BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 438 – Wireless Communication Laboratory

Experiment 00

Introduction to LabVIEW and NI USRP 2901

> New to LabVIEW? Follow Steps 1–3 to install and run the software.

> Already installed LabVIEW? Proceed to the rest of the lab sheet.

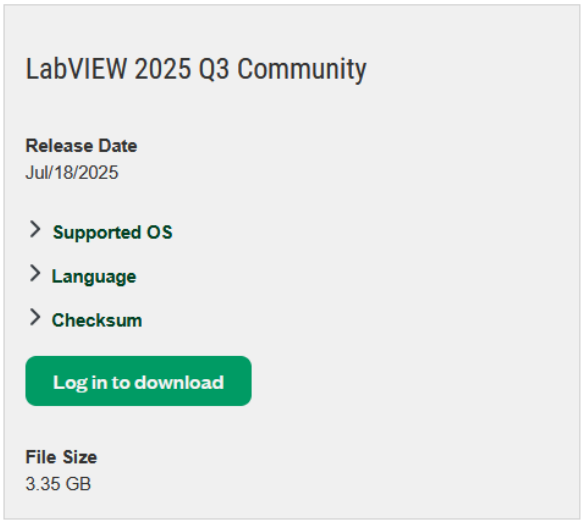
1. What is LabVIEW?

LabVIEW stands for **Laboratory Virtual Instrumentation Engineering Workbench**, a fully featured Integrated Development Environment (IDE) made by **National Instruments (NI)**. Its speciality is that it uses a graphical, flow-chart–like interface instead of traditional text-based code, which makes programs easier to understand for beginners. LabVIEW is a widely popular graphical programming tool for test, measurement, and control applications in industry and academia. Learners can get help from an active online community and resources such as the NI forums and LabVIEW Wiki.

2. LabVIEW Installation Guide

National Instruments provides a free-for-non-commercial-use version called LabVIEW Community Edition for both Windows (32-bit) and MacOS (64-bit) . This version provides all of the capabilities of the professional editions of LabVIEW. We will be using this for our laboratory experiments.

LabVIEW Community Edition is available for download on the **LabVIEW Community Edition** page. You need to create a free NI account to download. This account will give you a free 1 year license of LabVIEW community edition.

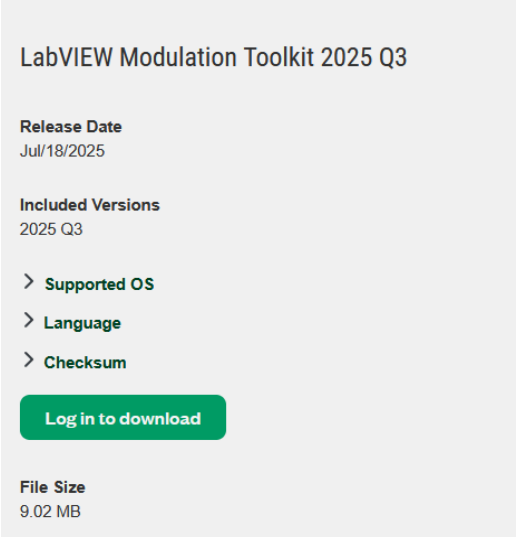


The installation process is straightforward. During the final step, you will be prompted to activate the license, which is completed automatically when you sign in using your NI account. You may follow this YouTube tutorial -

Downloading and Install LabVIEW Community Version

Our lab experiments require **Modulation Addon Toolkit** which does not come preloaded with the LabVIEW community edition. So after installing LabVIEW, go to this link -

LabVIEW Modulation Toolkit Download - NI



Download the Modulation Toolkit and install. Now, we are ready to do some experiments.

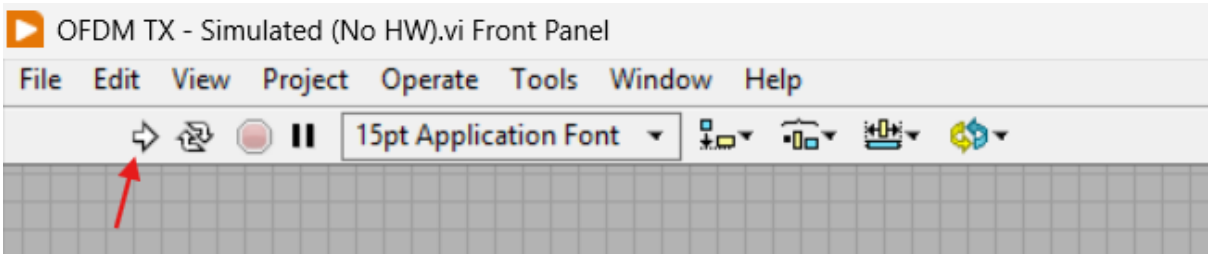
3. LabVIEW Quick Start: Open/Run a file

The following LabVIEW files, referred to as **Virtual Instruments (VIs)**, are designed for wireless communication. These files are simulation-based and do not require any hardware to run.

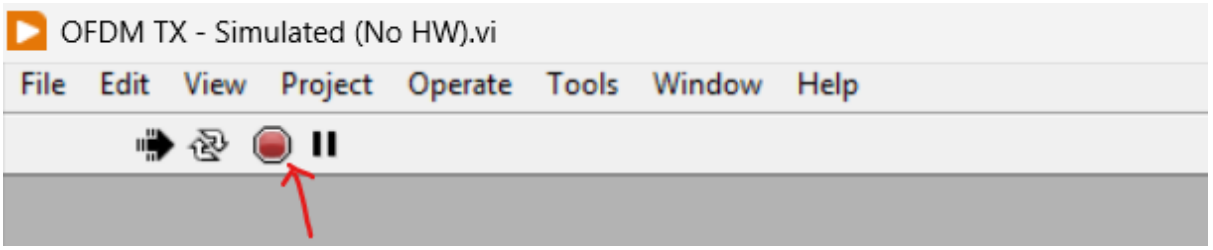
Link- LabVIEW Simulation VI Files

Download the VI files and open them with LabVIEW.

Click the Run button (white arrow symbol) in the toolbar (upper-left corner) to start simulation.



Click the Abort button (red circle) to stop the simulation.



Alternatively, you can find similar example VI files from the following installation directory. They come preloaded with the **LabVIEW Modulation Addon Toolkit**.

