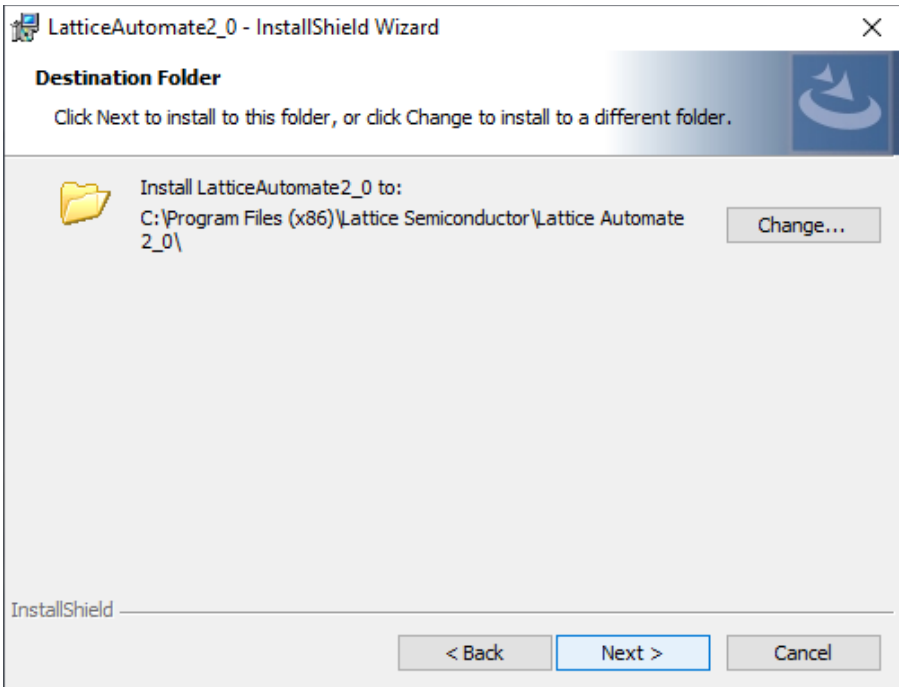


Figure 8.33: Next step

5. Now click on the **Install** button.

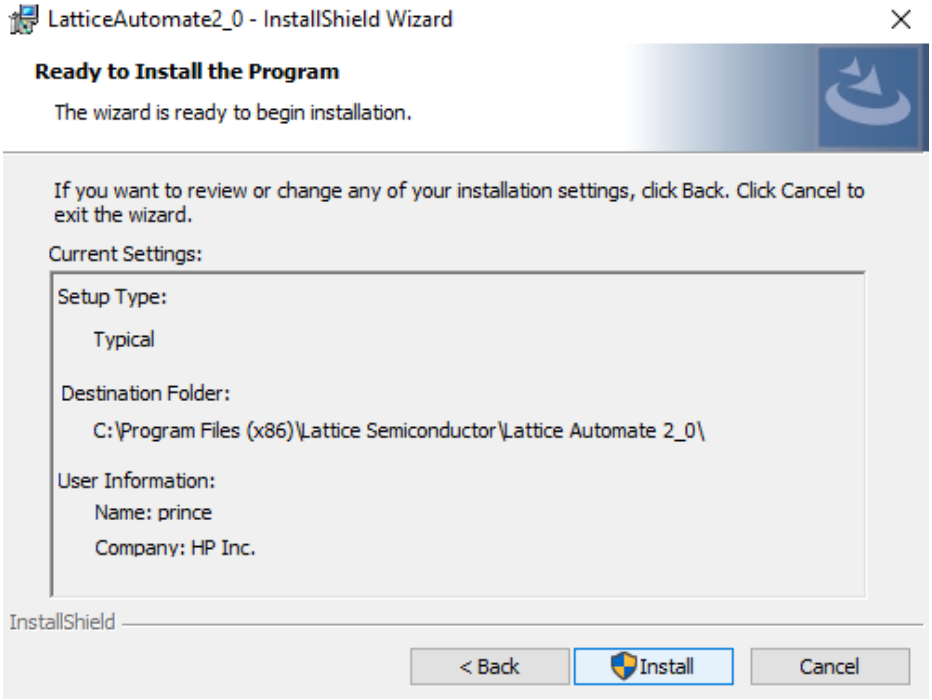


Figure 8.34: Click on Install

6. Wait for the **Next** button

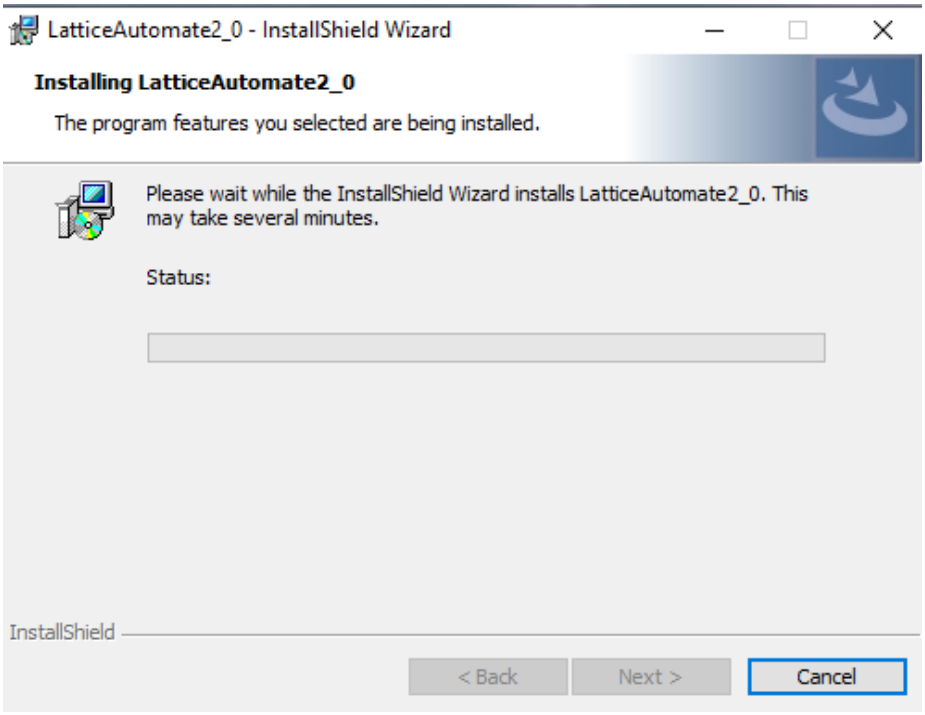


Figure 8.35: wait for the next

7. Wait for the Installation then click on the **Finish**.

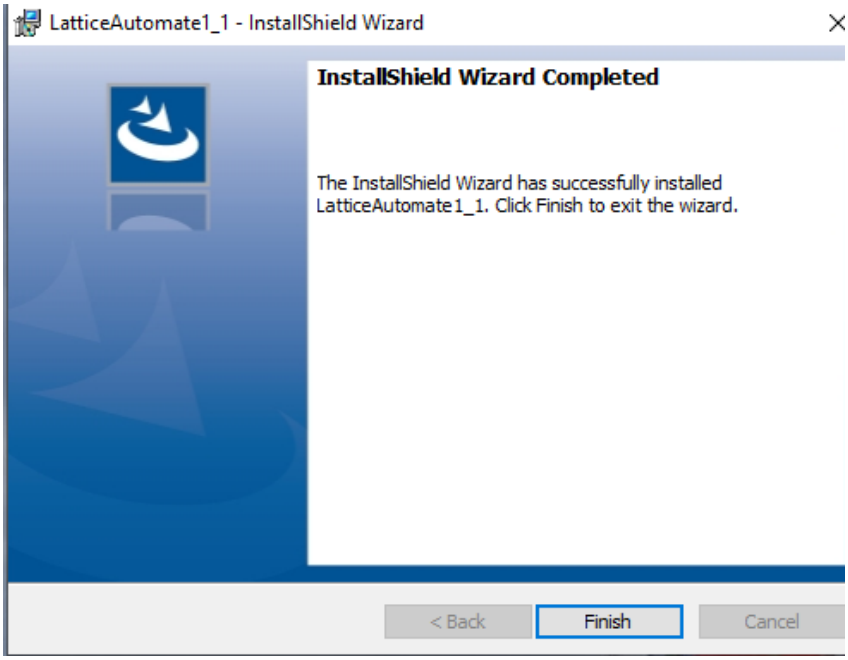


Figure 8.36: installation finish

Appendix D. Automate Stack 2.0 Bitfile and Binary Generation

D.1 Steps for bit file generation

MAIN SYSTEM

1. Open Generated Radiant Project in Radiant Tool.
2. Select Family: LFCPNX
3. Select Device: LFCPNX-100
4. Select Operating Condition: Industrial
5. Select Package: LFG672
6. Performance Grade: 9_High-Performance_1.0V
7. Part Number: LFCPNX-100-9LFG672I

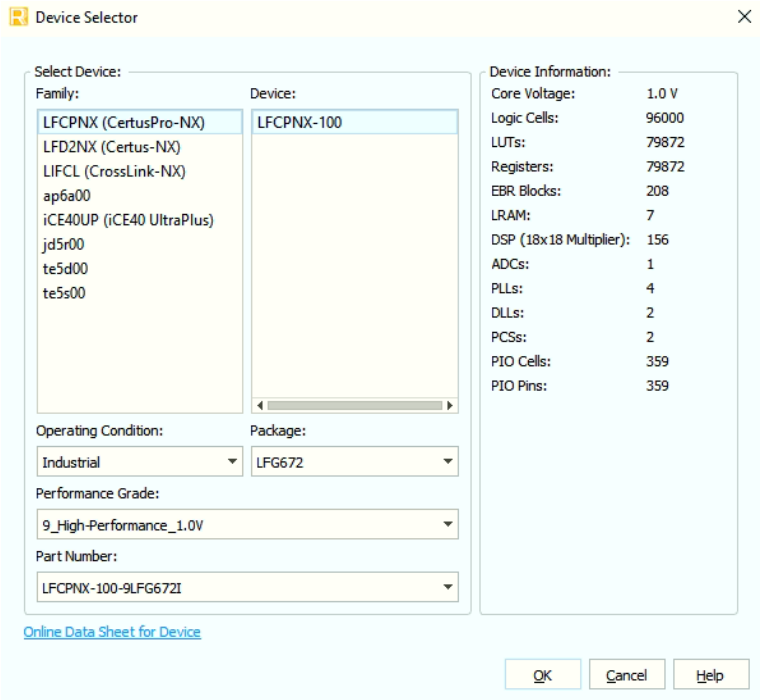


Figure 8.37: Lattice Radiant Device Selector for Main System

8. Change strategy as shown below: Frequency Parameter 250 MHz

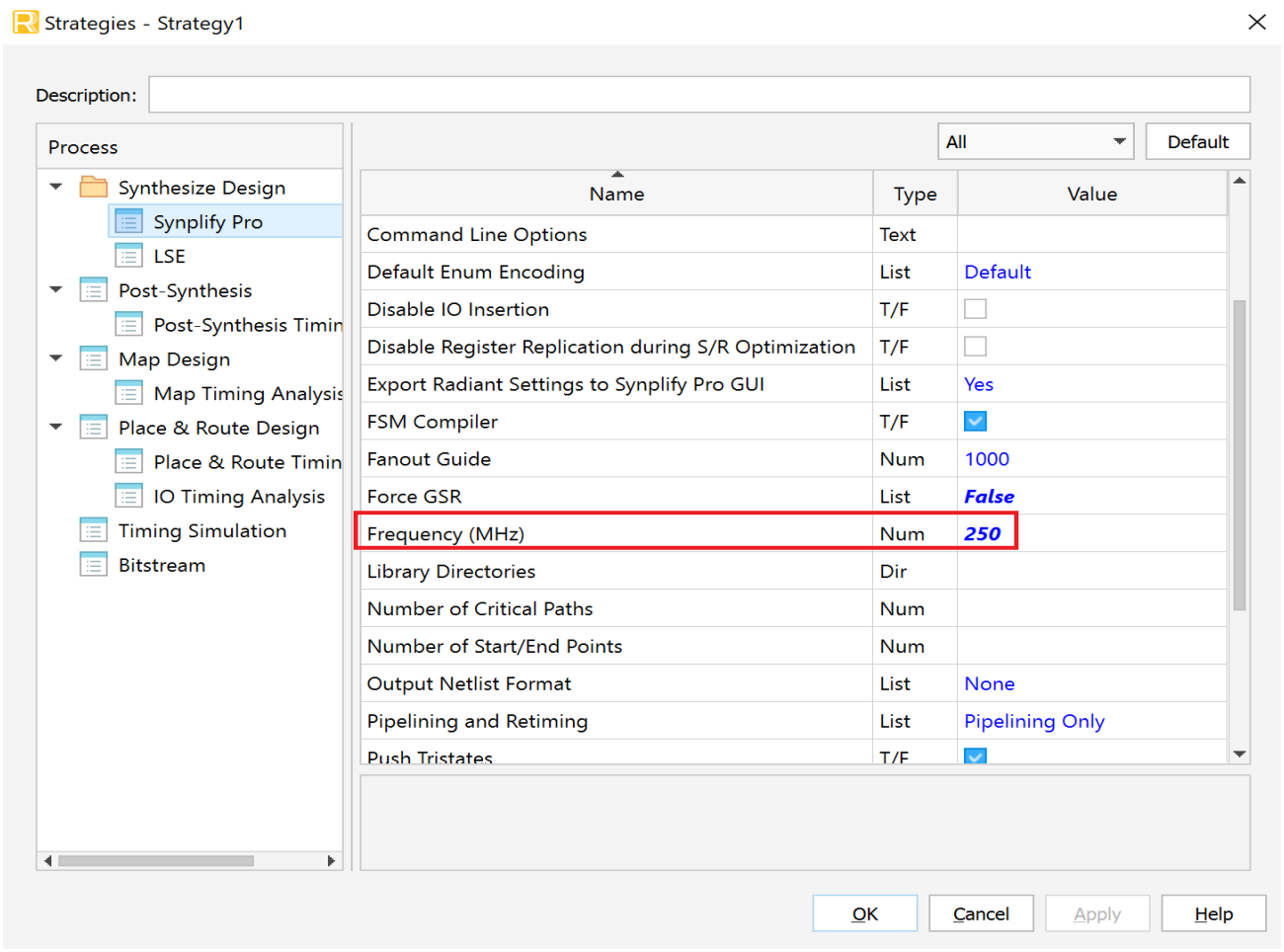


Figure 8.38: Strategy for Build Generation for Main System

9. Now go to the Strategy and select the Map Design
10. Now select the Map Timing Analysis.
11. Now select the highlighted part as mentioned below fig.

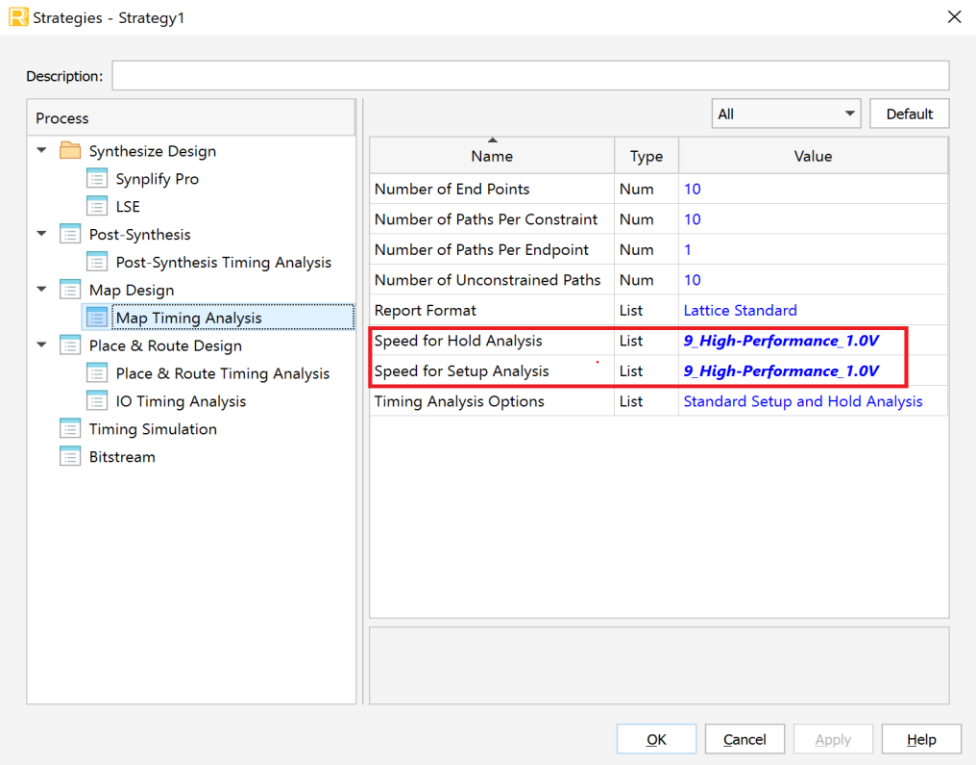


Figure 8.39: MAP analysis setting for Main system bitfile generation

12. Select the Place & Route Design
13. Select the only highlighted parts as mentioned below fig.

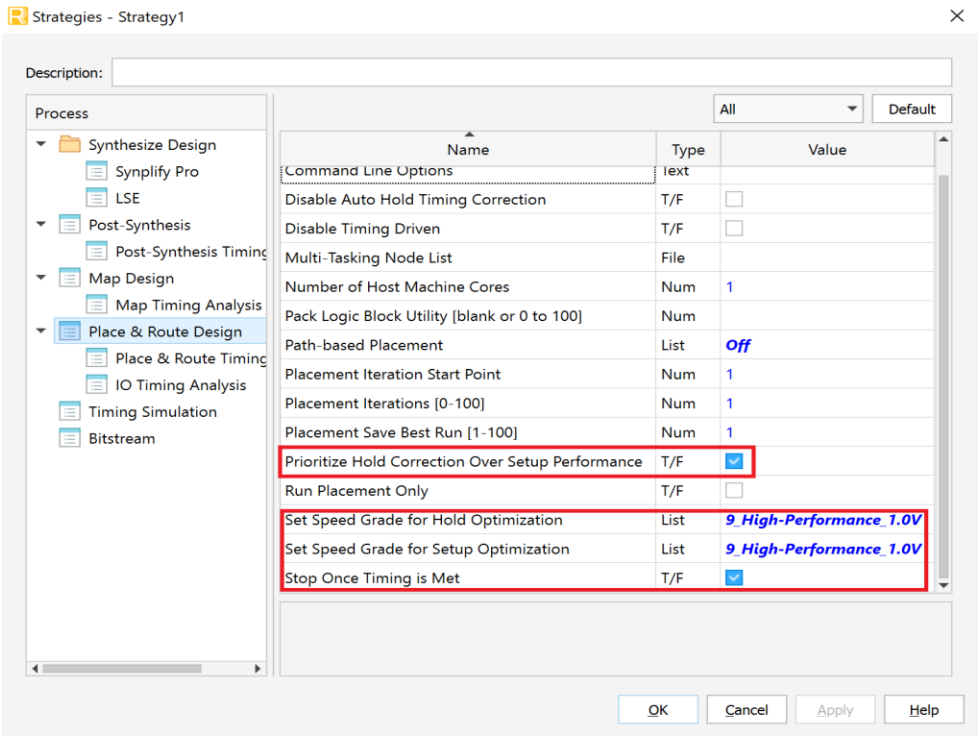


Figure 8.40: PAR setting for Main system bitfile generation

14. Select the Place and Route Timing Analysis.
15. Select the only highlighted parts as mentioned below fig.

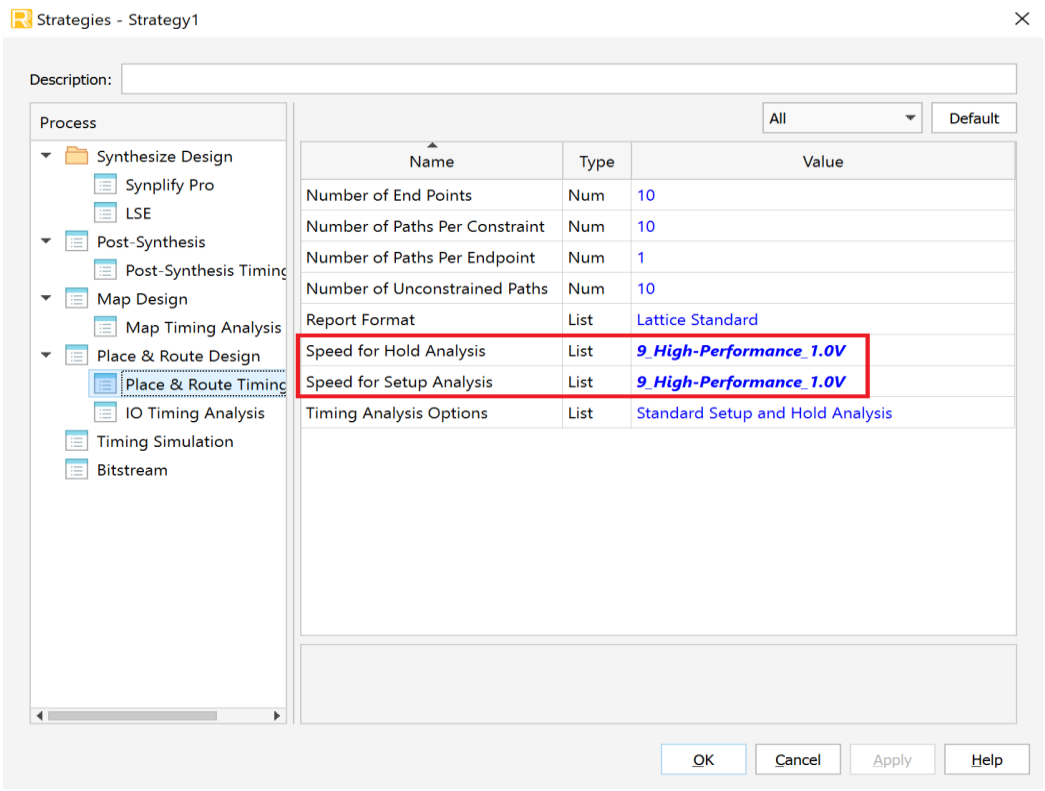


Figure 8.41: PAR Timing analysis setting for Main system bitfile generation

16. Use same PDC if FPGA is same otherwise update PDC file as per FPGA pins
17. Now click on the Device Constraint Editor as mentioned below.