C:\Program Files\NI\LVAddons\Modulation\1\examples\Modulation\simulation examples\Interactive

Open them with LabVIEW, start simulation and explore what those files do.

4. LabVIEW Workspace Description

LabVIEW VIs include two main parts-

1. Front Panel
2. Block Diagram

The front panel is the user interface of the VI. It contains controls (input terminals) and indicators (output terminals). You can think of controls as the keyboard or mouse of a desktop setup and indicators as the monitor. Controls are typically numeric input, knob, dials, push buttons, sliders, and strings. Indicators are typically numeric output, graphs, charts, LEDs and status strings. The Controls palette contains the controls and indicators which you can use to create the front panel.

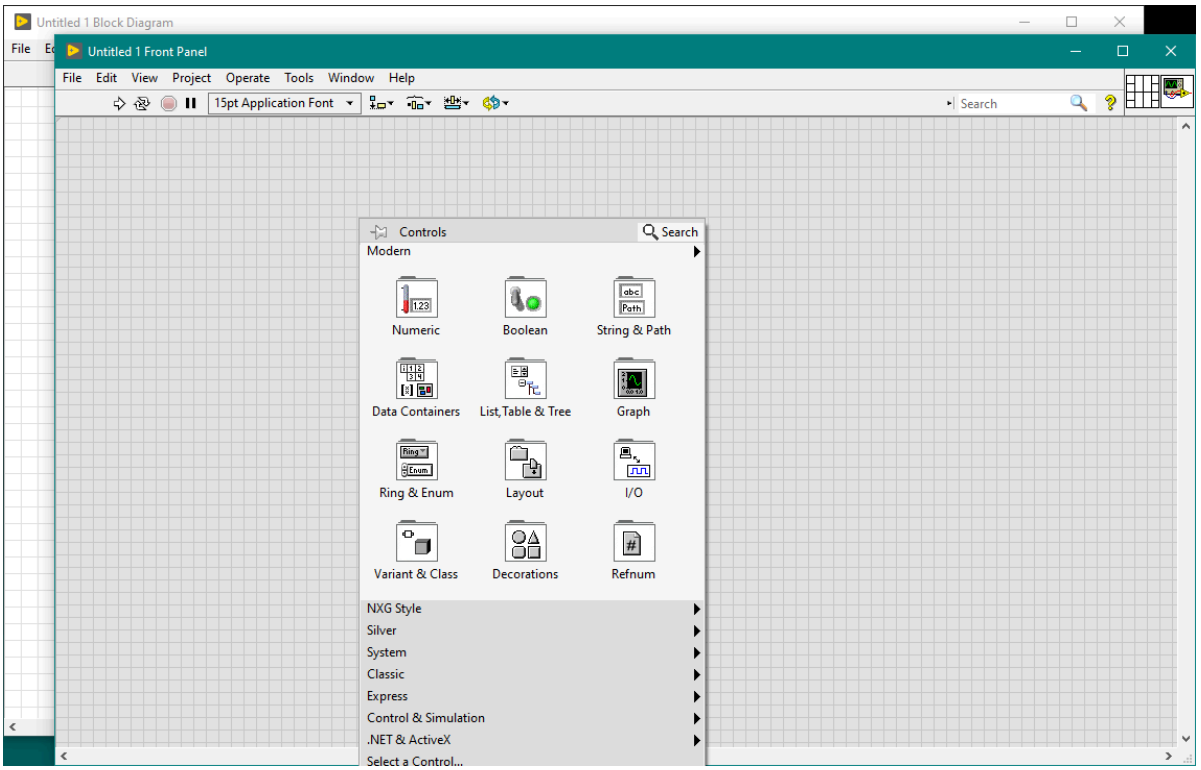
The block diagram contains actual code (graphical; not text) of the VI. It resembles a flowchart, showing how data flows from one element to another. You can think of a block diagram as the CPU of a desktop setup which is often not visible from the front view but does all the actual processing. **Every control/indicator in the front panel corresponds to an element in the block diagram.** Block diagram objects include terminals, subVIs, functions, constants, structures, and wires, which transfer data among other block diagram objects.

Press Ctrl+T to view both the front panel and block diagram side by side.

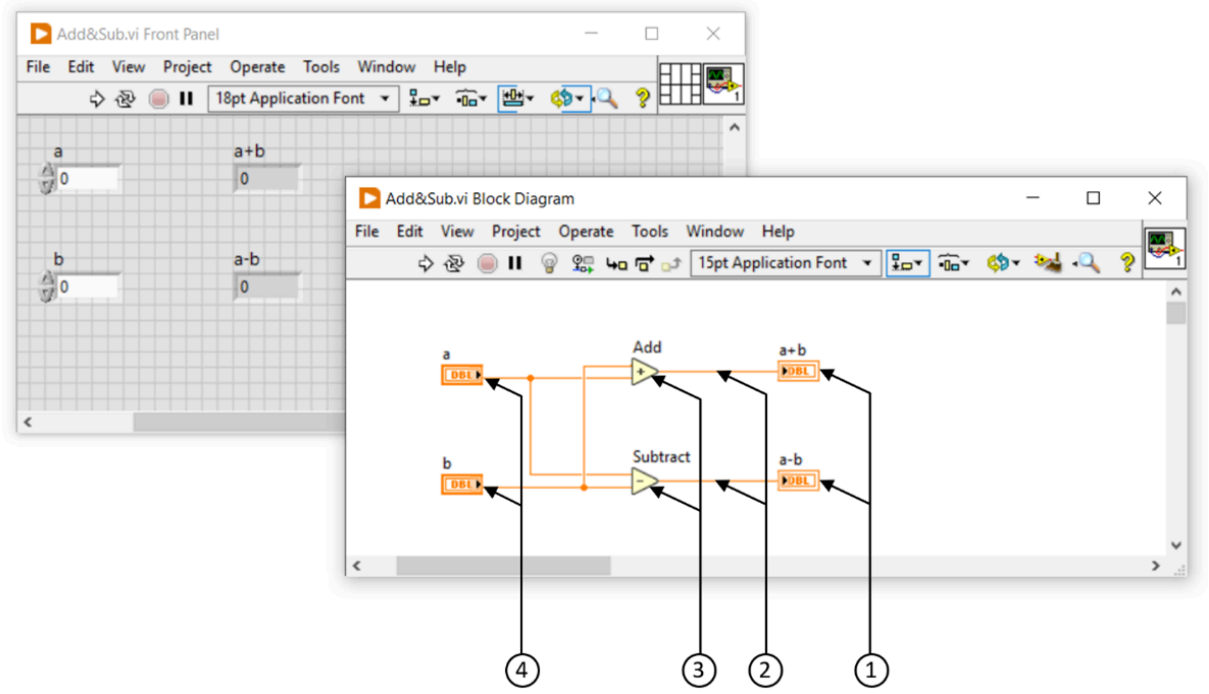
As EEE students, our job is to design the wireless communication system (Bitstream to Symbol Mapping, Modulation, Pulse Shaping Filter, Matched Filter, Demodulation, Symbol to

Bits etc.) in the block diagram and then view the results (transmitted and received signals, Constellation Diagram, BER, EbN0 etc.) in the front panel.

Front Panel



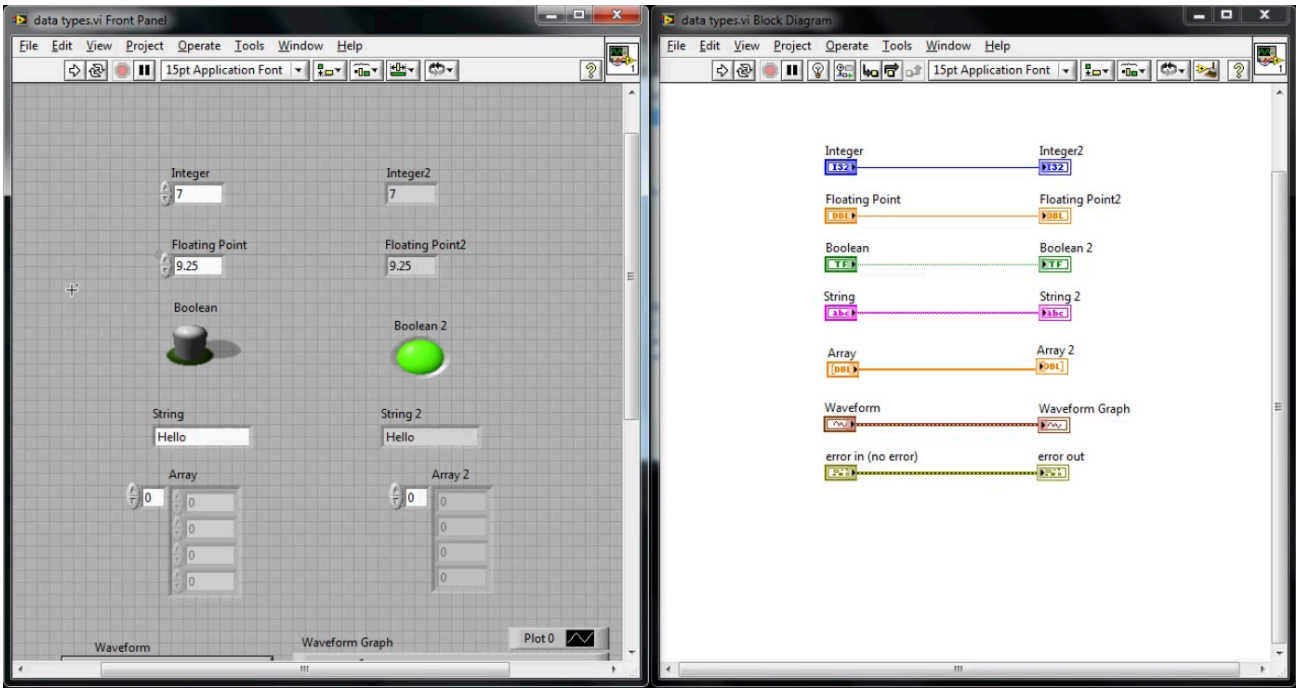
Block Diagram



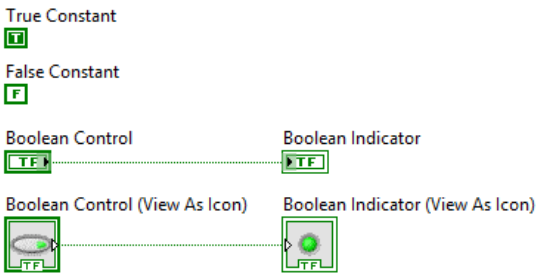
(1) Indicator Terminals | (2) Wires | (3) Nodes | (4) Control Terminals

4a. Data Types

LabVIEW has these data type-



1. **Boolean** (true/false)

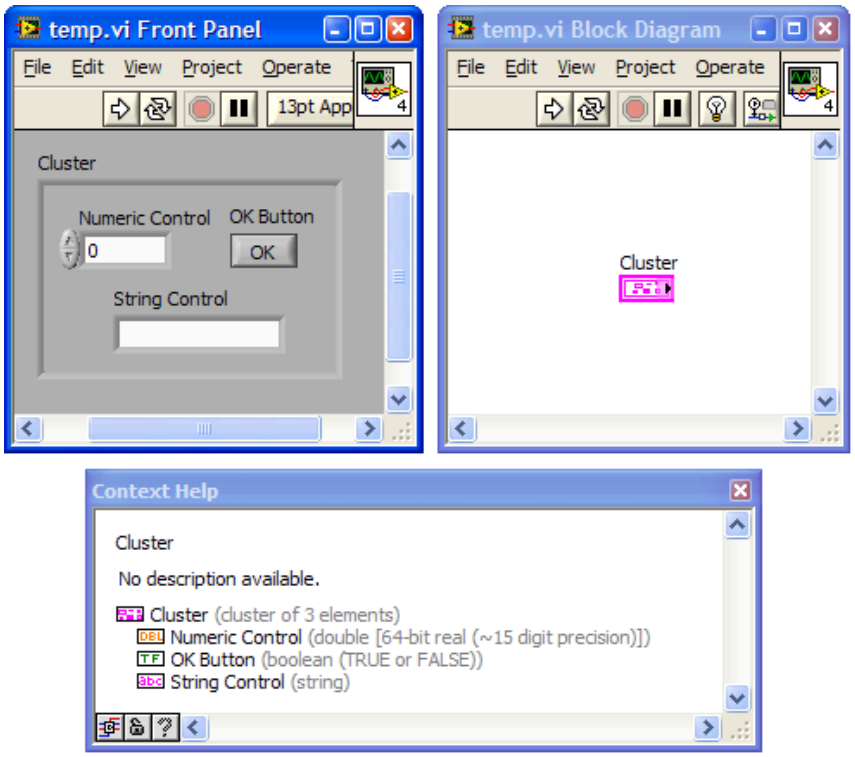


2. **Numeric** (integer/float/real/complex)