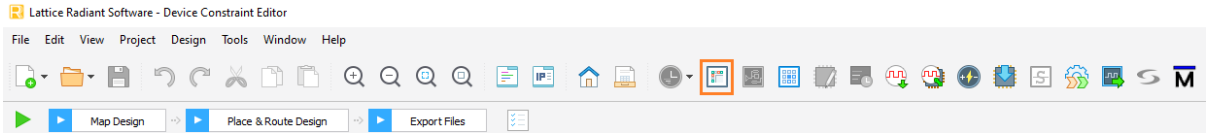


Figure 8.42: Device Constraint Selection for Main System

18. Now Click on the Global
19. Use below Global constraint: **Clock is 90 MHz.**

Name	Value
Junction Temperature(T)(C)	85
Voltage (V)	1
SysConfig	
SLAVE_SPI_PORT	DISABLE
MASTER_SPI_PORT	DISABLE
SLAVE_I2C_PORT	DISABLE
SLAVE_I3C_PORT	DISABLE
JTAG_PORT	ENABLE
DONE_PORT	DISABLE
INITN_PORT	DISABLE
PROGRAMN_PORT	ENABLE
BACKGROUND_RECONFIG	OFF
DONE_EX	OFF
DONE_OD	ON
MCCLK_FREQ	90
TRANSFR	OFF
CONFIG_IOSLEW	FAST

Figure 8.43: Global Constraints for Main System

20. Click on the run all. It generates a bit file.

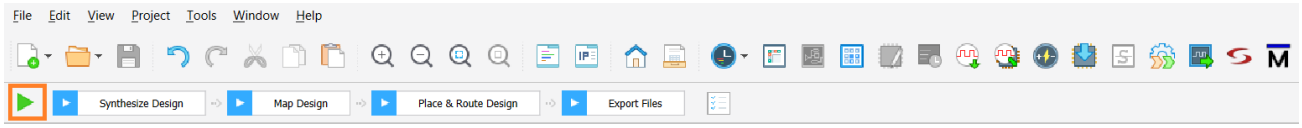


Figure 8.44. Run All button

21. Now open the propel builder 2.2 tool.
22. Double click on the system0_inst.
23. A pop-up will appear on the screen as mentioned below.

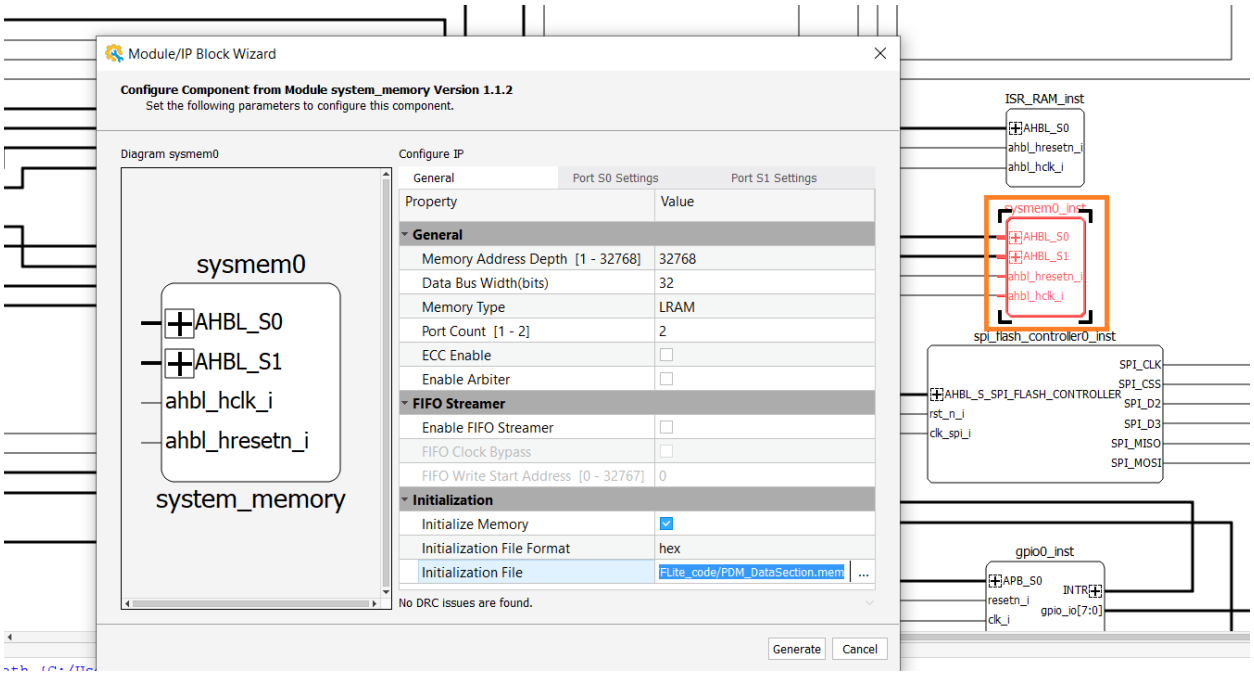


Figure 8.45. System Initialization File

24. Initialize Data memory with generated PDM_DataSection.mem file in TFLite_code folder of C project.
25. Click on the Generate button
26. Double click on the ISR_RAM_inst.
27. A pop-up will appear on the screen as mentioned below.

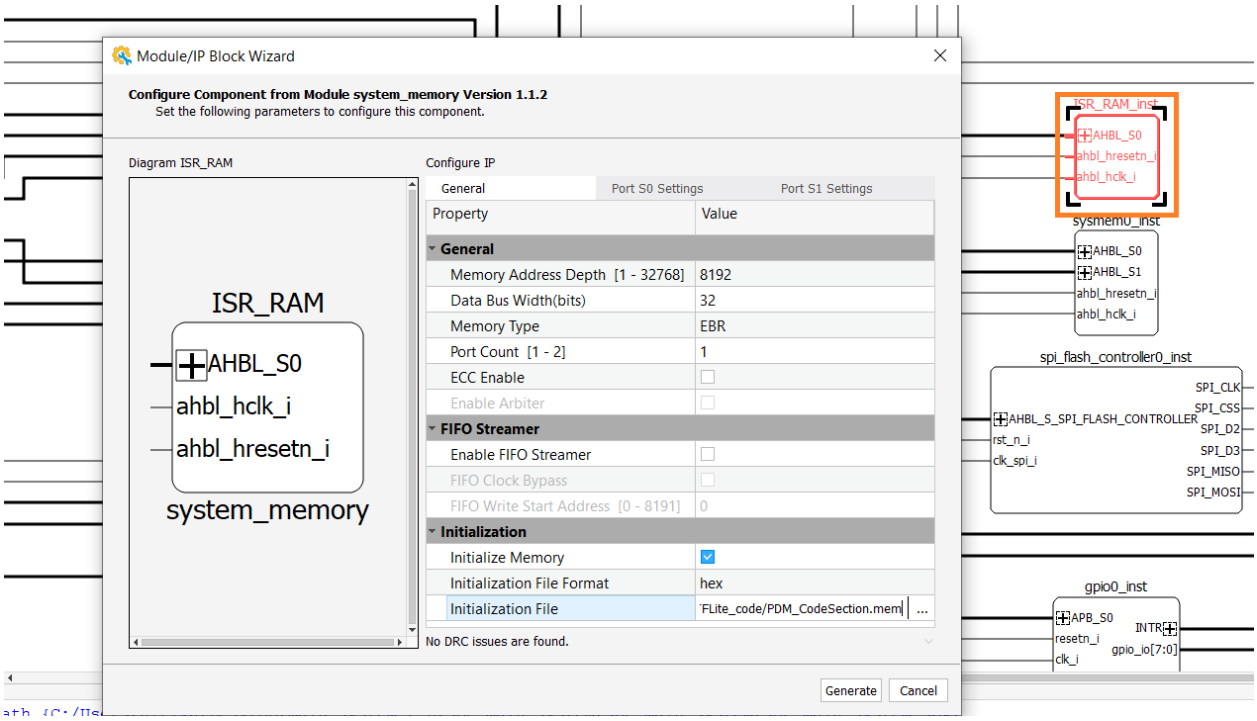


Figure 8.46. ISR RAM Initialization File

28. Initialize Data memory with generated PDM_codeSection.mem file in TFLite_code folder of C project.
29. Click on the Generate button
30. Click on the Validate button

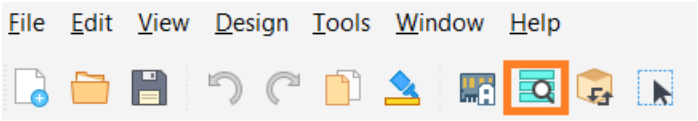


Figure 8.47. Validate Button

31. Now click on the Generate SGE button.

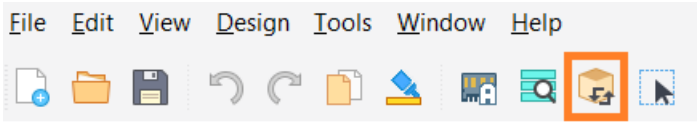


Figure 8.48. Generate SGE Button

32. Open the radiant tool from propel builder interface.

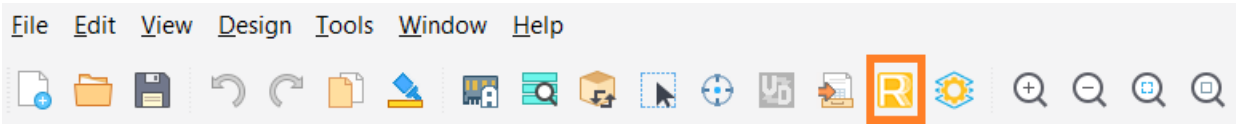


Figure 8.49. Radiant Tool Button

33. Select FPGA and update constraint (refer to steps 1 to 19).
34. Click on the run all. It generates a bit file.

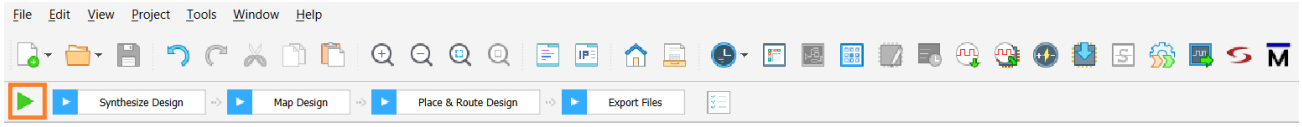


Figure 8.50. Run All Button

NODE SYSTEM

1. Open Generated Radiant Project in Radiant Tool.
2. Select Family: LFD2NX
3. Select Device: LFD2NX-40
4. Select Operating Condition: Commercial
5. Select Package: CABGA256
6. Performance Grade: 8_High-Performance_1.0V
7. Part Number: LFD2NX-40-8BG256C

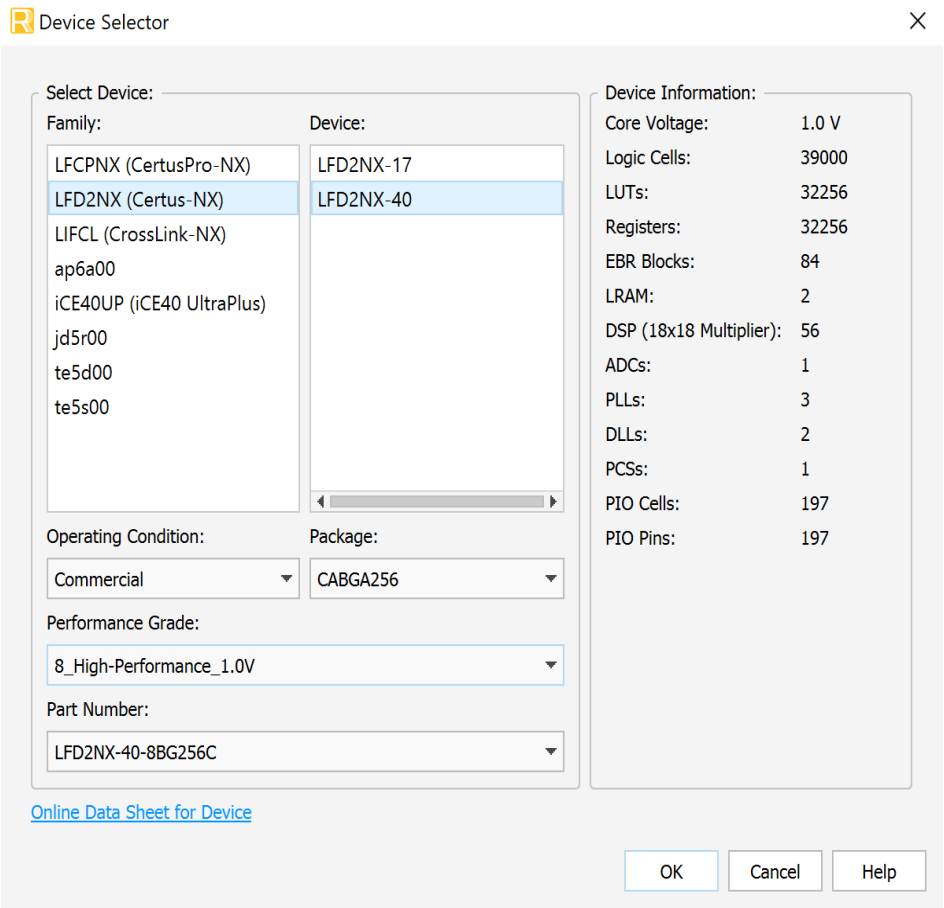


Figure 8.51: Lattice Radiant Device Selector for Node System

8. Change strategy as shown below: Frequency Parameter 150 MHz

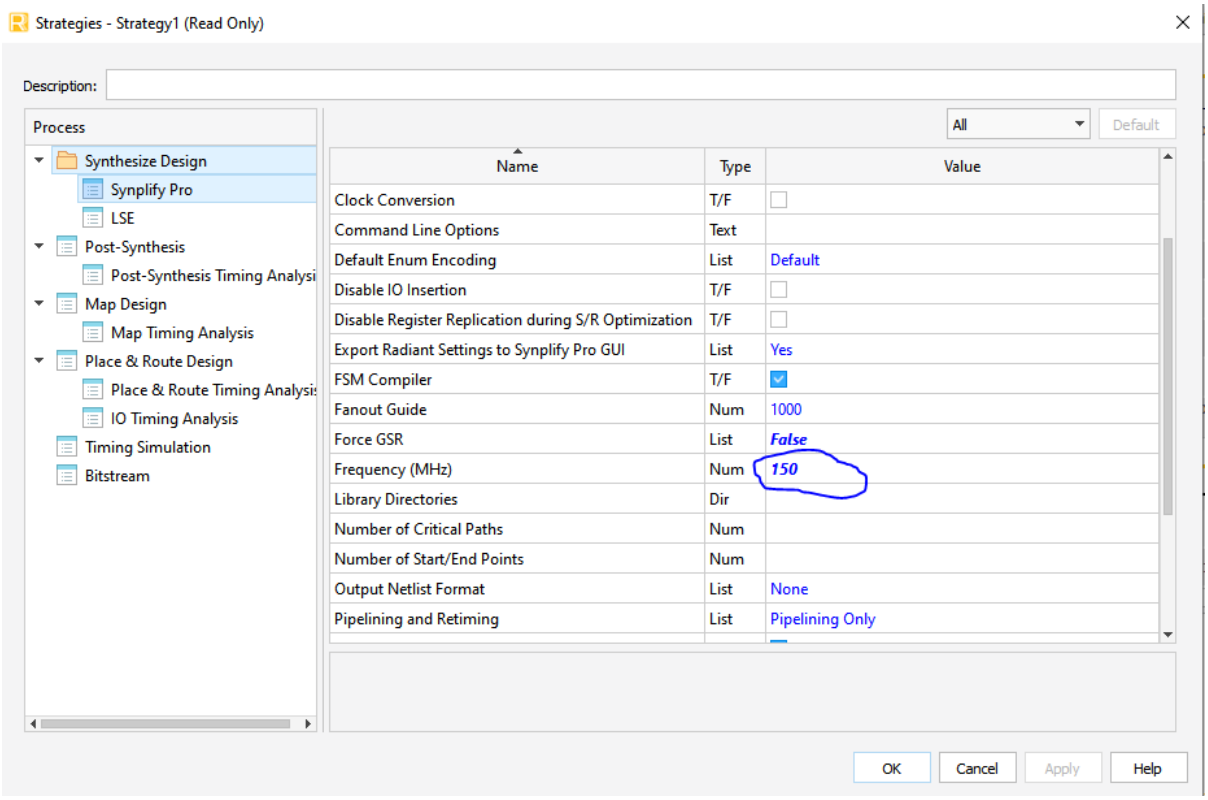


Figure 8.52: Strategy for Build Generation for Node System

9. Now go to the Strategy and select the Map Design
10. Now select the Map Timing Analysis.
11. Now select the highlighted part as mentioned below fig.

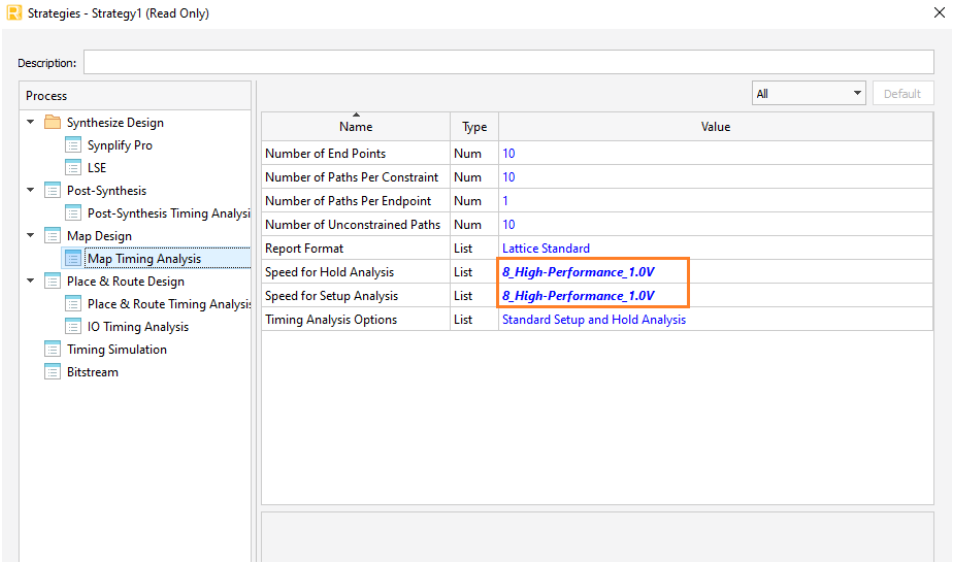


Figure 8.53: MAP analysis setting for Node system bitfile generation

12. Select the Place & Route Design

13. Select the only highlighted parts as mentioned below fig.

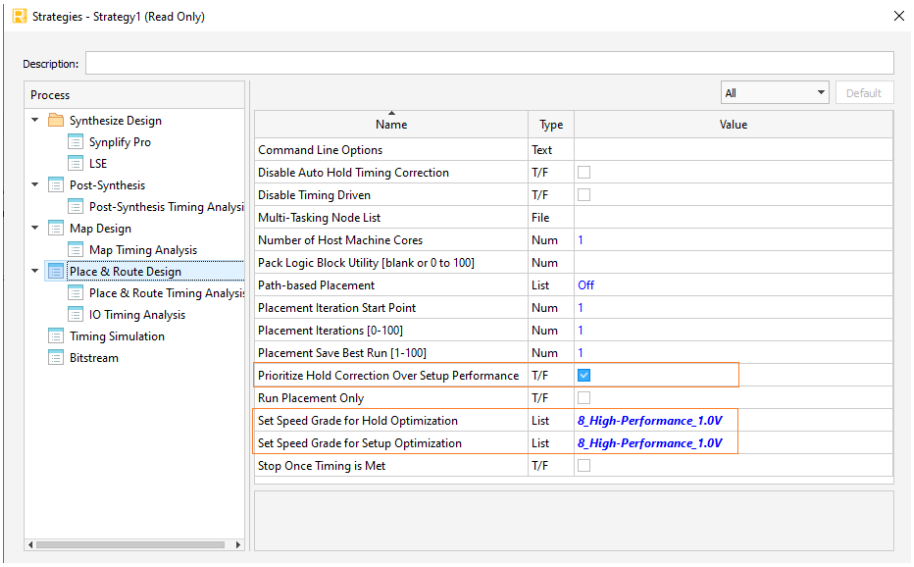


Figure 8.54: PAR setting for Node system bitfile generation

14. Select the Place and Route Timing Analysis.
15. Select the only highlighted parts as mentioned below fig.

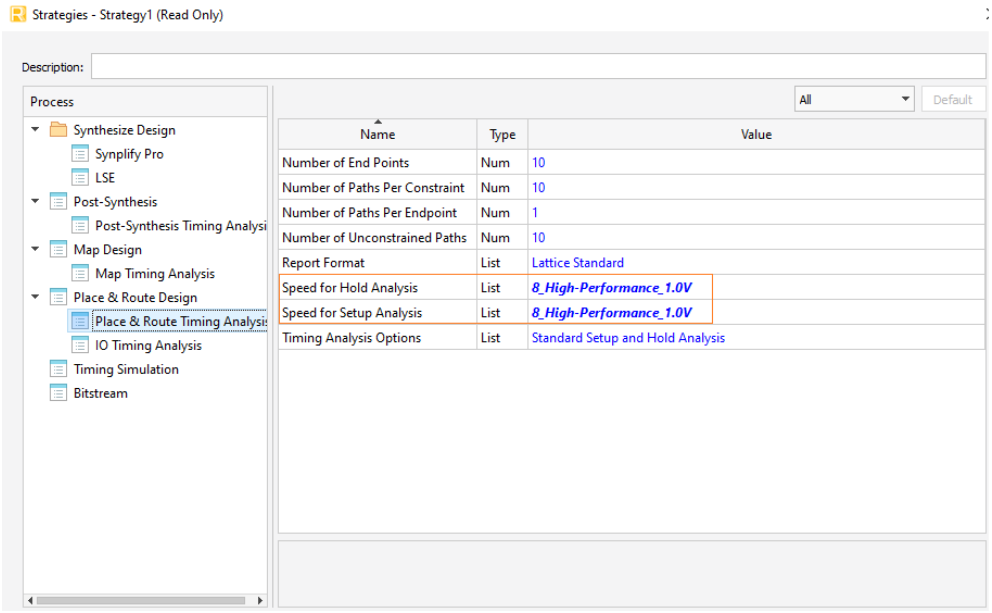


Figure 8.55: PAR Timing analysis setting for Node system bitfile generation

16. Use same PDC if FPGA is same otherwise update PDC file as per FPGA pins
17. Now click on the Device Constraint Editor as mentioned below.