3. **String** (character/text)

4. **Array** (1D, 2D or N-Dimensional array of Boolean or Numeric)

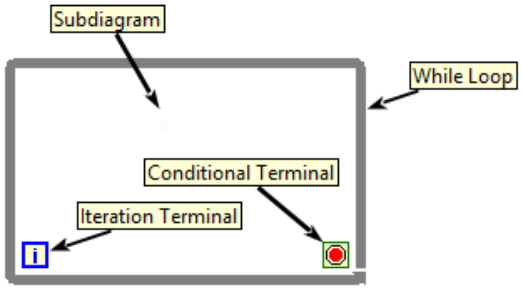
5. **Cluster** (a group of mixed data types bundled together)



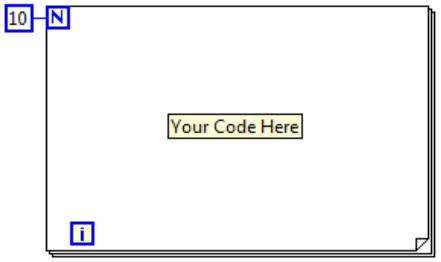
4b. Structures

LabVIEW has these structures-

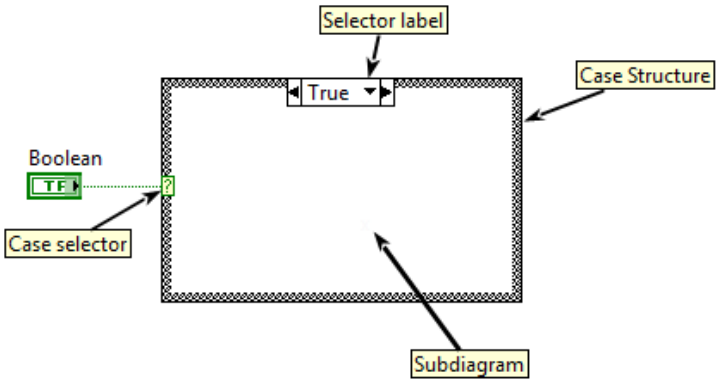
1. **While loop** (runs until stop button is pressed, executes at least once, iteration count starts from 0)



2. **For loop** (runs for a specific count, iteration count starts from 0)



3. **Case** (similar to switch-case structure of c programming)



5. LabVIEW Keyboard Shortcuts

(Most Used Shortcuts)

Ctrl + S = Save VI / changes in VI

Ctrl + C = Copy Element

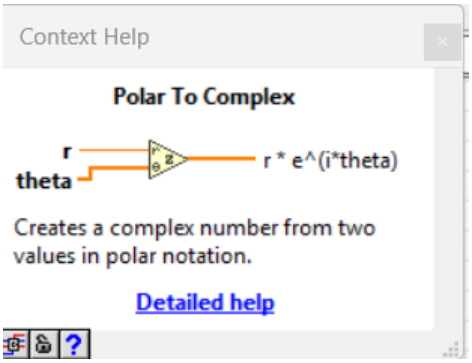
Ctrl + V = Paste Element

Ctrl + X = Cut Element

Ctrl + Z = Undo Changes

Ctrl + E = Switch between front panel and block diagram

Ctrl + H = Open context help window (select a block/element and open context help to see what it does, its input and output terminal data types)



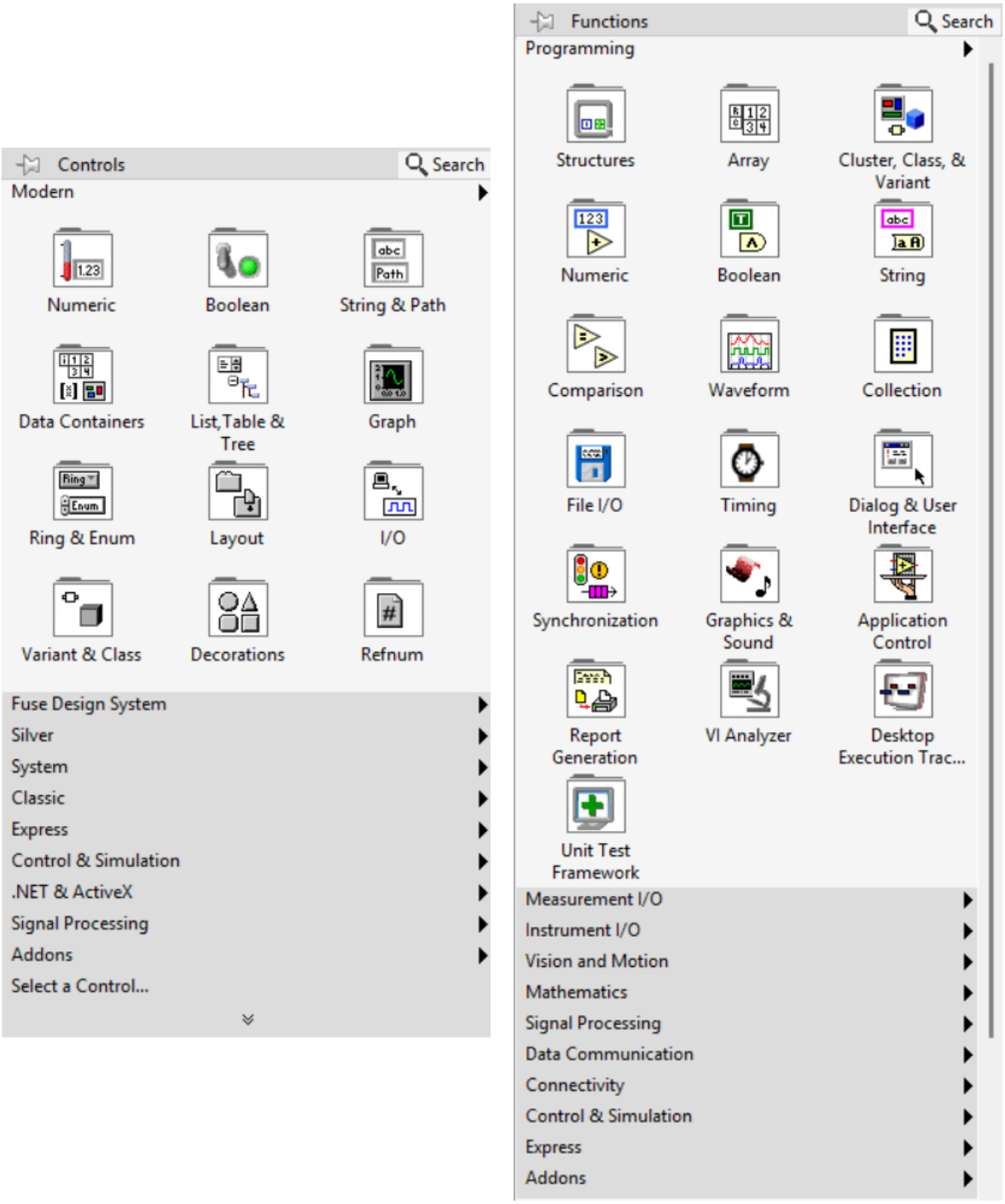
Ctrl + Mouse Wheel Rotate or Ctrl + (+/-) = Block Diagram zoom in/out