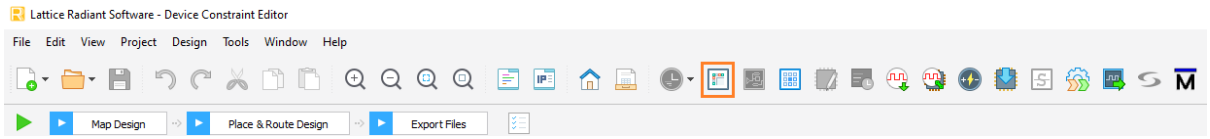


Figure 8.56: Device Constraint Selection for Node System

18. Now Click on the Global
19. Use below Global constraint: **Clock is 90 MHz.**

Name	Value
Junction Temperature(T)(C)	85
Voltage (V)	0.95
SysConfig	
SLAVE_SPI_PORT	DISABLE
MASTER_SPI_PORT	DISABLE
SLAVE_I2C_PORT	DISABLE
SLAVE_I3C_PORT	DISABLE
JTAG_PORT	ENABLE
DONE_PORT	DISABLE
INITN_PORT	DISABLE
PROGRAMN_PORT	ENABLE
BACKGROUND_RECONFIG	OFF
DONE_EX	OFF
DONE_OD	ON
MCCLK_FREQ	90
TRANSFR	OFF
CONFIG_IOSLEW	FAST
CONFIG_SECURE	OFF
WAKE_UP	ENABLE_DONE_SYNC
COMPRESS_CONFIG	OFF
EARLY_IO_RELEASE	OFF
BOOTMODE	DUAL
CONFIGIO_VOLTAGE_BANK0	NOT_SPECIFIED
CONFIGIO_VOLTAGE_BANK1	NOT_SPECIFIED
User Code	
UserCode Format	Binary
UserCode	00000000000000000000000000000000
Unique Id	0000

Figure 8.57: Global Constraints for Node System

20. Click on the run all. It generates a bit file.

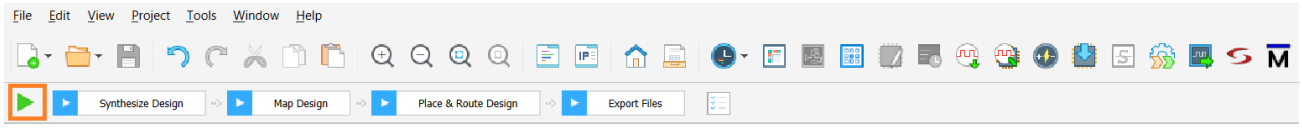


Figure 8.58. Run All

21. Now open the propel builder 2.2 tool.
22. Double click on the system0_inst.
23. A pop-up will appear on the screen as mentioned below.

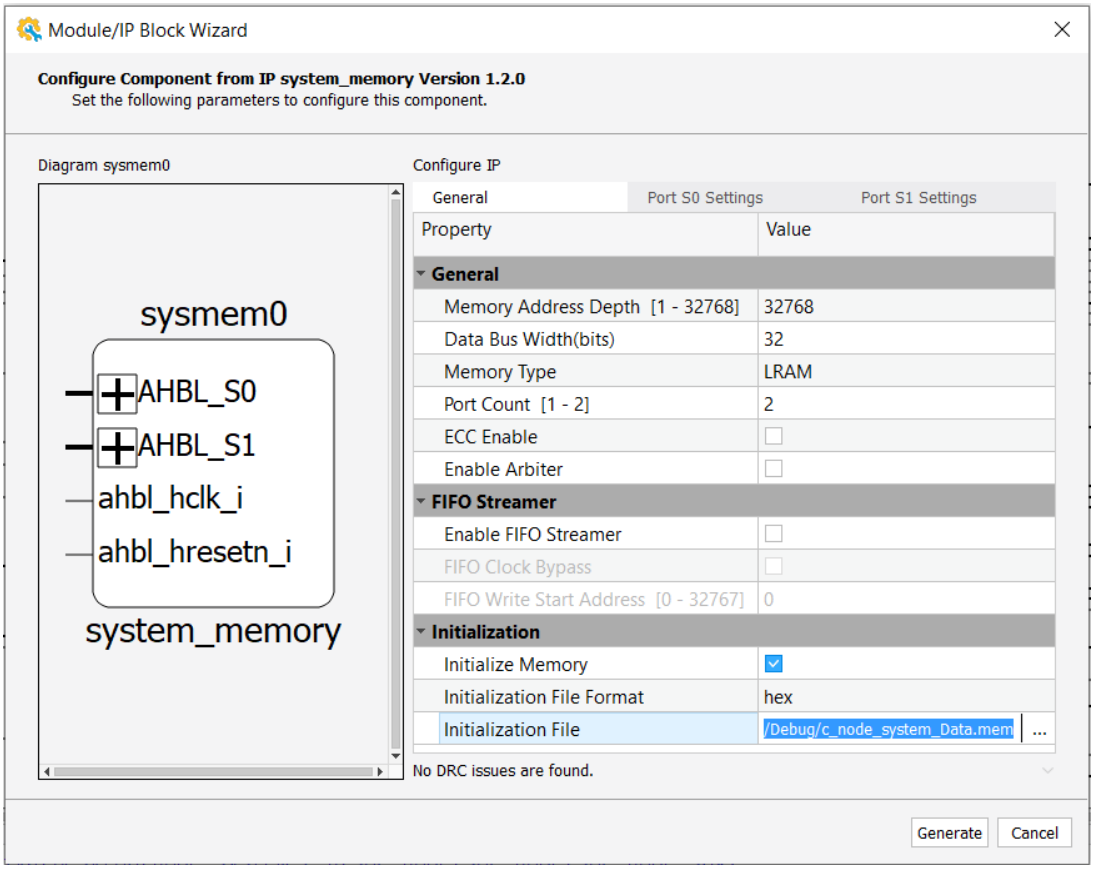


Figure 8.59. System0 Initialization

24. Initialize Data memory with generated c_node_system.mem file in debug folder of C project.
25. Click on the Validate button

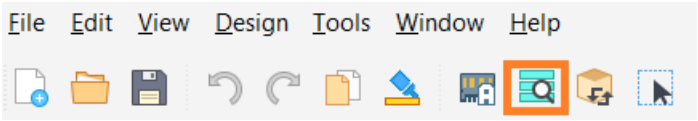


Figure 8.60. Validate Button

26. Now click on the Generate SGE button.

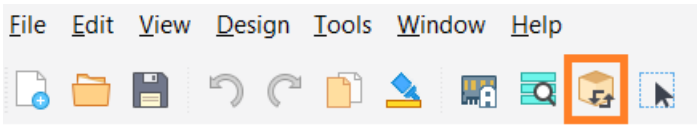


Figure 8.61. Generate SGE Button

27. Open the radiant tool from propel builder interface.

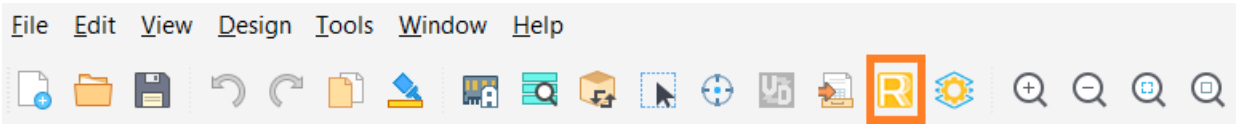


Figure 8.62. Radiant Tool Button

28. Select FPGA and update constraint (refer to steps 1 to 19).
29. Click on the run all. It generates a bit file.

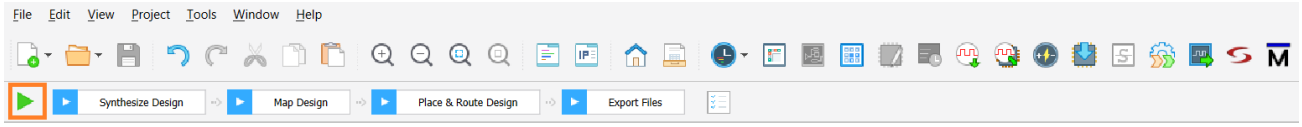


Figure 8.63. Run All Button

D.2 Steps for binary generation

1. Double click on the “Lattice Propel SDK 2.0” to open the dialogue box as shown in below fig.

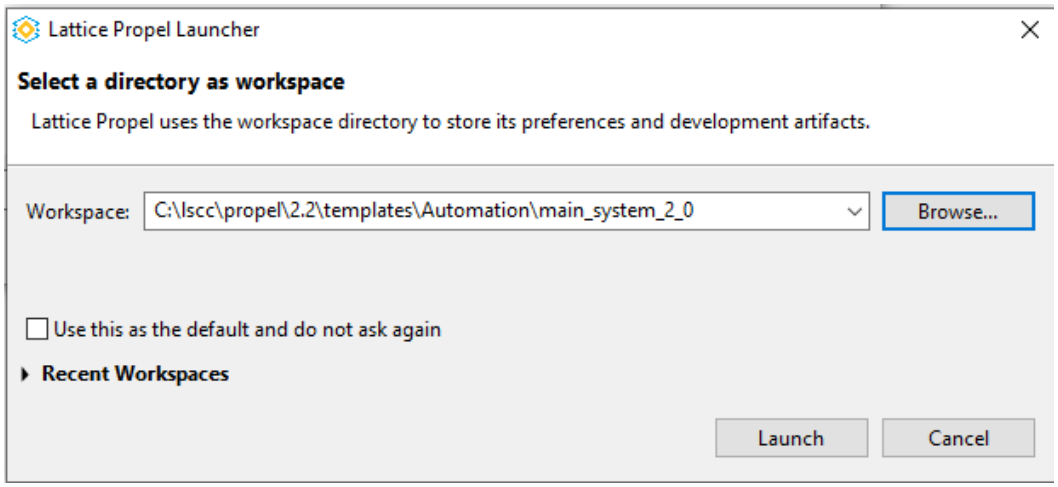


Figure 8.64: Select Directory

2. To select the workspace, browse to the template location
3. “C:\lscc\propel\2.0\templates\Automate\main_system” by clicking on the “Browse” option as shown in below Fig. and then click on the “Launch” to launch the workspace.

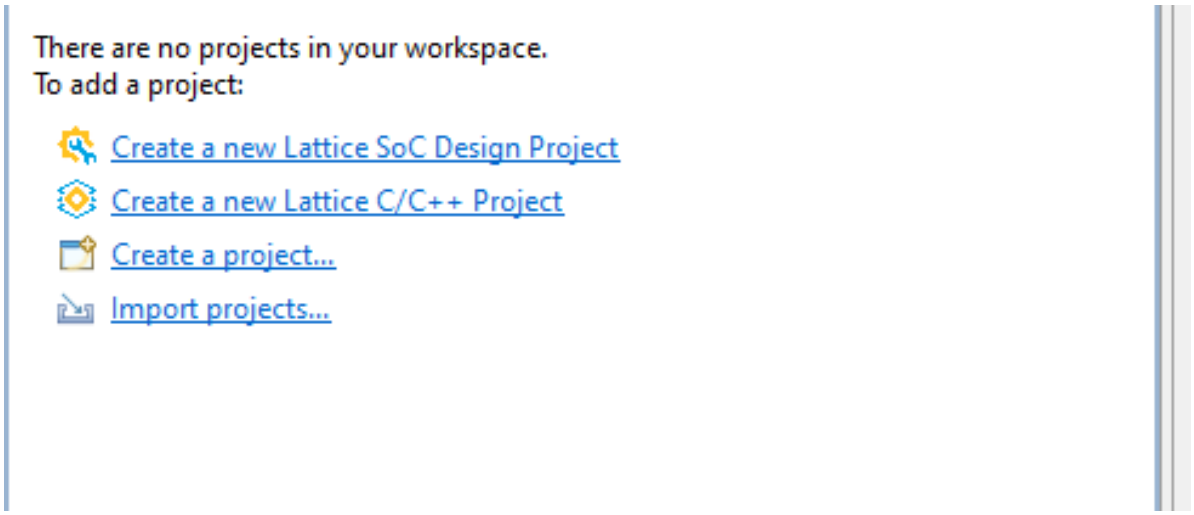


Figure 8.65: Import Project

4. Click on the “import” to import firmware project template.
5. Select Existing Project in Workspace from General list and click on next as shown in below fig.

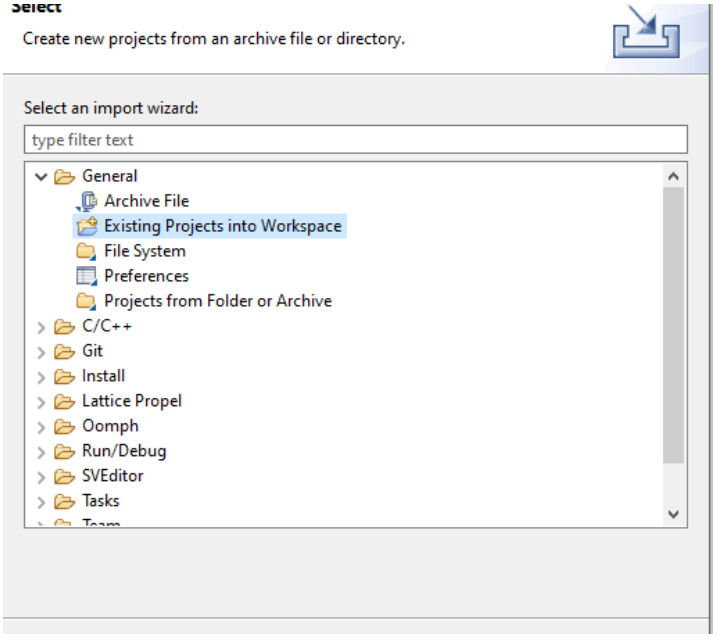


Figure 8.66: Existing Project into Workspace

6. Select the root directory and browse template location.
7. Select the project as shown in below fig. and click on finish.

Figure 8.67: Select project

8. Right click on the firmware project folder “TF_lite_RiscV_Acc” and select the option as shown in below fig. to clean the project before building.

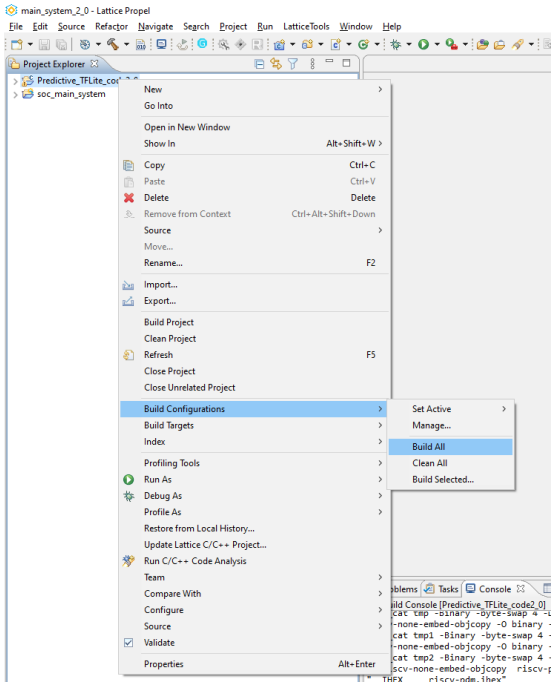


Figure 8.68: Build Configurations

9. After selecting the option as shown in above fig. observe the console and wait for the process to complete to 100%. After completion, the message shown in below fig. will appear on console.

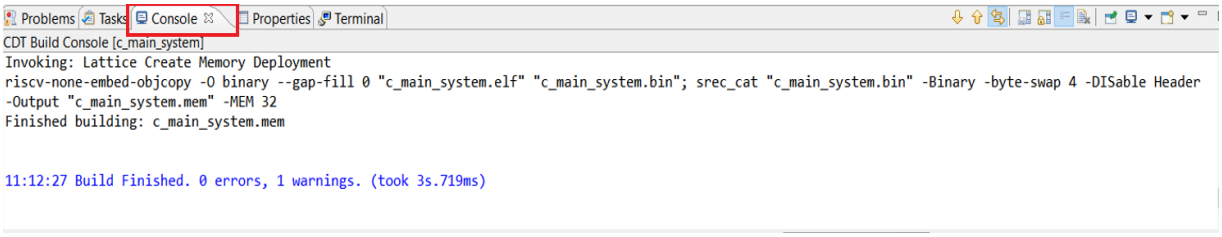


Figure 8.69: Console

10. After cleaning, right click on the “TF_lite_RiscV_Acc” and select the option as shown in below fig. to build the project.

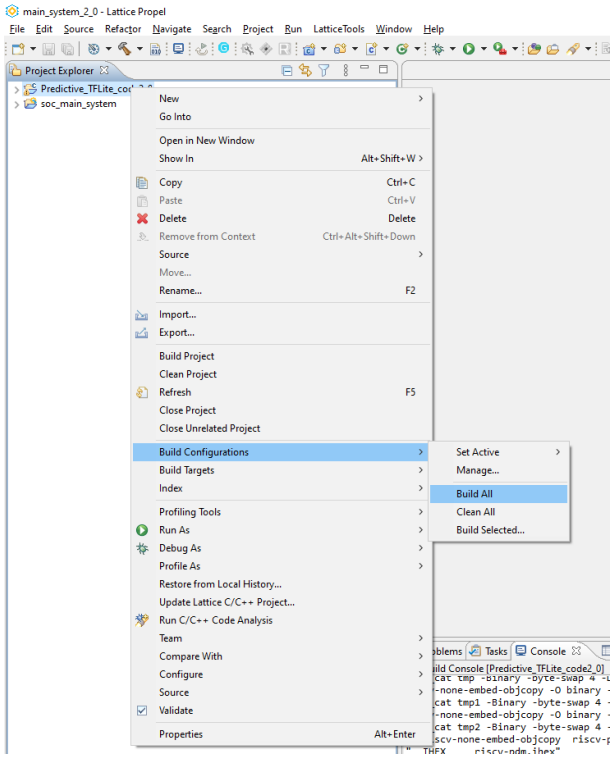


Figure 8.70: Build All

11. Wait for the process to complete to 100%. After completion, the message shown in below fig. will appear on console.

Figure 8.71: Completing Process

Appendix E. Programming the Automate Stack on Respective FLASH

E.1 Main System

This section provides the procedure for programming the SPI Flash on the CertusPro-NX Versa board for the main system.

There are two different files that should be programmed into the SPI Flash. These files are programmed to the same SPI Flash, but at different addresses:

- Bitstream (FPGA SOC Design)
- Binary (RISC V Firmware)

Board Jumper Connections

Ensure that following jumpers are connected on board-

1. Pin 1 and 2 of J32 and J33 should be shorted to select UART.
2. Pin 1 and 2 of J58 should be shorted to select the 3.3 V as Flash IO.

If you are programming the Main System Board for the first time, please refer to the troubleshooting section and then come back to this section to follow further steps.

To program the SPI Flash in Radiant Programmer:

1. Connect the CertusPro-NX Versa board to the PC using a USB cable.
2. Start Radiant Programmer. In the **Getting Started** dialog box, select **Create a new blank project**.