Ctrl + Shift + Mouse Left-click hold on + Mouse move = Drag the Front Panel/Block Diagram

Right Click = Open Control Palette in Front Panel/ Open Functions Palette in Block Diagram

We may need Numeric, Boolean, String & Path, Graph, Decorations from functions in the Front Panel.

In the block diagram, we will primarily use Structures, Array, Cluster-Class-Varaint, Numeric, String, Boolean, Waveform, also some blocks from Mathematics, Signal Processing and Modulation Addon.



Controls Palette and Functions Palette

(Less used shortcuts but useful)

Ctrl + P = Print Front Panel/ Block Diagram view as PDF

Ctrl + M = Change to Run Mode (Disables editing in front panel, useful during demonstration)

Ctrl + U = Cleans Up Block Diagram (Organizes the block diagram by reducing wire clutter and improving layout clarity)

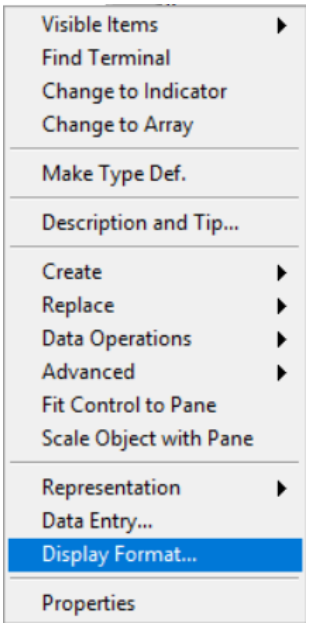
CTrl + T = View Front Panel and Block Diagram side by side

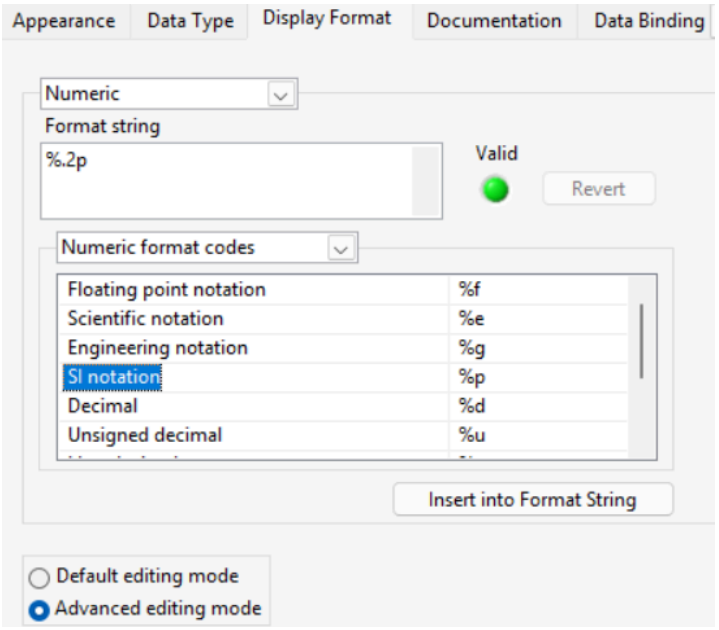
For more keyboard shortcuts, visit https://labviewwiki.org/wiki/Keyboard_shortcut

6. Some Useful Tips

6a. Change Display Format in Numerical Control/Indicator

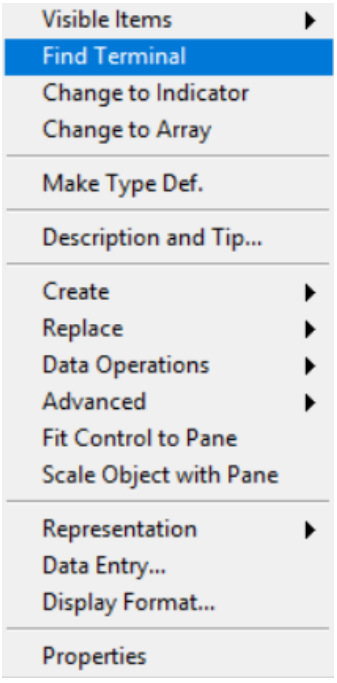
Select Numerical Control/ Indicator > Right Click > Select Display format > Advanced Editing Mode > Type %.2d (decimal)/ %.2f (float) / %.2p (scientific) as you wish.





6b. Find Terminals/Control/Indicators

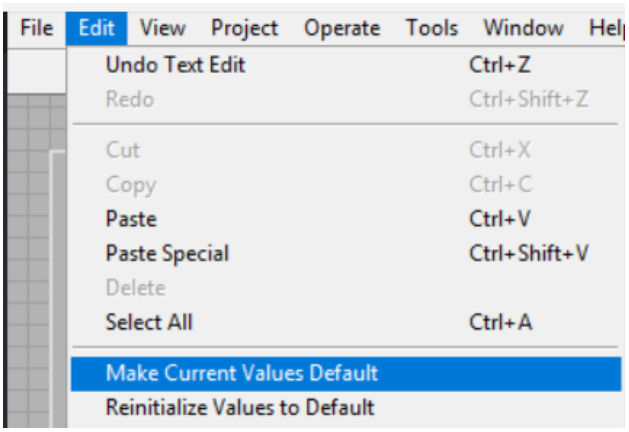
You can find corresponding terminals in the block diagram for any control/indicators in the front panel and vice versa. Simply select any terminal/control/block > Right click > Find Terminals/Controls/Indicators.