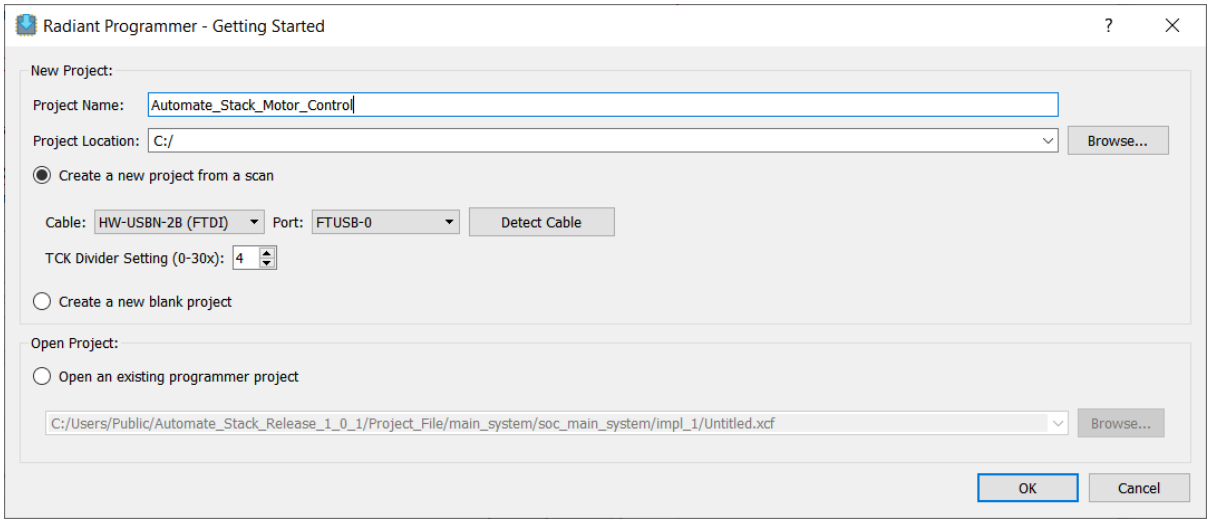


Figure 8.72: Radiant Programmer Default Screen

3. Click **OK.**

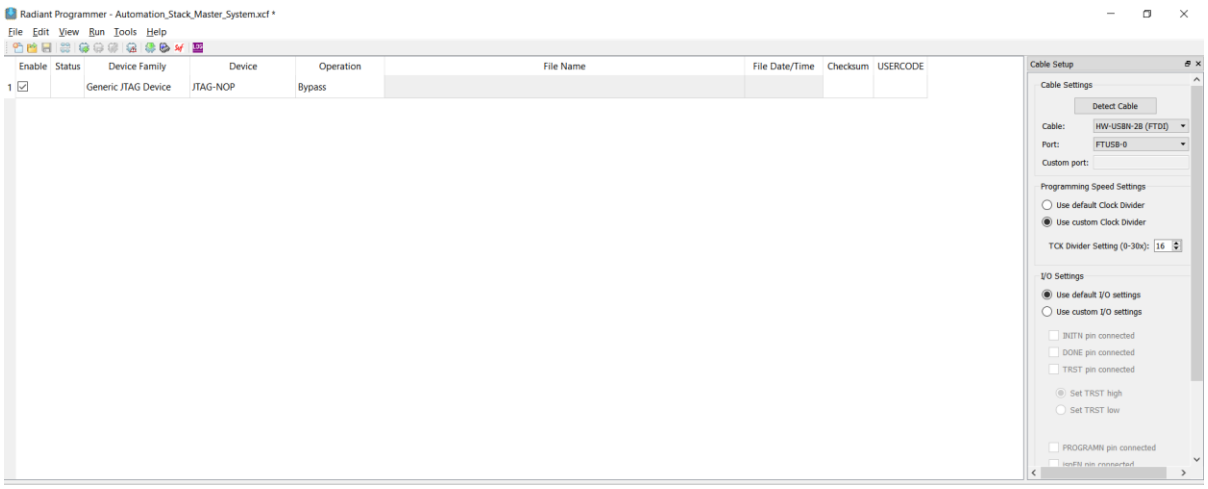


Figure 8.73: Radiant Programmer- Initial Project Window

4. In the Radiant Programmer main interface, select **LFCPNX** for **Device Family** and **LFCPNX-100** for **Device** or detect automatically as shown in below Figure

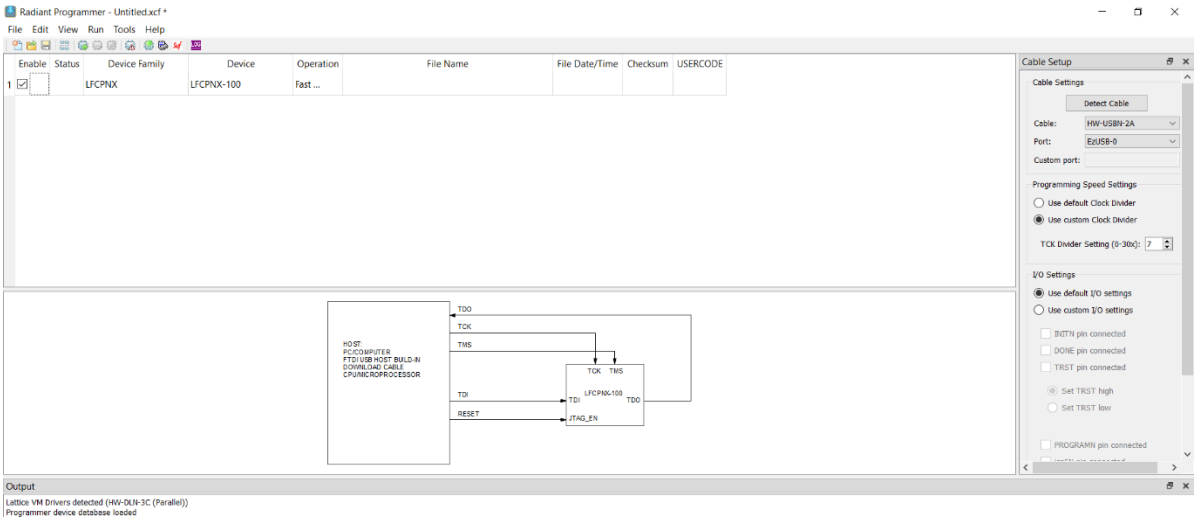


Figure 8.74: Radiant Programmer- Device Selection

5. Right-click and select **Device Properties**.

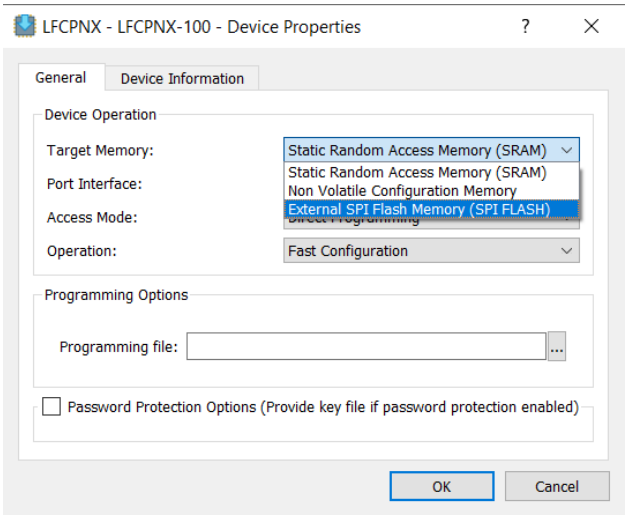


Figure 8.75: Radiant Programmer- Device Operation

6. Before programming, it is necessary to erase the flash memory. For this,

Apply the settings below:

a. Under Device Operation, select the options below:

- Target Memory – External SPI Flash Memory (SPI FLASH)
- Port Interface – JTAG2SPI
- Access Mode – Direct Programming
- Operation – Erase all

b. Under SPI Flash Options, select the options below:

- Family – SPI Serial Flash
- Vendor – Macronix
- Device – MX25L51245G
- Package – 8-land WSON

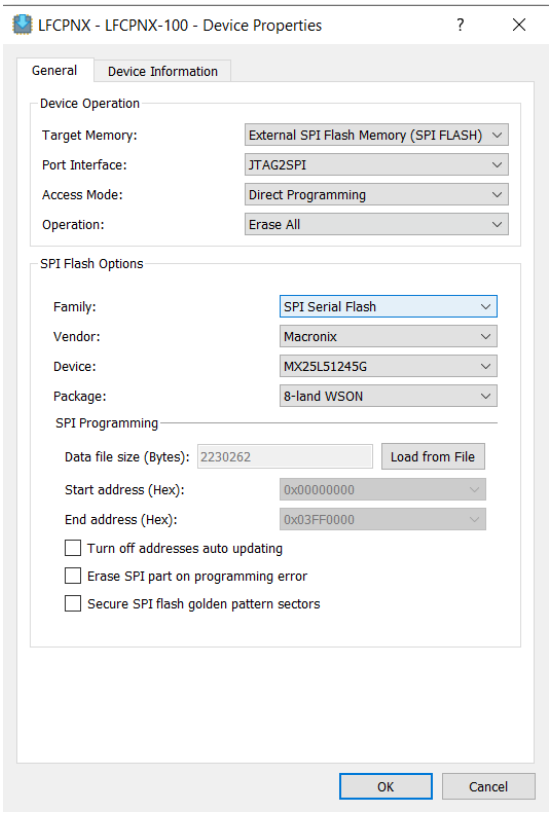


Figure 8.76: Erase all (Radiant Programmer)

7. Click OK and then click the Program Device icon or the menu item Run ->Program Device. This will erase the flash memory if any other data is already present in it.
8. After erasing the flash, power cycle the board and apply the settings below:
    a. Under Device Operation, select the options below:
    - Target Memory – External SPI Flash Memory (SPI FLASH)
    - Port Interface – JTAG2SPI
    - Access Mode – Direct Programming
    - Operation – Erase, Program, Verify

    b. Under SPI Flash Options, select the options below:
    - Family – SPI Serial Flash
    - Vendor – Macronix
    - Device – MX25L51245G
    - Package – 8-land WSON
9. To program the **bitstream file**, select the options as shown in below Fig.

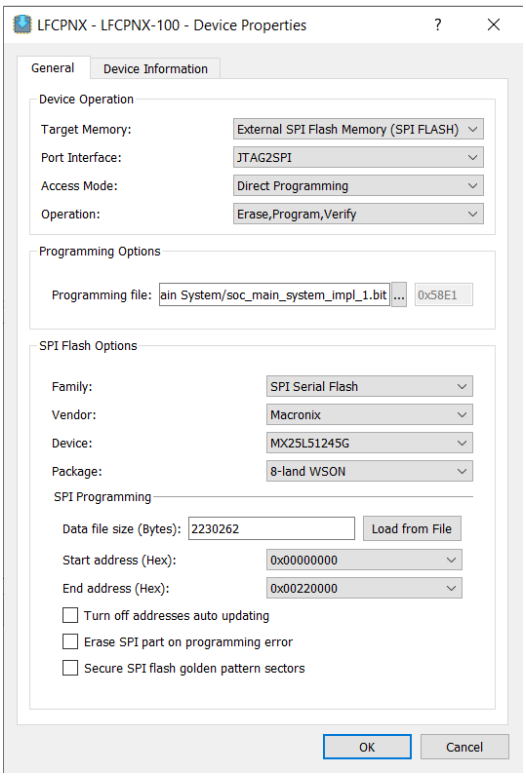


Figure 8.77: Radiant Programmer- Bitstream Flashing Settings

a. Under **Programming** Options, select the **soc_main_system_impl_1.bit** bitstream file in Programming file.

b. Click **Load from File** to update the **Data file size (Bytes)** value.

c. Ensure that the following addresses are correct:

- Start Address (Hex) – 0x00000000
- End Address (Hex) – 0x00200000

10. Then click the Program Device icon or the menu item Run ->Program Device.
11. Now Power cycle the CertusPro NX Versa Board.
12. To program the **firmware**, select the options as shown in below Figure.

a. Under **Programming Options**, select the **riscv-pdm.bin** binary file.

b. Ensure that the following addresses are correct:

- Start Address (Hex) – 0x00240000
- End Address (Hex) – 0x003D0000

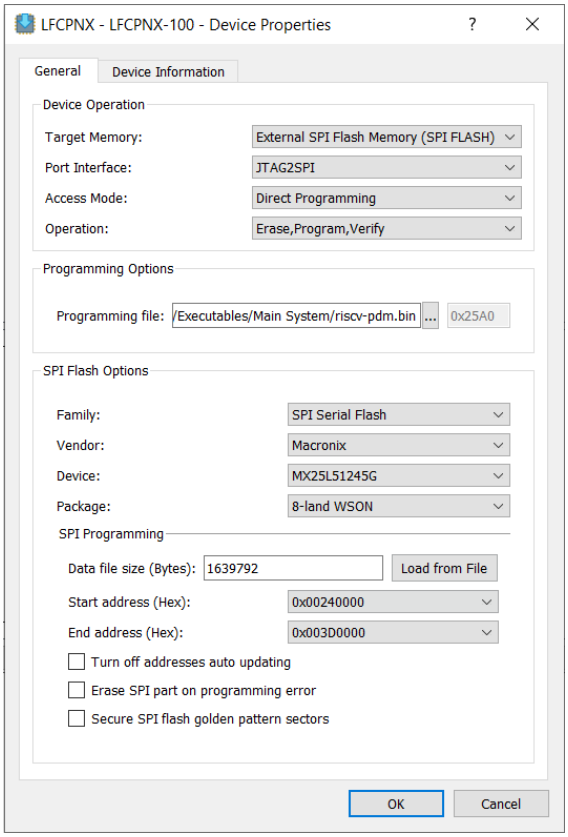


Figure 8.78: Radiant Programmer- Binary Flashing Settings

13. Then click the Program Device icon or the menu item Run ->Program Device.

E.2 Node

This section provides the procedure for programming the SPI Flash on the Certus-NX Versa board for node. There are two different files that should be programmed into the SPI Flash. These files are programmed to the same SPI Flash, but at different addresses:

- Bitstream
- Binary

Board Jumper Connections

Ensure that following jumpers are connected on board-

1. Pin 1 and 2 of JP25 and JP26 should be shorted to select UART.
2. Pin 1 and 2 of J47 should be shorted to select the 1.8 V as Flash IO.

To program the SPI Flash in Radiant Programmer:

1. Connect the Certus-NX Versa board to the PC using a USB cable.
2. Start Radiant Programmer. In the **Getting Started** dialog box, select **Create a new blank project**.

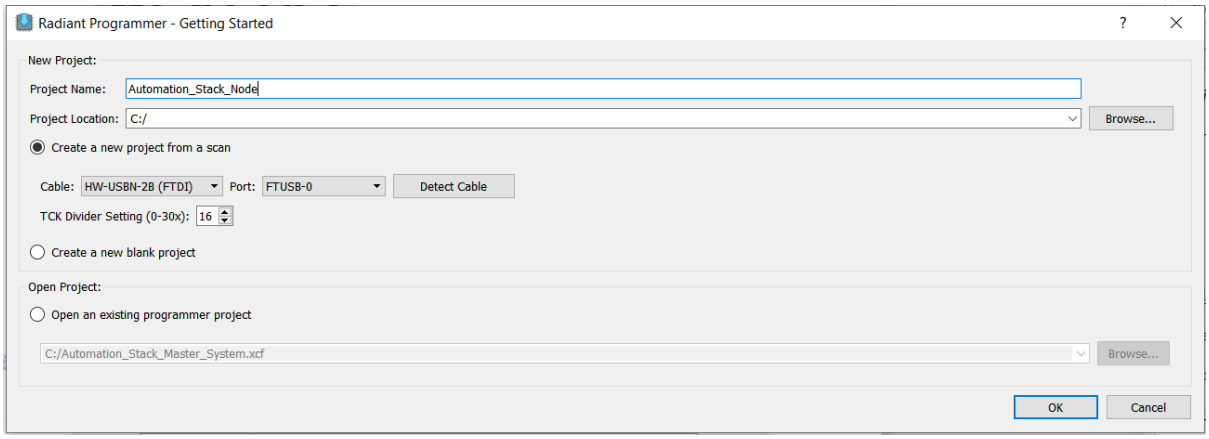


Figure 8.79: Radiant Programmer Default Screen

3. Click **OK**.

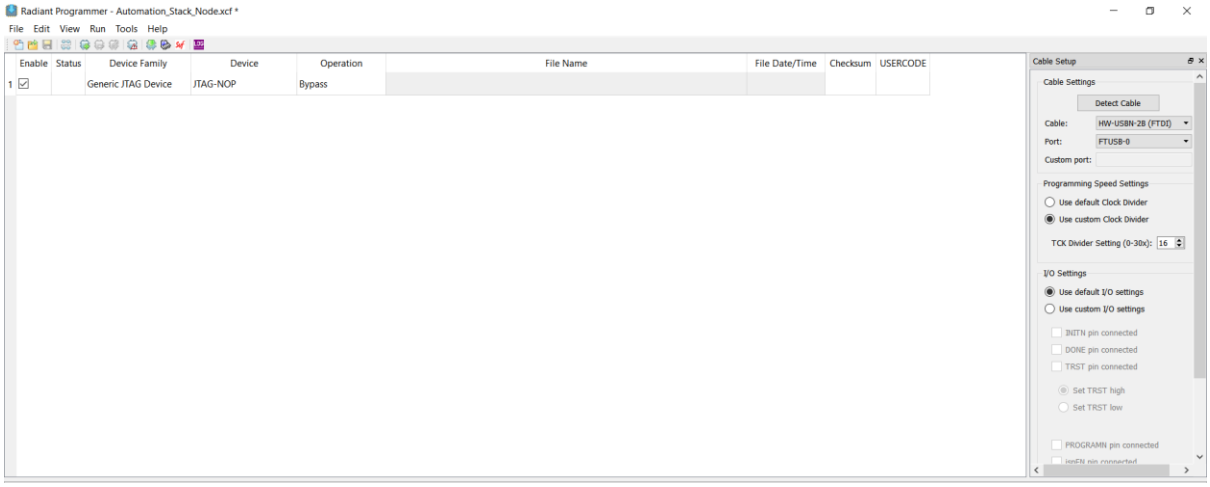


Figure 8.80: Radiant Programmer- Initial Project Window

4. In the Radiant Programmer main interface, select **LFD2NX** for **Device Family** and **LFD2NX-40** for **Device** as shown in below Figure

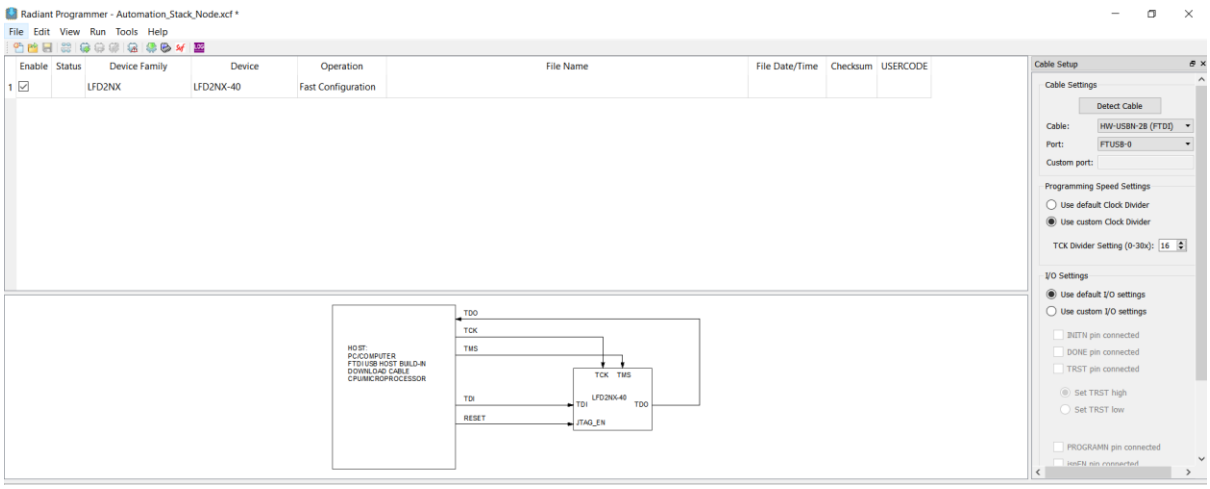


Figure 8.81: Right-click and select Device Properties.