6c. Make Current Values Default

You can save any input values for control blocks in the front panel. It will save a bunch of time when you close and open the file again.

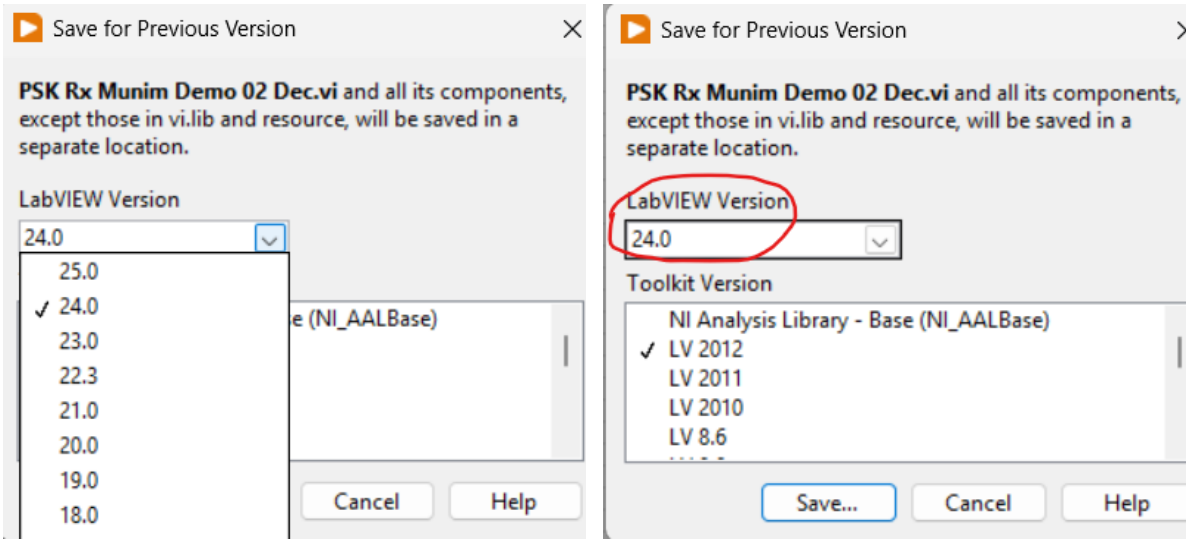
Toolbar > Edit Tab > Make Current Values Default



6d. Save for Previous Edition

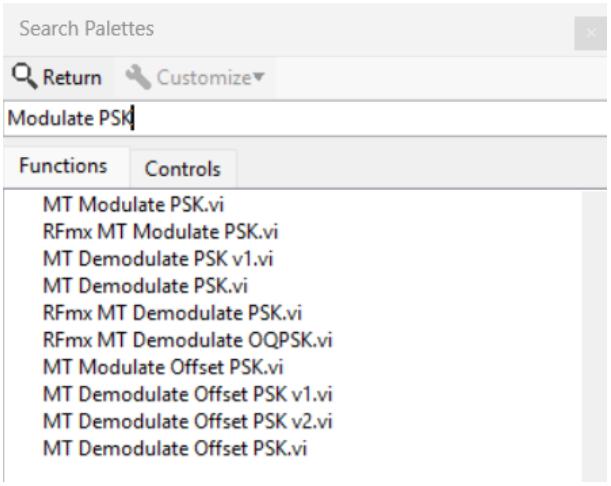
LabVIEW is **backward** compatible but not forward compatible. Older VIs can generally be opened in newer LabVIEW versions, but newer VIs cannot be opened directly in older versions unless you use "Save for Previous Version. Since we will be using LabVIEW 2025, our VI files can not be directly opened in the licensed version of LabVIEW 2024 which is installed in Wireless Lab PC. You need to use "Save for Previous edition" in order to do so.

Toolbar > File Tab > Save For Previous Edition > Select Appropriate Labview Version > Save



6e. Use "Search" Option to Find a Block

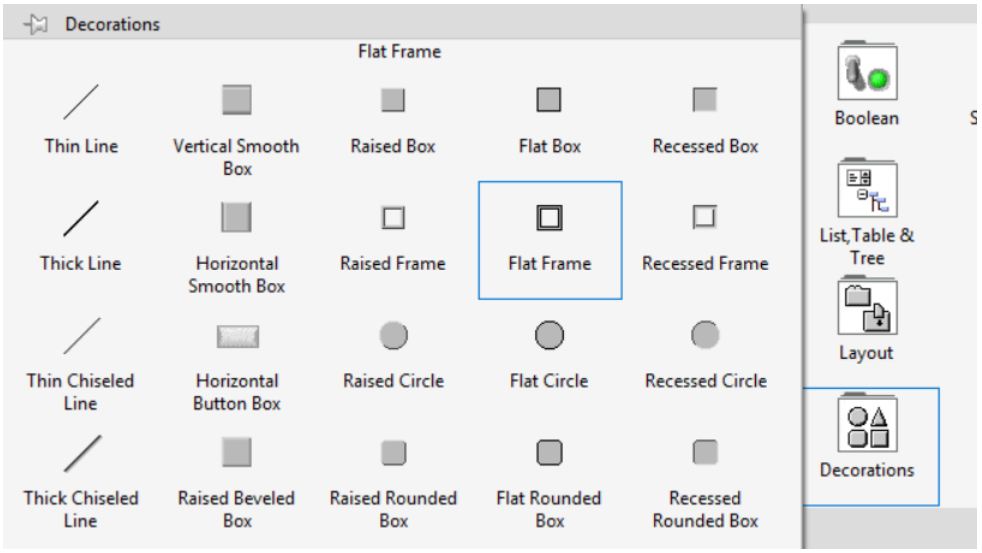
You can use the search dialog box in Controls Palette or Functions Palette in order to find any block, which is quicker.



6f. Decorations

You can modify the front panel to improve readability, clarity, and overall visual appearance.

Controls Palette > Decorations



Students are encouraged to watch the following YouTube playlist provided by NI for additional understanding of LabVIEW fundamentals.

Playlist Link- LabVIEW Fundamentals

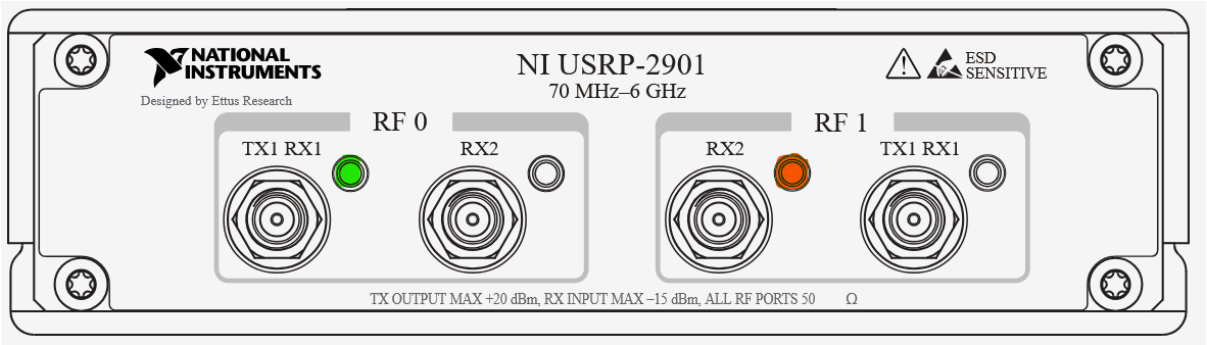
7. What is NI USRP 2901 Device?

NI USRP-2901 (**Universal Software Radio Peripheral)** is a SDR (**Software Defined Radio**) device with a tunable RF transceiver covering roughly 70 MHz to 6 GHz, supporting up to about 56 MHz of instantaneous bandwidth for real-time wireless experiments. It provides two RF channels with full-duplex, MIMO-capable operation over USB 3.0, making it well suited for teaching and prototyping modern communication systems in the lab.

We will use NI LabVIEW software to control NI USRP 2901 devices in the lab.

8. USRP 2901 Front Panel and Back Panel Description

This device has two RF channels- RF0 channel and RF1 channel. Each channel has two connector ports- TX1/RX1 and RX2. TX1/RX1 port can act as both transmitter and receiver, but not simultaneously. RX2 can only act as a receiver. Each channel can handle signals independently, so you can use both at once for different tasks. In our lab, we have connected a VERT-2450 antenna to these RF connectors.



USRP 2901 Model Front Panel

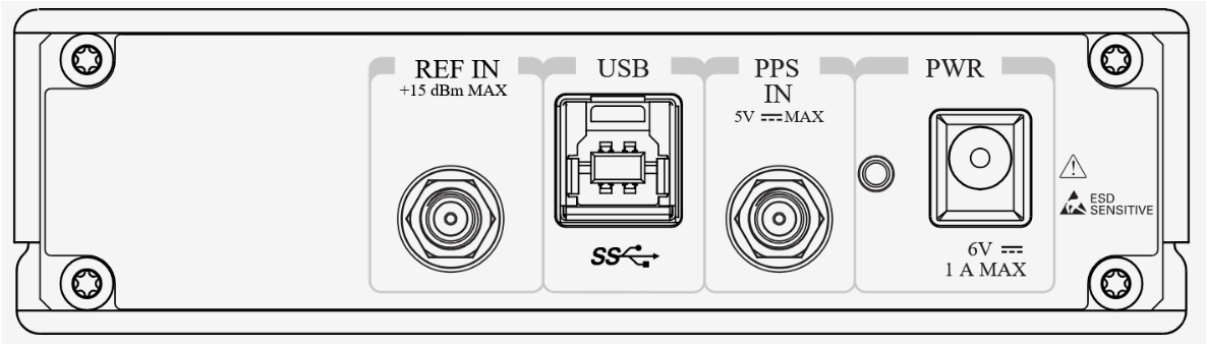
Each connector port has a LED which indicates its status.

TX1/RX1 **Green** = The connector port is transmitting data

TX1/RX1 **Red** = The connector port is receiving data.

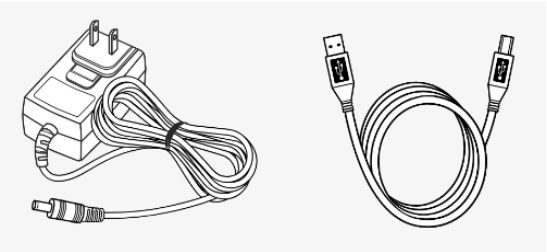
RX1 **Red** = The connector port is receiving data.

OFF = This connector port is not active.



USRP 2901 Model Back Panel

The USB 3.0 port is used to connect the device to the PC. Normally, USB power from the PC is enough to do basic transceiver action and signal processing in the device. But it is recommended to power the device with a 6 V, 1 A external DC power connector if you use both channels simultaneously.



For further info, you can visit-

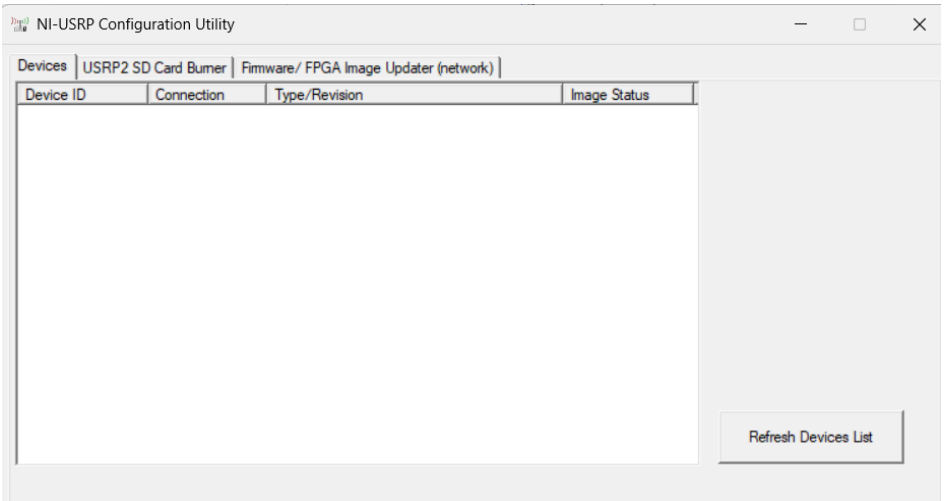
NI USRP 2901 Specifications-

https://www.ni.com/docs/en-US/bundle/usrp-2901-specs/

NI USRP 2901 Getting Started Guide -
https://www.ni.com/docs/en-US/bundle/usrp-290x-getting-started/