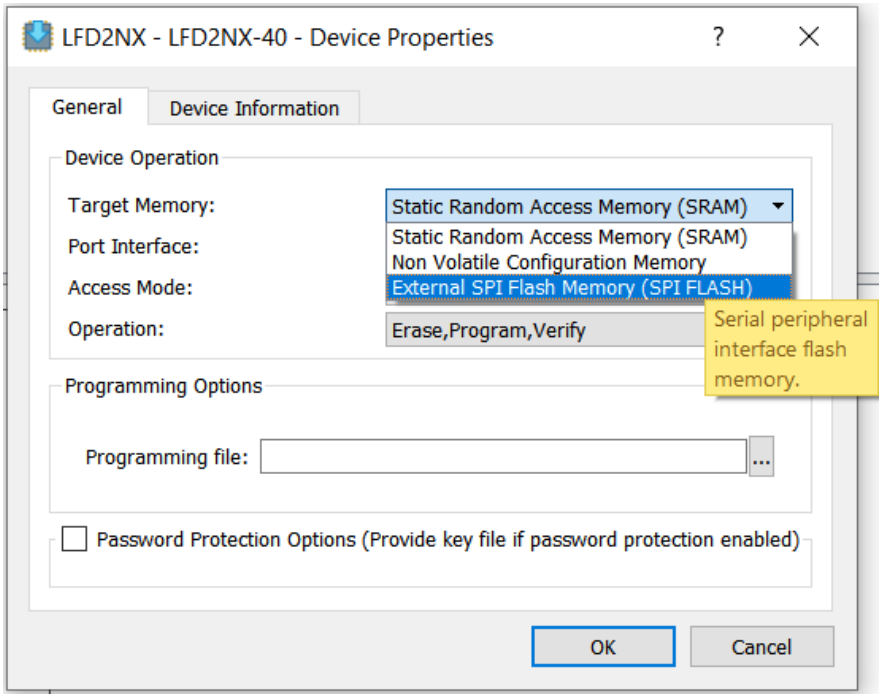


Figure 8.82: Radiant Programmer- Device Operation

5. Before programming, it is necessary to erase the flash memory. For this, Apply the settings below:
    a. Under Device Operation, select the options below:
    - Target Memory – External SPI Flash Memory (SPI FLASH)
    - Port Interface – JTAG2SPI
    - Access Mode – Direct Programming
    - Operation – Erase all

    b. Under SPI Flash Options, select the options below:
    - Family – SPI Serial Flash
    - Vendor – Micron
    - Device – MT25QU128
    - Package – 8-pin SOP2

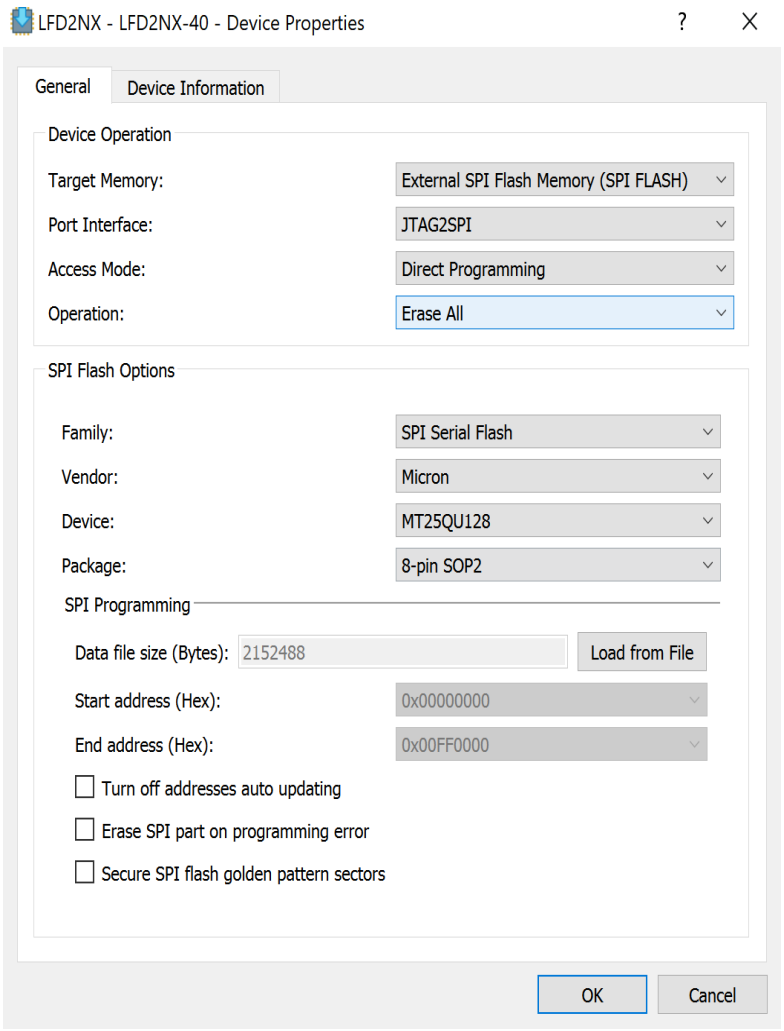


Figure 8.83: Erase all (Radiant Programmer)

6. Click OK and then click the Program Device icon or the menu item Run ->Program Device. This will erase the flash memory if any other data is already present in it.
7. After erasing the flash, power cycle the board and apply the settings below:
    a. Under Device Operation, select the options below:
    - Target Memory – External SPI Flash Memory
    - Port Interface – SPI
    - Access Mode – Direct Programming
    - Operation – Erase, Program, Verify

    b. Under SPI Flash Options, select the options below:
    - Family – SPI Serial Flash
    - Vendor – Micron
    - Device – MT25QU128
    - Package – 8-pin SOP2
8. To program the bitstream file, select the options as shown in below Figure

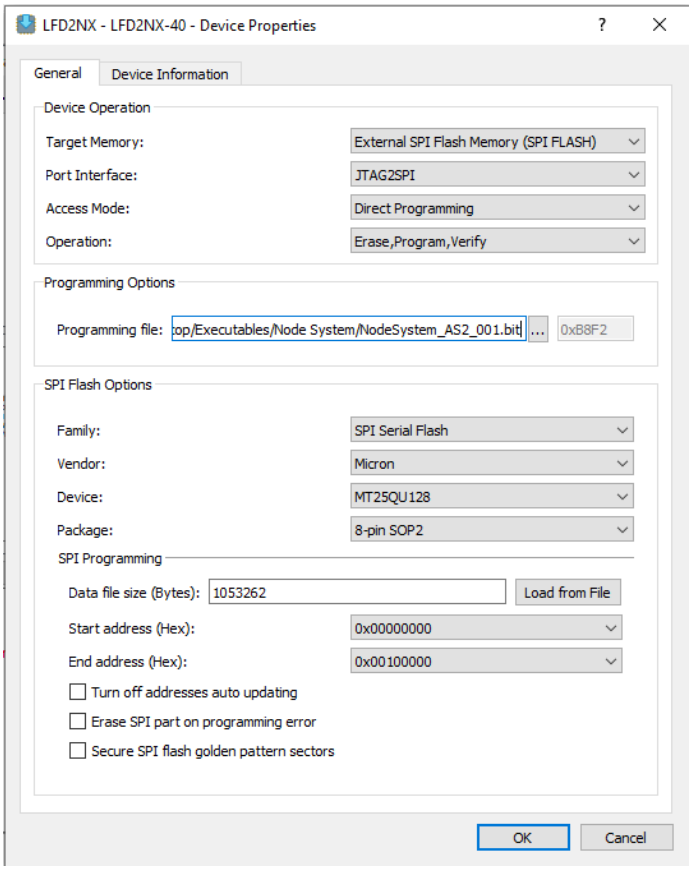


Figure 8.84: Radiant Programmer- Bit stream Flashing Settings

a. Under **Programming Options**, select the **NodeSystem_AS2_001.bit** bitstream file in Programming file.
b. Click **Load from File** to update the **Data file size (Bytes)** value.
c. Ensure that the following addresses are correct:

- Start Address (Hex) – 0x00000000
- End Address (Hex) – 0x00100000

9. Then click the Program Device icon or the menu item Run ->Program Device.
10. To program the firmware, select the options as shown in below Figure.
    a. Under **Programming Options**, select the **NodeSystem_AS2_001.bin** binary file.
    b. Ensure that the following addresses are correct:
    - Start Address (Hex) – 0x00140000
    - End Address (Hex) – 0x00240000
11. Then click the Program Device icon or the menu item Run ->Program Device.

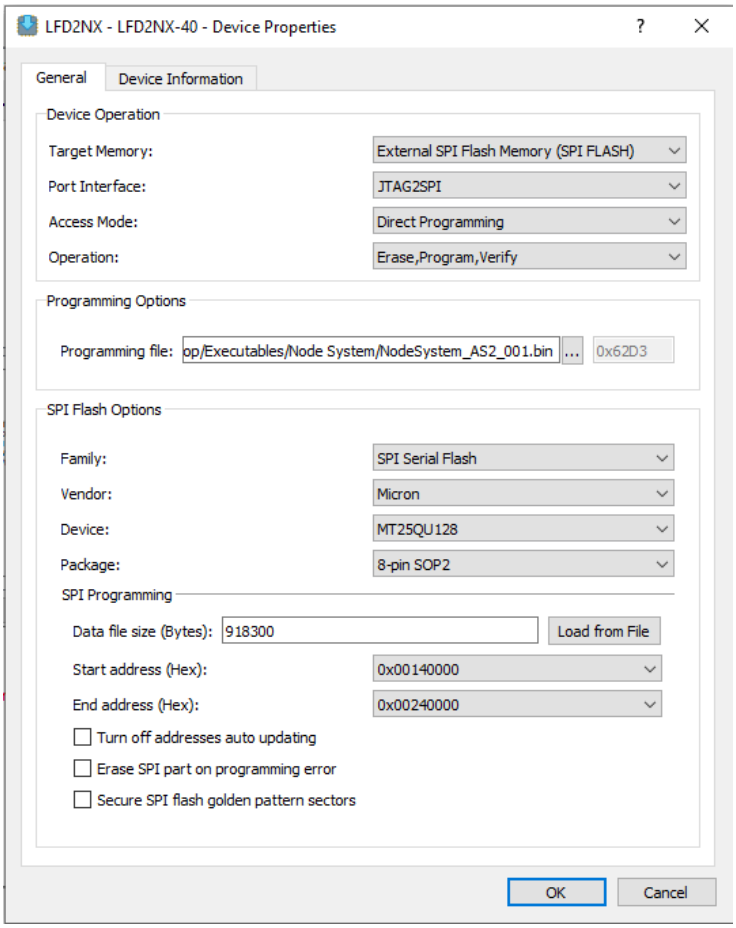


Figure 8.85: Radiant Programmer- Binary Flashing Settings

Note: After programming the Boards, do power cycle the CertusPro NX Versa board and each Certus NX versa boards and then press the system Reset button SW 3.

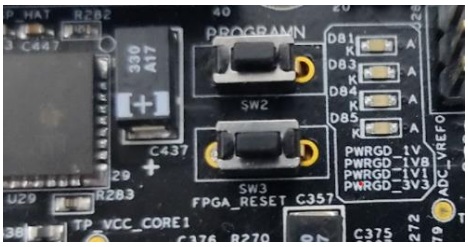


Figure 8.86: Reset Button SW3 of CertusPro NX Versa Board

Figure 8.87: Reset Button SW3 of Certus NX Versa Board

Appendix F. Troubleshooting (Main System Board)

If you are programming the Main System board for the first time then follow the following one time procedure to avoid the firmware booting issue. It is because, when the boards are delivered from the foundry it is programmed in the quad mode. But SPI flash Controller starts with serial mode (default) for commands and then it selects quad mode for read operation.

To program the SPI Flash in Quad mode :

1. Connect the CertusPro-NX Versa board to the PC using a USB cable.
2. Start Radiant Programmer. In the **Getting Started** dialog box, select **Create a new blank project**.

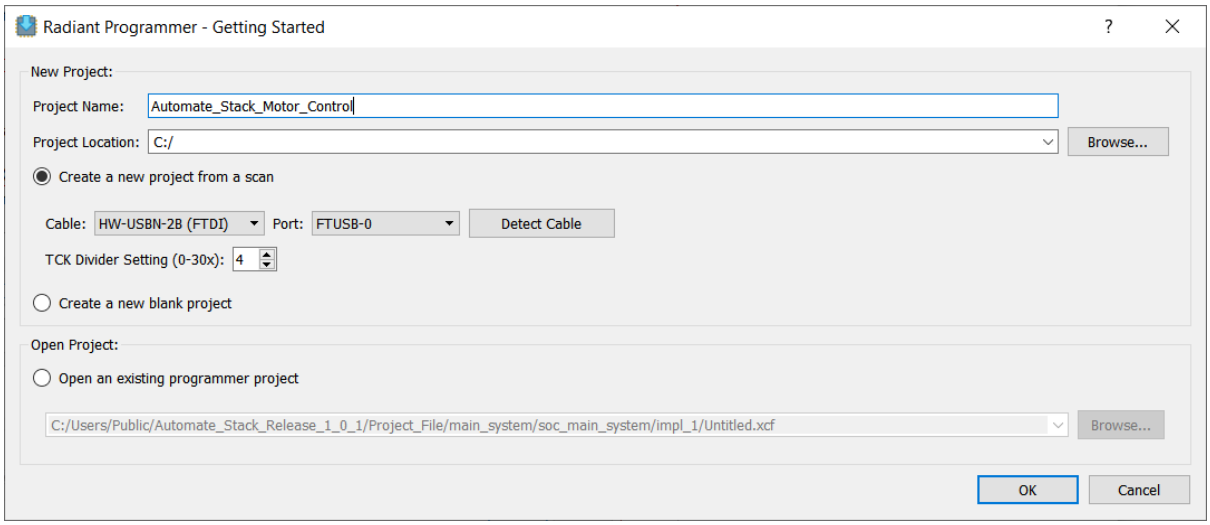


Figure 8.88: Radiant Programmer Default Screen

3. Click OK.

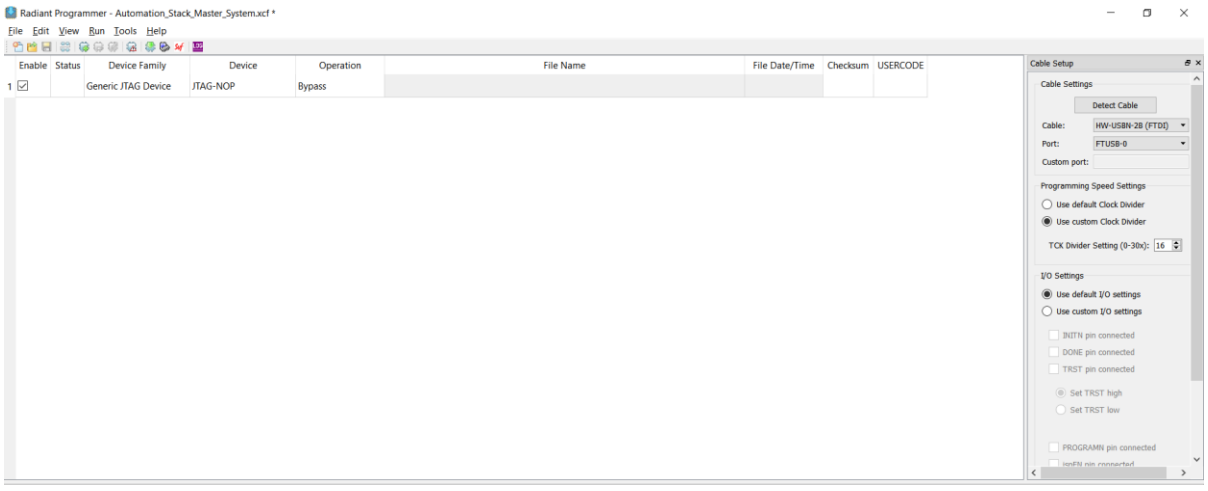


Figure 8.89: Radiant Programmer- Initial Project Window

4. In the Radiant Programmer main interface, select **LFCPNX** for **Device Family** and **LFCPNX-100** for **Device or** detect automatically as shown in below Figure.

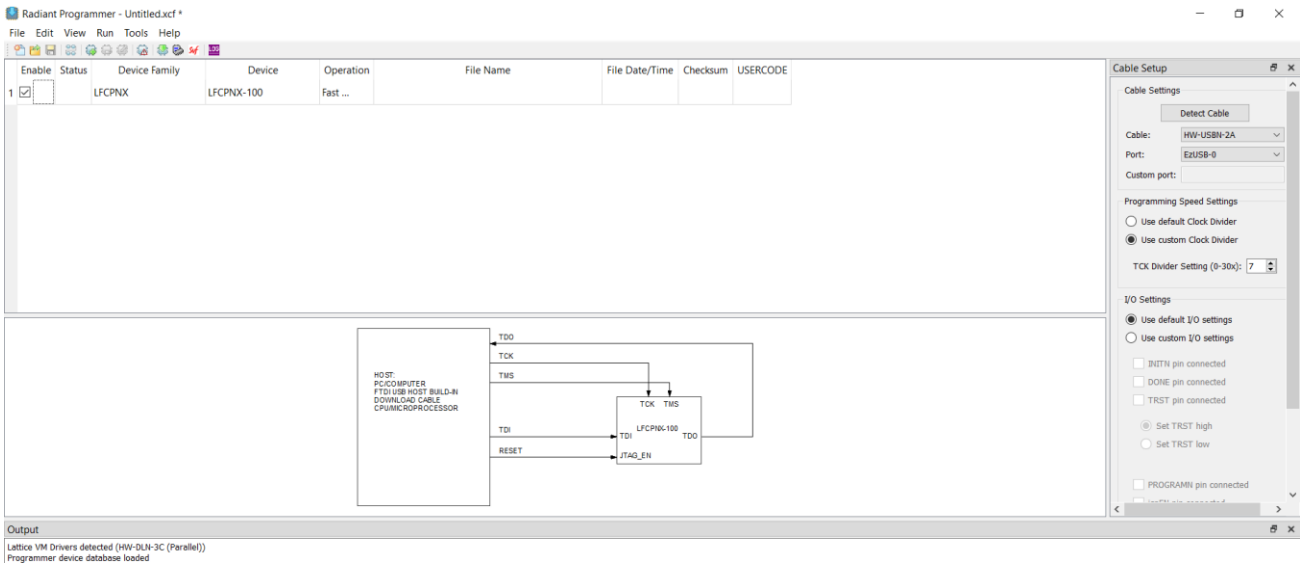


Figure 8.90: Radiant Programmer- Device Selection

5. Right-click and select **Device Properties**.

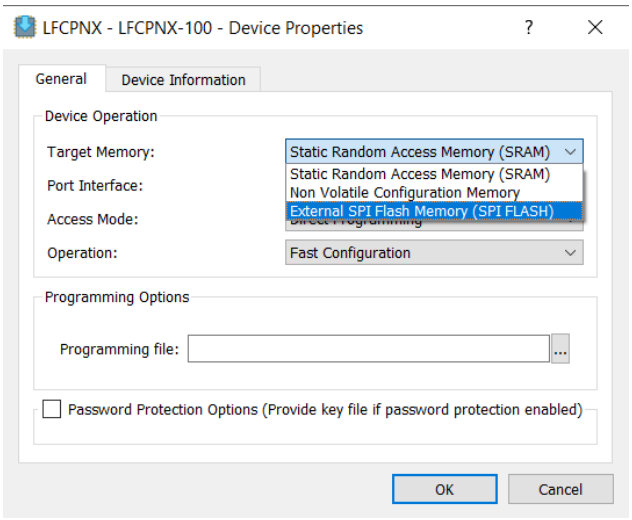


Figure 8.91: Radiant Programmer- Device Operation

6. To program the binary file, apply the settings below:
    a. Under Device Operation, select the options below:
    - Target Memory – External SPI Flash Memory (SPI FLASH)
    - Port Interface – JTAG2SPI
    - Access Mode – Direct Programming
    - Operation – Erase, Program, Verify Quad 1

    b. Under SPI Flash Options, select the options below:
    - Family – SPI Serial Flash
    - Vendor – Macronix
    - Device – MX25L51245G
    - Package – 8-land WSON

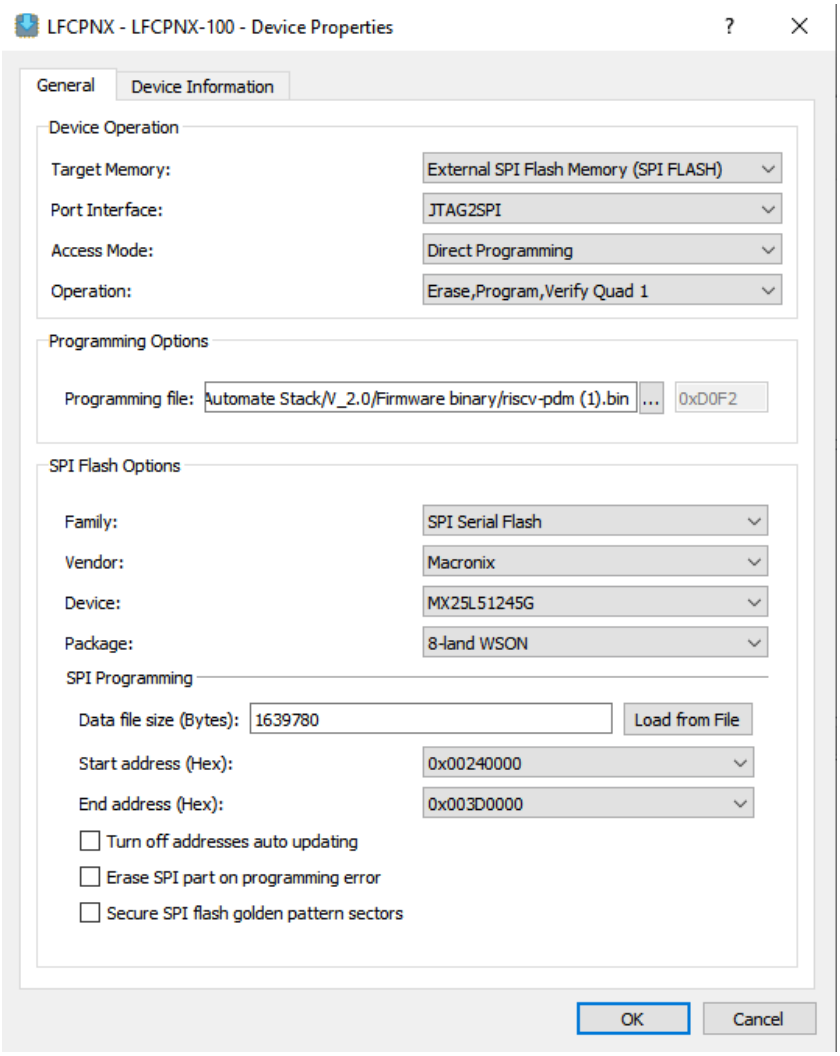


Figure 8.92: Quad Mode Programming (Radiant Programmer)

7. Under **Programming Options**, select the **riscv-pdm.bin** binary file.
    a. Ensure that the following addresses are correct:
    - Start Address (Hex) – 0x00240000
    - End Address (Hex) – 0x003D0000
8. Click OK and then click the Program Device icon or the menu item Run ->Program Device. After that power cycle the board.
9. To program the **bitstream file**, select the options as shown in below Figure.
10. Under **Programming Options**, select the **soc_main_system_impl_1.bit** bitstream file in Programming file.

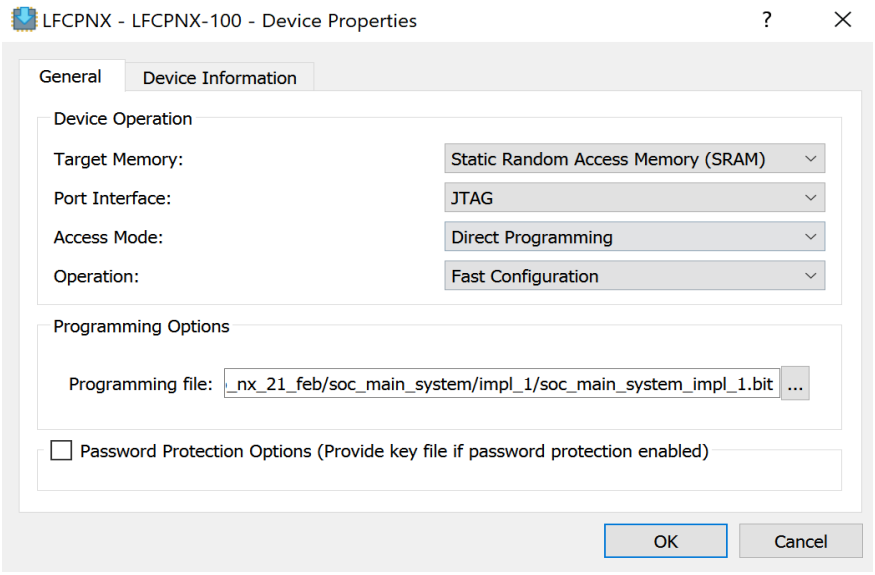


Figure 8.93: Bitfile Programming

11. Then click the Program Device icon or the menu item Run ->Program Device.
12. Now it is required to erase the SPI flash. For that, apply the settings below:
    a. Under Device Operation, select the options below:
    - Target Memory – External SPI Flash Memory (SPI FLASH)
    - Port Interface – JTAG2SPI
    - Access Mode – Direct Programming
    - Operation – Erase All

    b. Under SPI Flash Options, select the options below:
    - Family – SPI Serial Flash
    - Vendor – Macronix
    - Device – MX25L51245G
    - Package – 8-land WSON

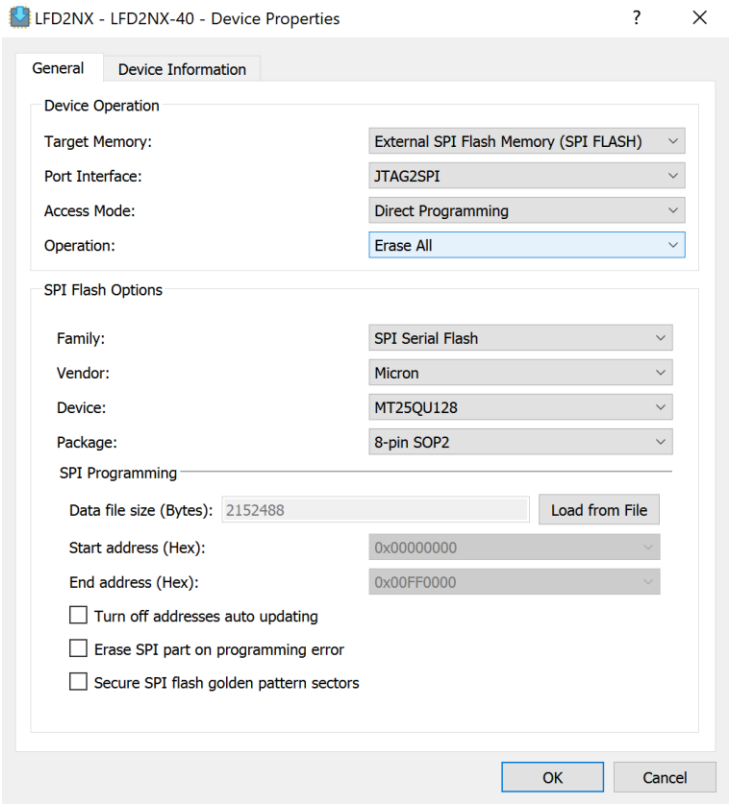


Figure 8.94: Erase all (Radiant Programmer)

13. Then click the Program Device icon or the menu item Run ->Program Device.
14. Now Power cycle the CertusPro NX Versa Board.

Note: This is a one-time process which is needed to follow for every new board.

Appendix G. Debugging Using Dock light

User does not need R-Pi board or any server or client setup to run basic demo from docklight. Docklight tool is available on web so user can download **version of tool**.

Docklight can be used as host for debugging. It supports UART protocol with various standard baud rates.

1. User needs to send each command manually to demonstrate any functionality of the system. It supports same UART packet type as GUI. Brief explanation of UART request and response packets is explained in further sections of this Appendix. **Lattice_Automate_Stack_1_1_Docklight.ptp** basic docklight script is provided with the demo package. Explanation of basic command is given in further sections of this Appendix. User can add more commands in .ptp file based on requirement.

Basic minimal list of procedures are also defined in this Appendix run basic demo from docklight.

Here are basic steps to run demonstration using docklight:

2. HW(A CertusPro-NX Board and Certus-NX Boards) should be programmed with appropriate executable files as given in Appendix E
3. Docklight tool should be installed in host PC.
4. HW connection should be proper as given in below fig.

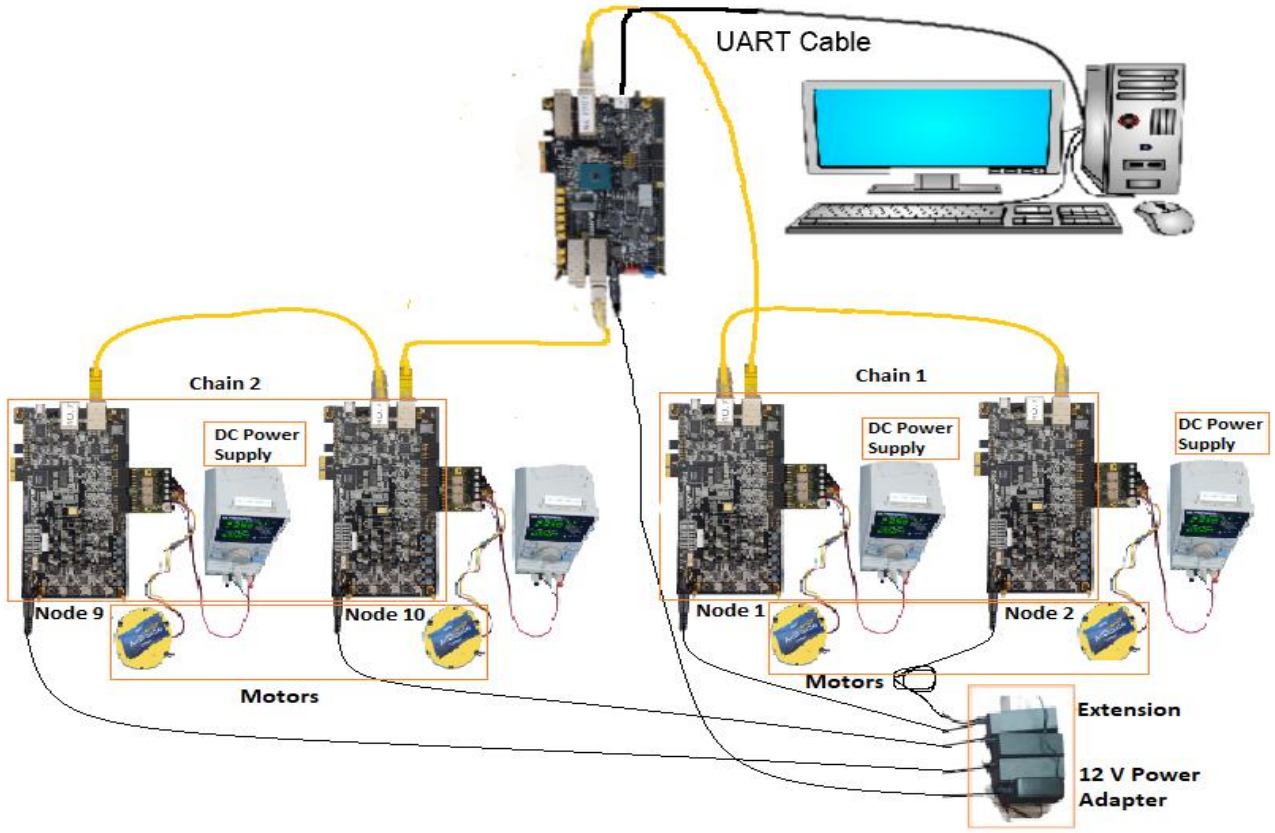


Figure 8.95: Setup for docklight

5. Open the Docklight application

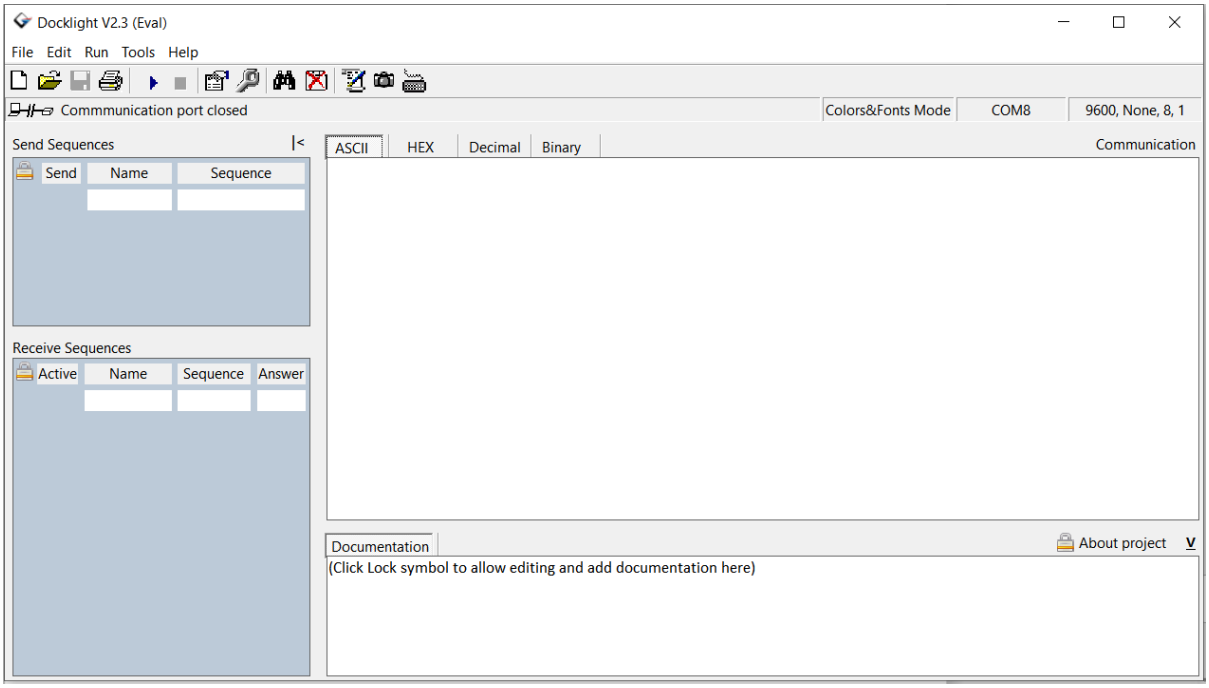


Figure 8.96: Docklight Default Screen

6. Now open the Docklight script **Lattice_Automate_Stack_2_0_Docklight.ptp**

7. Select the correct comm port and baud rate 9600.

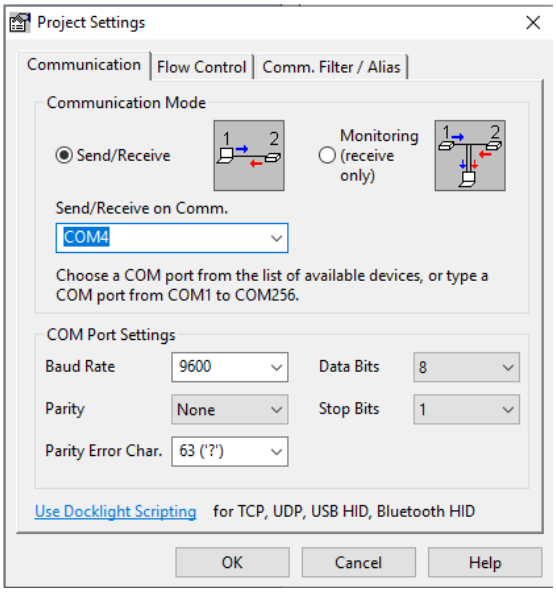


Figure 8.97: Select Com port and Baud rate

8. Click on the Run in the Docklight.

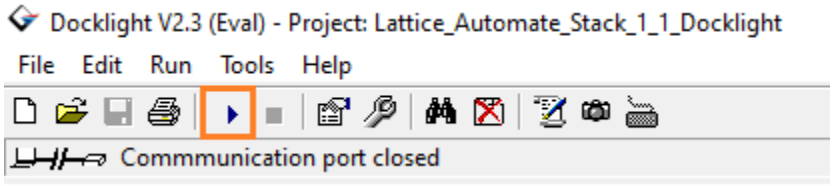


Figure 8.98: Run button

9. Press System Reset of Main System Board.

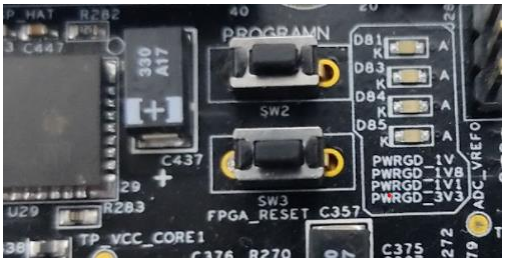


Figure 8.99: Reset the main board(CertusPro-NX Versa)

10. System initialization will appear in the ASCII tab.

```
Main System Ready!<CR><LF>
Automate Stack2.0 ver 0.1.0!<CR><LF>
Version Date 06/10/2022<CR><LF>
Multi Link for Main System detected<CR><LF>
Node num 16, Node Data length 64<CR><LF>
Broad Cast Start<CR><LF>
 Org:detected_nodes 10001<CR><LF>
 Chain : 1 ACTIVE NODE: 1<CR><LF>
Chain : 1 FINAL ACTIVE NODE 1<CR><LF>
PHY LINK EXPECTED: 3<CR><LF>
BEFORE: TIMER PHY LINKS MAIN and NODES 3<CR><LF>
After Node Enable: 1<CR><LF>
Chain 1 nodes reg : 1<CR><LF>
INIT_DONE<CR><LF>
Node num 16, Node Data length 64<CR><LF>
Broad Cast Start<CR><LF>
 Org:detected_nodes 20101<CR><LF>
 Chain : 2 ACTIVE NODE: 1<CR><LF>
Chain : 2 FINAL ACTIVE NODE 1<CR><LF>
PHY LINK EXPECTED: 3<CR><LF>
BEFORE: TIMER PHY LINKS MAIN and NODES 3<CR><LF>
After Node Enable: 1<CR><LF>
Chain 2 nodes reg : 1<CR><LF>
INIT_DONE<CR><LF>
Sys Init Done.<CR><LF>
PU Seq Start.<CR><LF>
Motor Status Value RPM: 0<CR><LF>
Motor Status Value RPM: 0<CR><LF>
PU Seq Done<CR><LF>
PDM INIT DONE. INPUT ADDRESS: e89a0<CR><LF>
<LF>
 free up ether ip flag<LF>
```

Figure 8.100: System Initialization

11. User refer section **Steps to demonstrate of basic functionality** to run basic functionalities of the system.

G.1 UART Command's Description

User can refer this section for UART read/write request and response commands.

Write Request Command (TX):

CC 77 10 00 00 01 00 00 18 70 19 00 01 00 00 00

CMD LEN Read write Address Data

CC 77 : Magic No. For Command packet

CMD Len: 2 byte for packet length

Data Write: 0x00000100

Data Read: 0x00000200

Address: Address to Write or Read

Data: Data will be present from byte position 12(index 12)

Write Response Command (RX):

AA 88 0C 00 00 01 00 00 00 00 00 00

Packet Length Response Packet Error / No Error

AA 88 : Magic Word

Packet Length: 2 byte of packet length

Response Packet Code:

Data Write Response: 0x00000100

Data Read Response: 0x00000200

Error/ No Error :

No Error: 0x00000000

Error: 0x00000001

Read Request Command (TX):

CC 77 0C 00 00 02 00 00 18 00 19 00

CMD LEN Read write Address

CC 77 : Magic No. For Command packet

CMD Len: 2 byte for packet length

Data Write: 0x00000100

Data Read: 0x00000200

Address: Address to Write or Read

Data: Data will be present from byte position 12 (index 12)

Read Response Command (RX):

AA 88 10 00 00 02 00 00 00 00 00 00 00 00 00 00

Packet Length Response Packet Error / No Error Data

AA 88 : Magic Word

Packet Length: 2 byte of packet length

Response Packet Code:

Data Write Response: 0x00000100

Data Read Response: 0x00000200

Error/ No Error :

No Error: 0x00000000

Error: 0x00000001

G.2 Commands

The configuration settings for the motor will be applied by the user to control the motor.

1. Main system commands - to enable different mode

A. **CHAIN_1_SELECT** : Chain 1 of nodes select, set by the user.
Command: CC 77 10 00 00 01 00 00 18 70 19 00 01 00 00 00

B. **CHAIN_2_SELECT** : Chain 2 of nodes select, set by the user.
Command: CC 77 10 00 00 01 00 00 18 70 19 00 02 00 00 00

C. **CHAIN_1_NODE_SELECT** : Node select from chain 1, set by the user.
Command: CC 77 10 00 00 01 00 00 04 70 19 00 01 00 00 00

Note: This Command is only for Chain 1 and Node 1

D. **CHAIN_2_NODE_SELECT** : Node select from chain 2, set by the user.
Command: CC 77 10 00 00 01 00 00 1C 70 19 00 01 00 00 00

E. **ALL_CHAIN_TX_ENABLE** : Both chain of nodes select, set by the user.
Command: CC 77 10 00 00 01 00 00 20 70 19 00 01 00 00 00

F. **SINGLE_CHAIN_TX_ENABLE** : one by one chain select mode enable, set by the user.
Command: CC 77 10 00 00 01 00 00 20 70 19 00 00 00 00 00

G. **PDM_NORMAL_PACKET_ ENABLE** : PDM normal packet enable, set by the user.
Command: CC 77 10 00 00 01 00 00 24 70 19 00 00 00 00 00

H. **PDM_EXTENDED_PACKET_ENABLE** : PDM extended packet enable, set by the user.
Command: CC 77 10 00 00 01 00 00 24 70 19 00 01 00 00 00

I. **MOTOR_STATUS_READ_MAIN_SYSTEM** : Motor status read from main system register bank, set by the user.
Command: CC 77 0C 00 00 02 00 00 24 70 19 00 01 82 10 00

2. MOTOR Config Command

A. **NODE_LED_ON** : Node LED ON configuration , set by the user.
Command: CC 77 10 00 00 01 00 00 54 40 18 00 00 00 00 00

B. **NODE_LED_OFF** : Node LED OFF configuration , set by the user.
Command: CC 77 10 00 00 01 00 00 54 40 18 00 FF FF FF FF

C. **MIN_RPM** : Minimum rpm limit of motor, set by the user.
Command: CC 77 10 00 00 01 00 00 00 40 18 00 78 00 04 96

D. **MAX_RPM** : Maximum rpm limit of motor, set by the user.
Command: CC 77 10 00 00 01 00 00 04 40 18 00 10 0E 00 00

E. **RPM_PI_KI** : Configuration of motor, set by the user.
Command: CC 77 10 00 00 01 00 00 08 40 18 00 10 00 40 00

F. **RPM_PI_KP** : Configuration of motor, set by the user.
Command: CC 77 10 00 00 01 00 00 0C 40 18 00 80 00 00 08

G. **TARGET_RPM 120** : Target rpm on which the motor is to run, set by the user.
Command: CC 77 10 00 00 01 00 00 1C 40 18 00 78 00 00 00

H. **TARGET_RPM 500** : Target rpm on which the motor is to run, set by the user.
Command: CC 77 10 00 00 01 00 00 1C 40 18 00 78 00 00 00

I. **TARGET_RPM 1000** : Target rpm on which the motor is to run, set by the user.
Command: CC 77 10 00 00 01 00 00 1C 40 18 00 78 00 00 00

J. **TARGET_RPM 1500** : Target rpm on which the motor is to run, set by the user.
Command: CC 77 10 00 00 01 00 00 1C 40 18 00 78 00 00 00

K. **TARGET_RPM 1800** : Target rpm on which the motor is to run, set by the user.
Command: CC 77 10 00 00 01 00 00 1C 40 18 00 78 00 00 00

L. **PI_RESET** : Configuration of motor, set by the user.
Command: CC 77 10 00 00 01 00 00 18 40 18 00 00 00 00 01

M. **STROBE_FUNCTION** : Strobe function configuration, set by the user.
Command: CC 77 10 00 00 01 00 00 18 40 18 FF 00 00 00 00

N. **MOTOR_ POWER (38%)** : Motor power configuration , set by the user.
Command: CC 77 10 00 00 01 00 00 14 40 18 00 80 01 00 00

O. **MOTOR_POWER**(10%) : Motor power configuration , set by the user.
Command: CC 77 10 00 00 01 00 00 14 40 18 00 80 01 00 00

P. **MOTOR_START** : Motor start configuration of motor, set by the user.
Command: CC 77 10 00 00 01 00 00 18 40 18 00 00 00 00 10

Q. **MOTOR_STOP** : Motor stop configuration of motor , set by the user.
Command: CC 77 10 00 00 01 00 00 18 40 18 00 00 00 00 12

R. **MOTOR_POWER_OFF** : Motor power off configuration of motor, set by the user.
Command: CC 77 10 00 00 01 00 00 18 40 18 00 00 00 00 00

S. **PDM_OFFSET** : PDM offset configuration , set by the user.
Command: CC 77 10 00 00 01 00 00 30 40 18 00 40 0F C8 00

T. **PDM_PEAK_DETECT** : PDM peak detect configuration , set by the user.
Command: CC 77 10 00 00 01 00 00 30 40 18 00 02 0F C8 00

U. **PDM_START** : PDM start configuration, set by the user.
Command: CC 77 10 00 00 01 00 00 30 40 18 00 09 0F C8 00

Motor Status Command

A. **PDM_READY_CHECK** : PDM Ready check configuration , set by the user.
Command: CC 77 0C 00 00 02 00 00 38 40 18 00 40 0F C8 00

B. **PDM_LOCK_CHECK** : PDM lock check configuration , set by the user.
Command: CC 77 0C 00 00 02 00 00 2C 40 18 00 40 0F C8 00

PDM Data Fetched Command

A. **PDM_DATA_FETCHED** : PDM data fetched configuration , set by the user.
Command: CC 77 10 00 00 01 00 00 0C 70 19 00 00 00 00 00

B. **PDM Health Status Command Health_Status**: PDM data fetched configuration, set by the user.
Command: CC 77 10 00 00 02 00 00 70 70 19 00

00 - 1st node

01 - 2nd node

02 - 3rd node and so on

Steps to demonstrate of basic functionality.