9. Connect USRP 2901 with PC

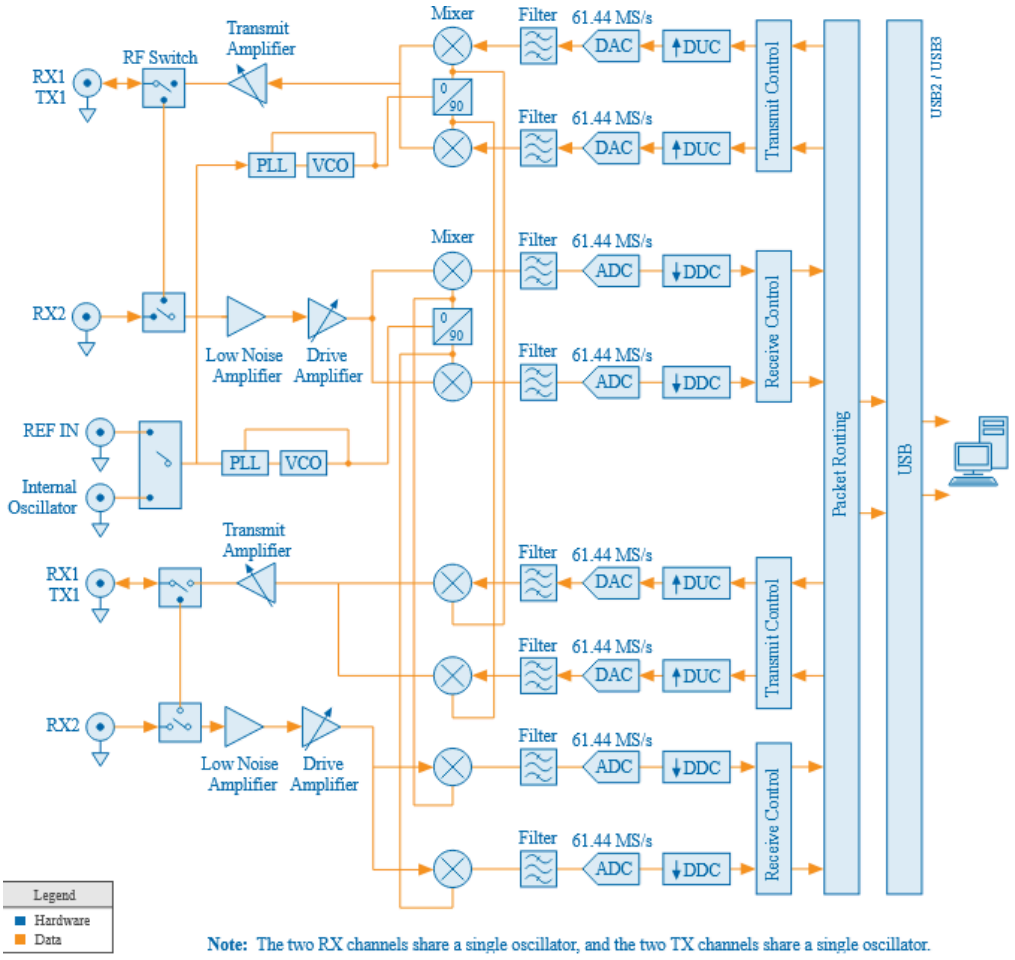
Connect the USRP 2901 module with the PC by using a USB 3.0 cable. You need to check whether the PC is able to detect the USRP properly. To do so, open **NI-USRP Configuration Utility** on the PC. If the device is connected properly, you should be able to see it in the Devices list. Otherwise, check the usb connection again and click “Refresh Device List”.



10. How does USRP 2901 work?

Signals transmitted by the USRP-2901 are upsampled, reconstructed, filtered, upconverted, and amplified before being transmitted.

Signals received by the USRP-2901 are amplified, downconverted, filtered, digitized, and decimated before being passed to the host computer.



The USRP-2901 has two local oscillators, one for the transmit (Tx) channels and one for the receive (Rx) channels. While different frequencies can be used for the Tx and Rx channels, the two Tx channels are locked to the same frequency, and the two Rx channels are locked to the same frequency.

Transmit Path:

- The host computer synthesizes baseband I/Q signals and transmits the signals to the device over a USB 3.0 or USB 2.0 connection.
- The digital upconverter (DUC) mixes, filters, and interpolates the signal to 61.44 MS/s.
- The digital-to-analog converter (DAC) converts the signal to analog.
- The bandpass filter reduces noise and high frequency components in the signal.
- The mixer upconverts the signals to a user-specified RF frequency.
- The PLL controls the VCO so that the device clocks and LO can be frequency-locked to a reference signal.
- The transmit amplifier amplifies the signal and transmits the signal through the antenna.

Receive Path:

- The low-noise amplifier and drive amplifier amplify the incoming signal.
- The phase-locked loop (PLL) controls the voltage-controlled oscillator (VCO) so that the device clocks and local oscillator (LO) can be frequency-locked to a reference signal.
- The mixer downconverts the signals to the baseband in-phase (I) and quadrature-phase (Q) components.
- The bandpass filter reduces noise and high frequency components in the signal.
- The analog-to-digital converter (ADC) digitizes the I and Q data.
- The digital downconverter (DDC) mixes, filters, and decimates the signal to a user-specified rate.
- The downconverted samples are passed to the host computer over a USB 3.0 or USB 2.0 connection.

11. Some Precautions

1. USRP devices are very costly, so handle with great caution to prevent any mechanical damage.
2. USRP devices are ESD (Electrostatic Discharge) sensitive, meaning static electricity can harm internal circuits. So-
    a. Always ground yourself before handling the USRP or its RF cables.
    b. Avoid touching the antenna connectors or any exposed metal parts of the device directly.
    c. Do not connect or disconnect RF cables while the device is powered on.
3. Keep the device away from liquid, dust or direct sunlight.
4. Do not attempt to open, modify, or repair the USRP; if the device appears damaged or malfunctioning, report it to the lab attendant immediately.

12. Acknowledgement

The labsheet is prepared by Kazi Ahmed Akbar Munim and S. M. Azmain Awsaf under the supervision of Dr. Lutfa Akter and Dr. Md. Forkan Uddin at the Department of EEE, BUET, on 28/12/2025.

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