1. Basic Communication test
    a. Select the Chain.
    b. Select the node for Motor Control
    c. Send LED ON and OFF commands.
2. Both Chain Communication

d. Select any one chain number
e. Select the nodes for selected chain.
f. Send the command for selected node.
g. Select another chain number
h. Select node for another chain.
i. Send command for another chain.
j. Command will be send to all the both chain

3. Motor Configuration Test
    a. Select the Chain.
    b. Select the node for Motor Control
    c. Send the Motor config command.
4. Motor Status Test
    a. Select the Chain.
    b. Select the node for Motor Control
    c. Send the motor Status command.
5. Motor Start Test
    a. Select the Chain.
    b. Select the node for Motor Control
    c. Send the PDM Offset command.
    d. Send the Min RPM command.
    e. Send the MAX RPM command.
    f. Send the PI KI command.
    g. Send the PI KP command.
    h. Send the Target 120 command.
    i. Send the PI Reset command.
    j. Send the Strobe function command.
    k. Send the Motor Power 10 % command.
    l. Send the Motor Start command
    m. Send the strobe function command.
    n. Send the Motor Stop command.
    o. Send the strobe function command.
6. PDM Data Fetched Test

PDM Data can be fetched from one node at a time.

    a. Select the Chain.
    b. Select the node for Motor Control
    c. Send all the motor start test commands till step “m”.
    d. Send the Motor Power 38% command.
    e. Send the Target RPM 500 command then Strobe function command.

    Note: Match the RPM Lock Status

    f. Send the Target RPM 1000 command then Strobe function command.

    Note: Match the RPM Lock Status

    g. Send the Target RPM 1500 command then Strobe function command.

Note: Match the RPM Lock Status

h. Send the Target RPM 1800 command then Strobe function command.

Note: Match the RPM Lock Status

i. Send the PDM Peak Detect command then Strobe Function command.

j. Send the PDM Start command then Strobe Function command.

k. Send PDM Ready Check command and check the status

l. Send the PDM call node command.

m. Wait for the PDM data response on docklight

Then bit for the health status, it will take around 2min, do not send any command before getting health status response.

n. Send the Motor Stop command.

Appendix H. OpcUA Modeler (Server End)

H.1 OpcUA Modeler Installation

1. Open the terminal in Raspberry pi.
2. Write the Command **sudo apt install python3.6**
3. Write the Command **sudo apt-get install python3-pyqt5**
4. Write the Command **pip3 install opcua-modeler**
5. Now go to the directory using this command **cd /usr/local/bin**
6. For opening the OPCUA Modeler **./opcua-modeler**
7. OPCUA Modeler will open.

Note: PyQT 5 is required.

Note: Python 3.6+ is required.

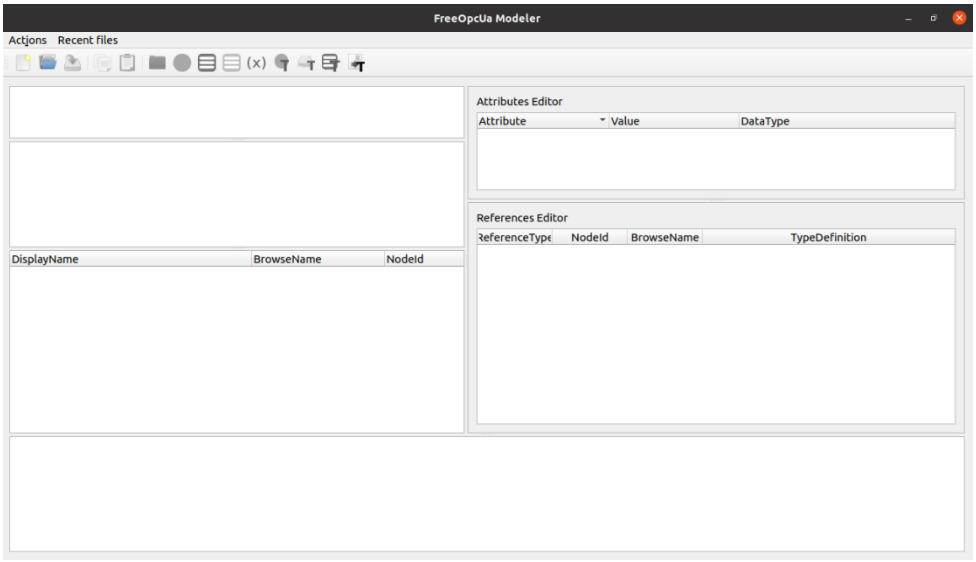


Figure 8.101: OPCUA Modeler

H.2 OPCUA_Modeler : For creating a new Xml (Information model)

1. After OPCUA Modeler installation process start from the below steps.
2. Now go to the **Actions** and Create a **New Model.**
3. Click on the below NamespaceArray and create a new **add space**.
4. Gui contain default information model like root, objects, types, views.

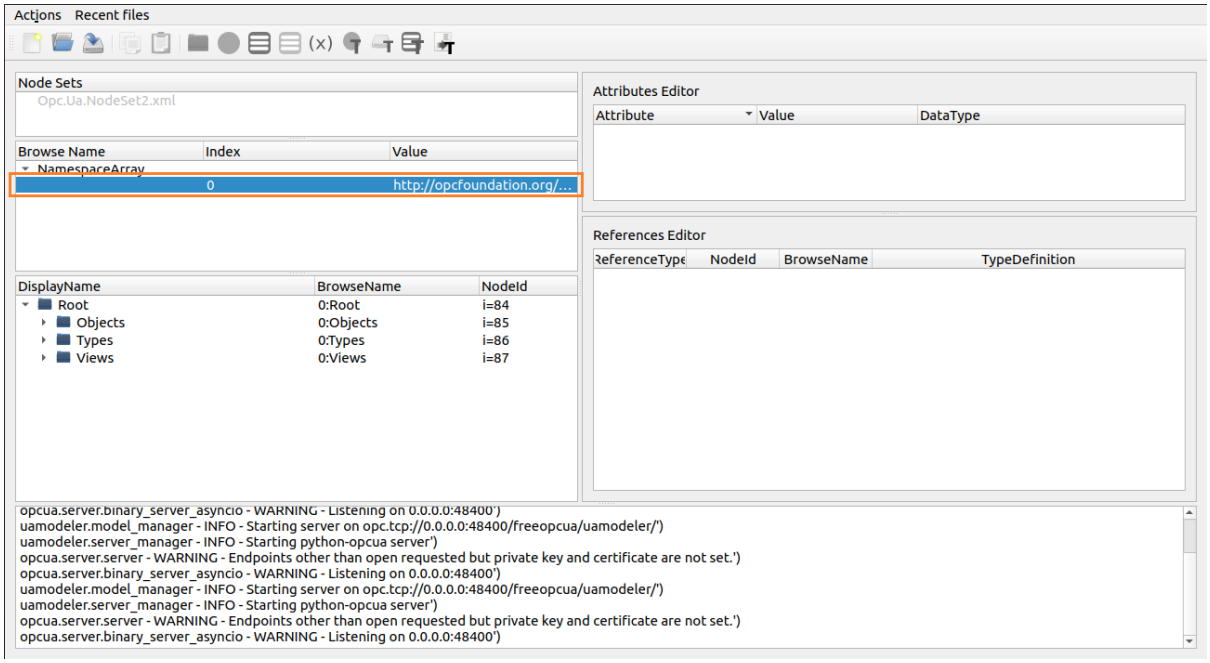


Figure 8.102: Create OpcUA Modeler xml file

5. Give the name as **MainSystem** in **add space**.

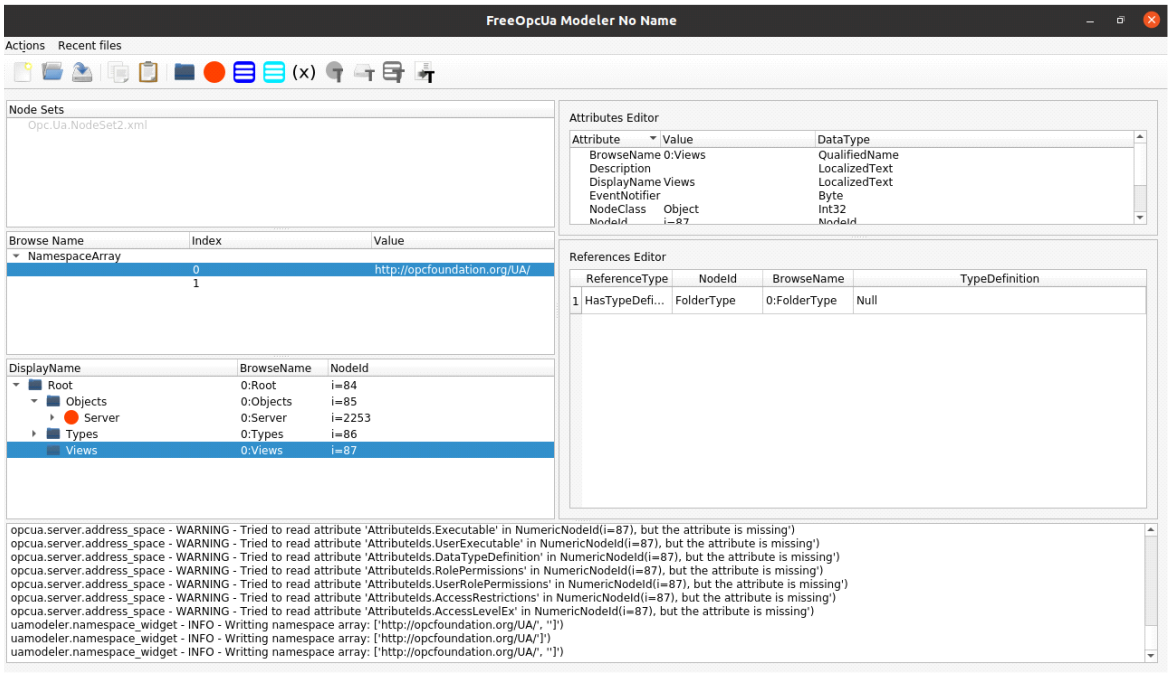


Figure 8.103: Create Main system

6. After add space, it will show in Value.
7. NamespaceArray are specified as variables, method and structure types information.

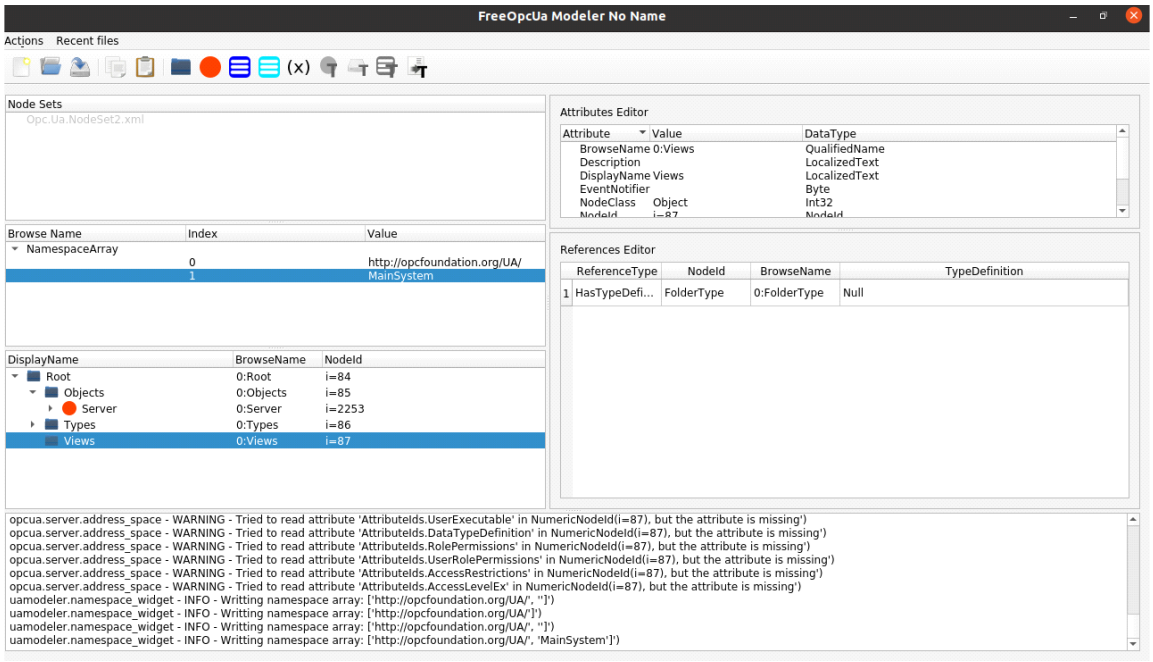


Figure 8.104: Add namespacearray in Browse

8. Press the right click on the Objects and make a new object and give the name: node1
9. In the object, specified name space as Mainsystem and default Object structure type as BaseObjectType.
10. Now check the Auto Nodeid then it will detect automatically.

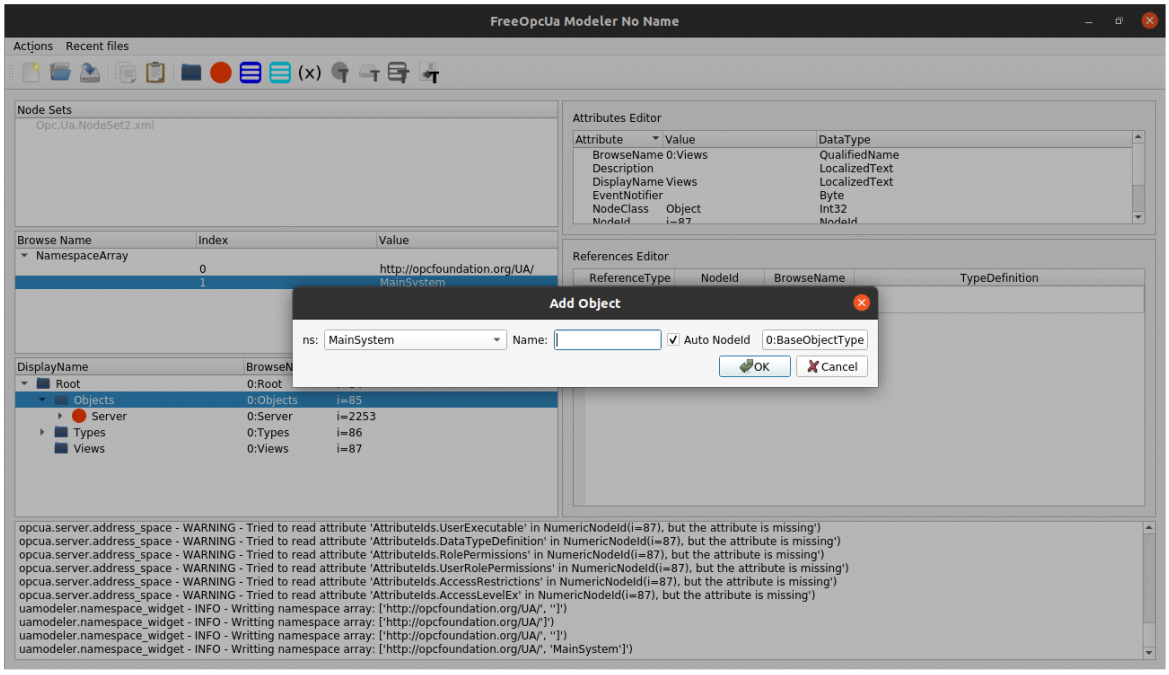


Figure 8.105: Object name

11. If want to change something else then change manually.

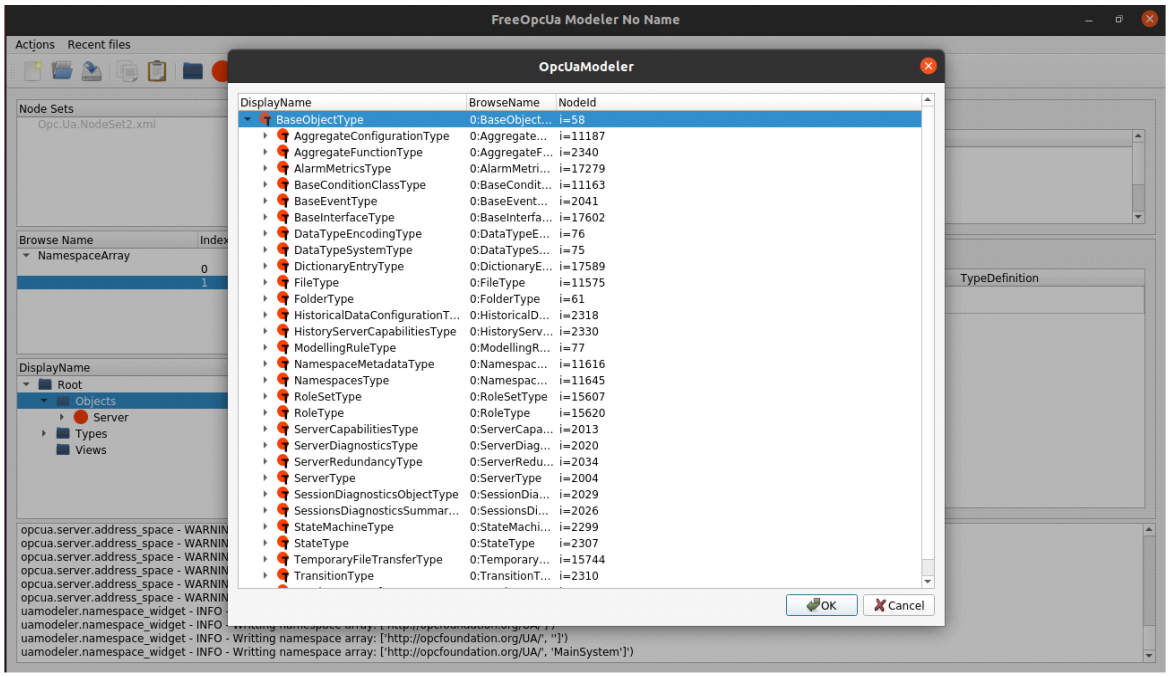


Figure 8.106: manual selection of node id

12. Now click **OK**.

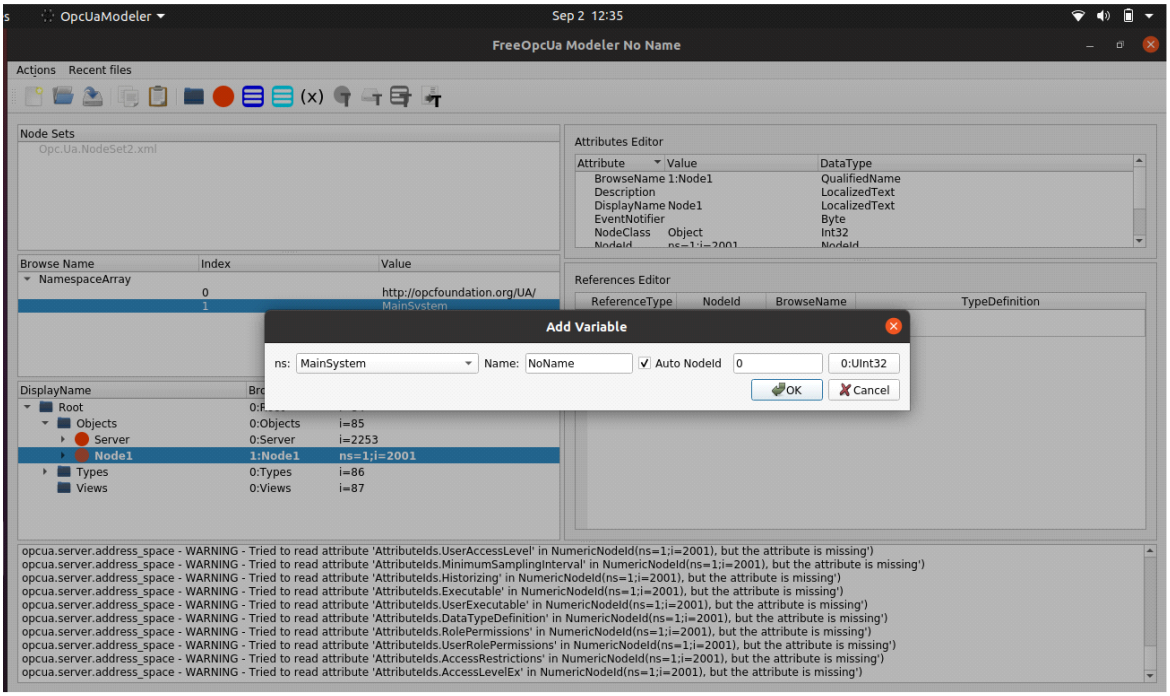


Figure 8.107: Add Variable

13. Now define a variable in Node1 objects then press the right click on Node1 and specify namespace, variable name (TargetRPM) and data type like integer, unsigned integer or boolean.

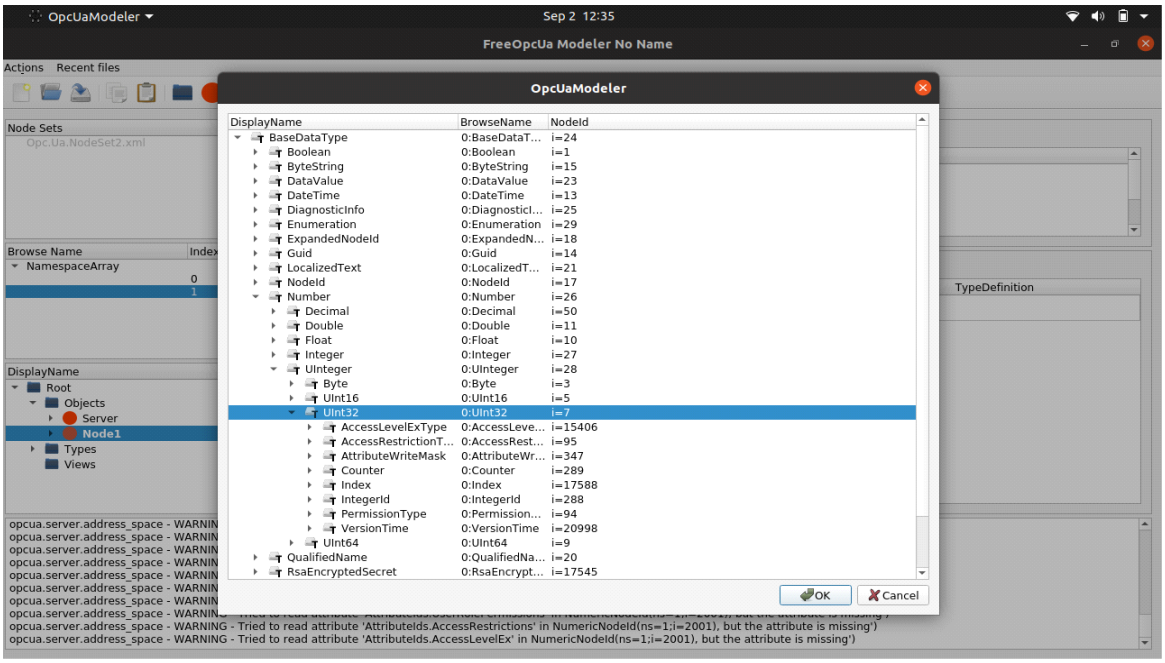


Figure 8.108: Define Variable

14. Now add a method name as **MotorStart** and also define input: Arg Name as **motorInput** and output: Arg Name as **motorOutput** .
15. Click **Ok**.
16. Input arguments send by a client side and server will provide output on the client side.

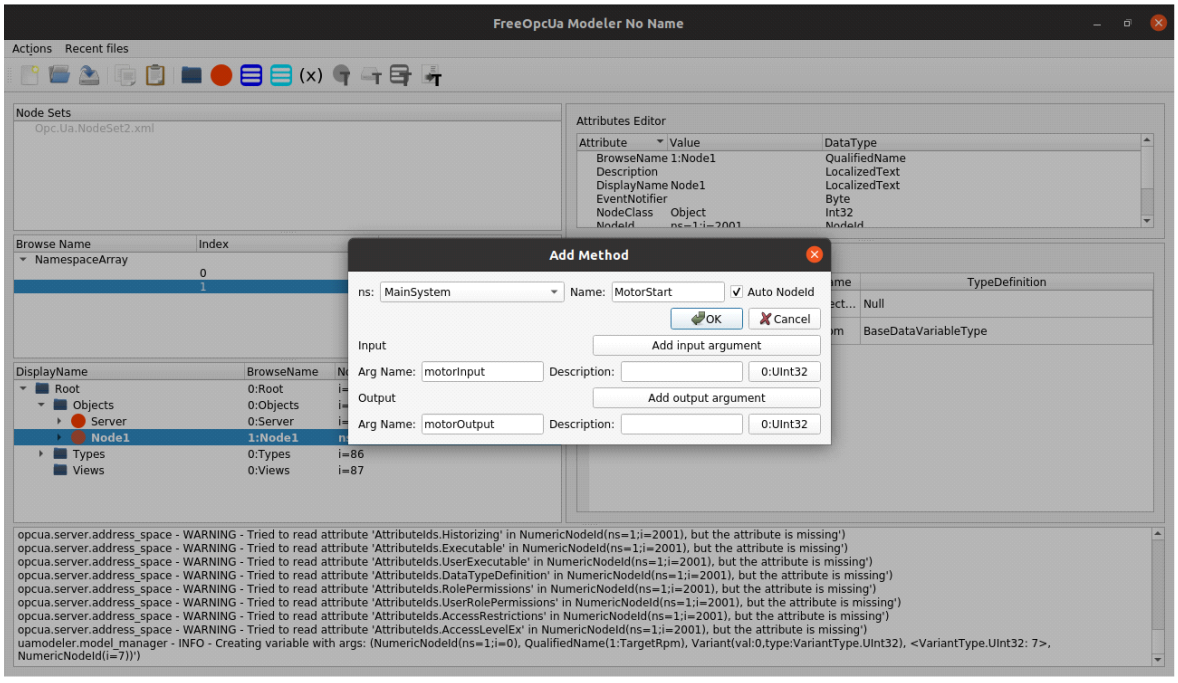


Figure 8.109: Add Method

17. Node1 have structure tree of information model.

18. These steps is to make a new information model for using opcua-modeler.

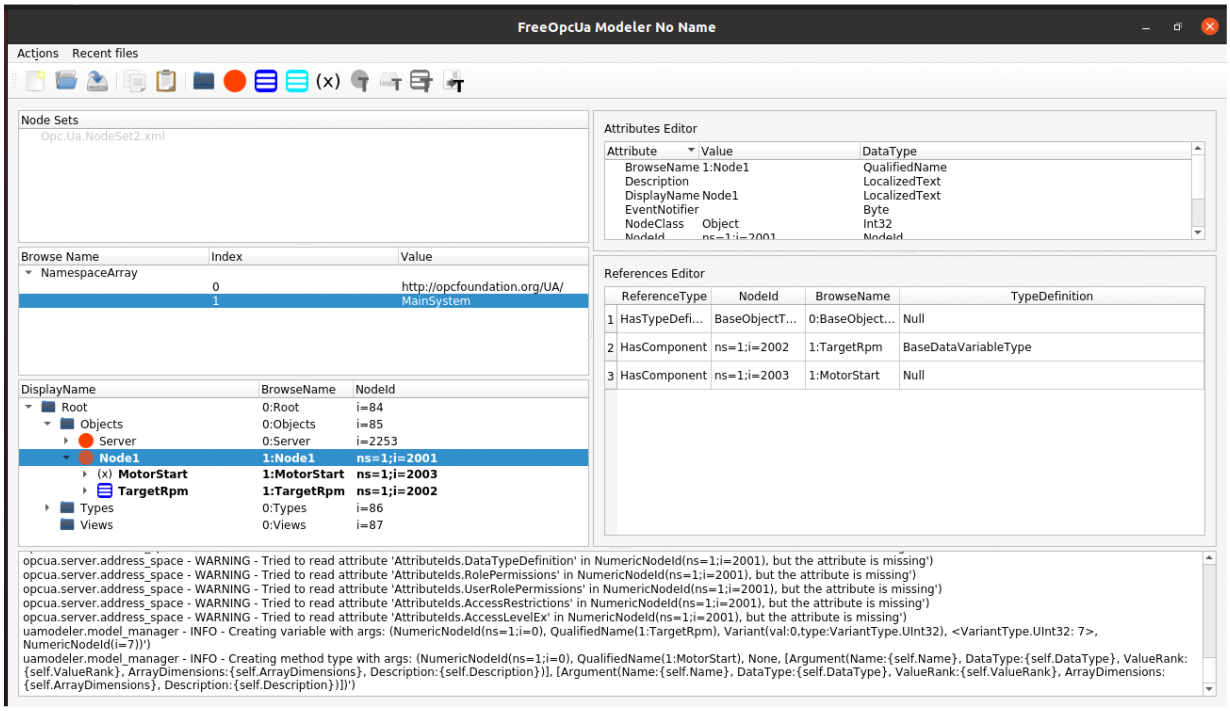


Figure 8.110: opcua modeler

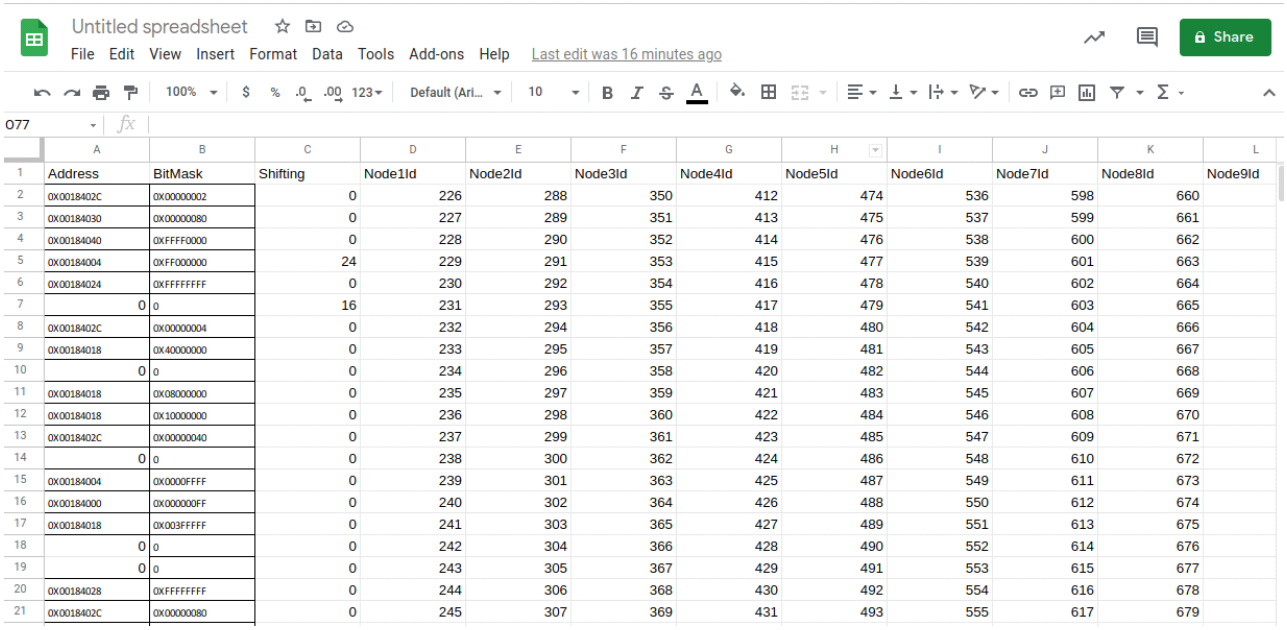
19. If any variables or method in xml information model using opcua-modeler then run ./xmlCmd_script.sh for register all variables and method callbacks in xml .c and .h file.
20. Xml .c and .h file generate Node set compiler.
21. This script is located in Scripts directory.

```
pi@raspberrypi:~/Lattice_Automate_Stack_1_1/OPCUA_Server/OPCUA_ServerApp/Scripts $ ./xmlCmd_script.sh
INFO:__main__:Preprocessing (existing) ../lib/open62541/deps/ua-nodeset/Schema/Opc.Ua.NodeSet2.xml
INFO:__main__:Preprocessing ../tools/Review.xml
INFO:__main__:Generating Code for Backend: open62541
INFO:__main__:NodeSet generation code successfully printed
pi@raspberrypi:~/Lattice_Automate_Stack_1_1/OPCUA_Server/OPCUA_ServerApp/Scripts $
```

Figure 8.111: xml script

Appendix I. CSV (Comma separated value) File

1. CSV file is a text file, it contains a list of data separated by commas.



	A	B	C	D	E	F	G	H	I	J	K	L
1	Address	BitMask	Shifting	Node1Id	Node2Id	Node3Id	Node4Id	Node5Id	Node6Id	Node7Id	Node8Id	Node9Id
2	0X0018402C	0X00000002	0	226	288	350	412	474	536	598	660	
3	0X00184030	0X00000080	0	227	289	351	413	475	537	599	661	
4	0X00184040	0XFFFF0000	0	228	290	352	414	476	538	600	662	
5	0X00184004	0XFF000000	24	229	291	353	415	477	539	601	663	
6	0X00184024	0XFFFFFFFF	0	230	292	354	416	478	540	602	664	
7	0	0	16	231	293	355	417	479	541	603	665	
8	0X0018402C	0X00000004	0	232	294	356	418	480	542	604	666	
9	0X00184018	0X40000000	0	233	295	357	419	481	543	605	667	
10	0	0	0	234	296	358	420	482	544	606	668	
11	0X00184018	0X08000000	0	235	297	359	421	483	545	607	669	
12	0X00184018	0X10000000	0	236	298	360	422	484	546	608	670	
13	0X0018402C	0X00000040	0	237	299	361	423	485	547	609	671	
14	0	0	0	238	300	362	424	486	548	610	672	
15	0X00184004	0X0000FFFF	0	239	301	363	425	487	549	611	673	
16	0X00184000	0X000000FF	0	240	302	364	426	488	550	612	674	
17	0X00184018	0X003FFFFF	0	241	303	365	427	489	551	613	675	
18	0	0	0	242	304	366	428	490	552	614	676	
19	0	0	0	243	305	367	429	491	553	615	677	
20	0X00184028	0XFFFFFFFF	0	244	306	368	430	492	554	616	678	
21	0X0018402C	0X00000080	0	245	307	369	431	493	555	617	679	

Figure 8.112: CSV file

2. 1st column represents an address, this column contains an Address of (Main/Node) variable.
3. 2nd column represents a Bitmask, this column contains a Bitmask of (Main/Node) variable.
4. 3rd column represents a Shifting, this column contains a Shifting of (Main/Node) variable.
5. Nodeid column represents a Nodeid, this column contains all variable Nodeid of (Main/Node) variables.

Appendix J. Setting up the Auto-Bootable MQTT-Based Client

To set up the auto-bootable MQTT-based client, perform the steps in the sections mentioned below.

Unzip the folder:

1. Open the terminals
2. Unzip the bundle.
3. Run the command: **unzip Mqtt_Lattice_AutomateStack_2_0.zip.**

Perform the steps below after unzip:

1. Run the command: cd Mqtt_Lattice_AutomateStack_2_0/ lib/paho.mqtt.c/.
2. Run the command to clean the old package: **sudo make clean**.
3. Run the command for compilation: **sudo make && sudo make install**.

Run the commands below if you get the Open SSL error:

1. sudo apt-get install libssl-dev
2. sudo make && sudo make install

To make the new server executable, run the following commands:

1. cd Mqtt_Lattice_AutomateStack_2_0/Scripts/
2. sudo make clean
3. sudo make

Run the below command for installing the mosquitto broker:

1. sudo apt update && sudo apt upgrade
2. sudo apt install -y mosquitto mosquitto-clients sudo systemctl enable mosquitto.service
3. sudo nano /etc/mosquitto/mosquitto.conf
4. Mosquitto.conf file will open after this copy the below two command in that file.
5. listener 1883
6. allow_anonymous true
7. For save and close that mosquitto.cnfg file.
8. press ctrl+x
9. type y and press Enter

Automate the application:

10. Run the command: **sudo crontab -e**
11. Type 1 and press **Enter** to select the nano editor. The crontab opens.
12. Copy the line below and paste it in the crontab at the end of the file. **@reboot /home/pi/Mqtt_Lattice_AutomateStack_2_0/Scripts/autoapp.sh**
13. Press ctrl+x, type y and press **Enter**.

Setting Up the IPV4 Address and Router on Raspberry Pi:

1. Right-click on  at the right side of the window, and then click on **Wireless and Wired Network Settings**.

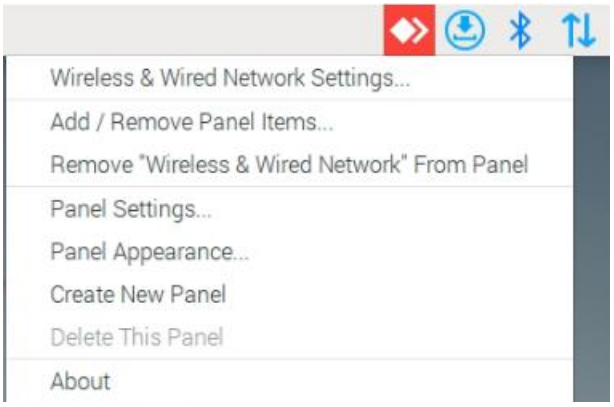


Figure 8.113. IPV4 Address Setting

2. The Network Preferences screen is displayed. Select the **eth0** from the drop-down menu.

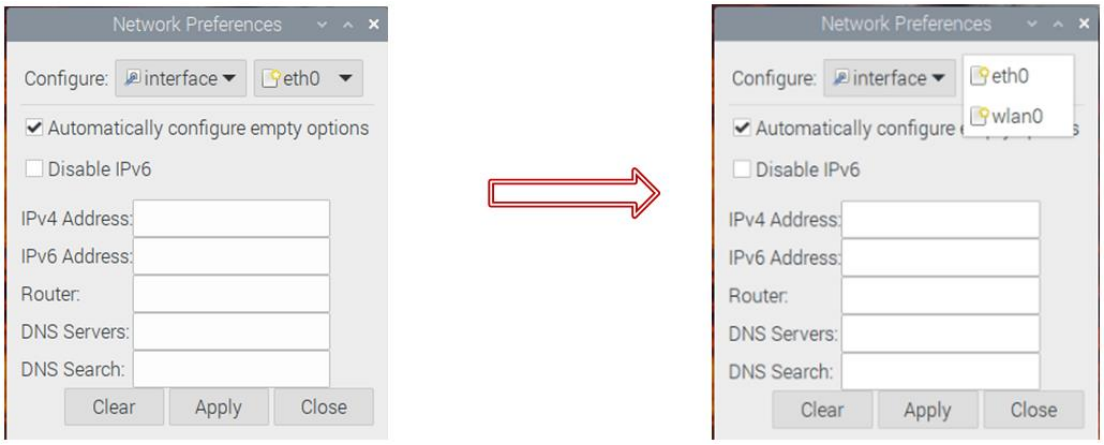


Figure 8.114. Network Preferences Settings

3. Untick the Automatically configure empty box.
4. Enter the IP address and router as mentioned in below figure and click **Apply**.

- **IPV4 Address – 10.0.1.112**
- **Router – 192.168.1.1**

Note: Router value same as the value of Default gateway in your laptop.

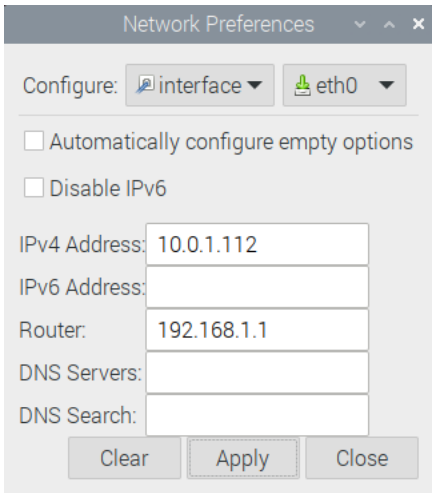


Figure 8.115. IP Configuration

5. Run this command to reboot the Raspberry Pi: **sudo reboot**.

Technical Support Assistance

Submit a technical support case through www.latticesemi.com/techsupport.

Revision History

Revision 1.0, June 2022

Section	Change Summary
	Initial release.

www.latticesemi.com