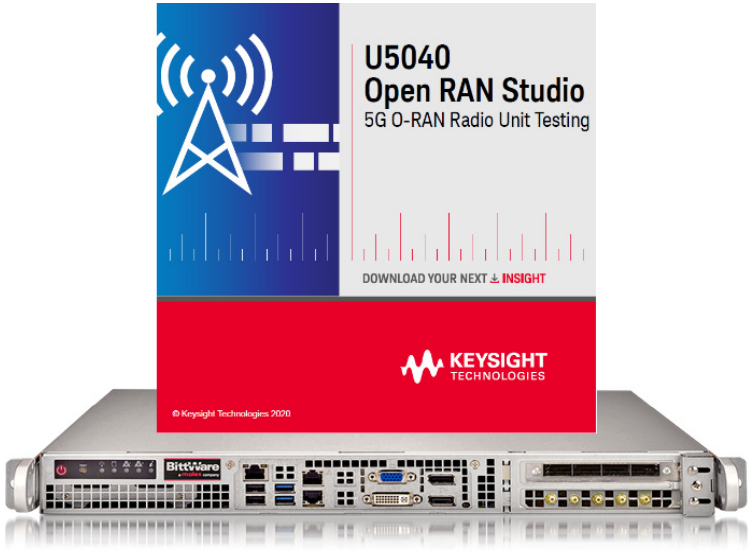
Measuring BER / BLER using ORAN Studio Solution (v1.2)

Reference Guide



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Overview

For seamless transmission of data, it is imperative to measure (and if possible, eradicate) errors, if any. With version 1.2, the Open RAN Studio software has been enhanced to provide a functionality to measure the Bit Error Ratio and the Block Error Ratio by measuring the ratio of incorrectly received bits / blocks to the total bits / blocks received from the O-RU.

Defining BER and BLER

The Bit Error Ratio (BER) is defined as the ratio of the bits wrongly received to all data bits sent. Current measurement type compares the transmitted bits with PN9 sequence and calculates error rate (that is, how many bits did not match PN9).

A Block Error Ratio (BLER) is defined as the ratio of the number of erroneous blocks received to the total number of blocks sent. Current measurement type compares the transmitted demodulated data sequence and may correct some error bits. For example, if we transmit data sequence “00000000”, but the demodulated bits are “01000000” due to noise (1-bit error / total 8 bits). After decoding this bit sequence, the original bit sequence “00000000” can be obtained, as the decoder correct error bits.

NOTE **You must install the license option U5040MULA to use the BER / BLER measurement application in the U5040A Open RAN Studio software.**

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Measuring BER / BLER using ORAN Studio Solution

Reference Guide

1. Measuring BER/BLER in Keysight Open RAN Studio Solution

Before we proceed to understand how to measure the BER / BLER, let us understand the prerequisites for the O-RAN Studio software to identify the data correctly to perform proper measurements.

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Section 1.1: Prerequisites to BER/BLER measurements

Following is the list of Hardware and Software components along with the license options.

1.1.1: Hardware components

Table 1 HW components for BER/BLER measurements

HW component	Product description
O-DU	▪ BittWare TeraBox 1000S FPGA server with the FPGA Ethernet Acquisition Module
O-RU	▪ Any Device Under Test
(Optional) Triggering Hardware	▪ N5182B MXG X-Series RF Vector Signal Generator OR ▪ M9019A PXIe 18-Slot Chassis ▪ M9037A PXIe Embedded Controller ▪ M9410A VXT PXI Vector Transceiver ▪ M9300A PXIe Reference Module
Automation	▪ BittWare Terabox server or a PC with Win 10 operating system
Cables*	
Optics	▪ QSFP28 (Qty. 2) ▪ Fiber Optic Single Mode (Qty. 1)
RF Cabling	▪ N Type to SMA Female adapters (Qty. 2) ▪ SMA Male to SMA Male cable (Qty. 2)
Comms	▪ USB to USB cable (Qty. 1)
Reference clock	▪ SMB Female (plug) to MMPX Male cable (Qty. 1) ▪ SMB Female (plug) to SMB Female (plug) cable (Qty. 1)
Networking	▪ Ethernet Cat 6 cable (Qty. 3)
Triggering	▪ SMB Female (plug) to MMPX Male cable (Qty. 1)

* Connection of the HW devices is shown further using the Cables listed in the table.

1.1.2: Software components

Table 2 SW components for BER/BLER measurements

SW component	Product description
Open RAN Studio	▪ U5040A Open RAN Studio Software v1.2.10720.0 or higher
	▪ License options: U5040BSCA, U5040IQEA and U5040MULA
Signal Studio	▪ Keysight PathWave Signal Studio Pro 5G NR v6.1.2.3 or higher
	▪ License options: N7631ORNC and N7631EMBC (reqd. if using VXT / MXG)
VSA	▪ Keysight PathWave 89601C - 89600 Vector Signal Analysis 2020 or higher
	▪ License option: 89601BHNC
Automation	▪ (Optional) Keysight PathWave Test Automation
	▪ License option: KS8400A
Triggering	▪ (Optional) Keysight M938xA Vector Signal Generator Drivers v2.1.150.4 ▪ License option: Not required
	▪ (Optional) Keysight Launch Modular TRX SW revision M.25.63 ▪ License options: N9060EM3E, Y9085EM0E, V9060EM0E and V9065EM1E

After the HW and SW components have been installed, let us understand how to generate the following files, which are required as inputs for the calculation of BER / BLER. Note that you may perform the steps to generate each of these files on a Win 10 PC. Thereafter, you may use those files as inputs to a system that has the BittWare server along with a triggering mechanism and automation enabled via TAP or your own automation system.

- Using the N7631C Signal Studio software
  - SCP file
  - Waveform file
- Using the U5040A Open RAN Studio software
  - ORSTX file
  - PCAP UL file
  - BER XML / BLER XML files

NOTE While the configuration of the generated SCP file is the same for BER and BLER measurements, the 'Channel Coding' setting in the Signal Studio software determines whether the SCP file is configured for measuring BER or BLER.

Section 1.2: Generating SCP & Waveform files with Signal Studio

The N7631C Signal Studio Pro for 5G NR interface allows for test waveforms to be downloaded into and played from Keysight instrumentation. This software runs in the BittWare server and is used to create the test waveforms for Open RAN Studio and for the signal source hardware of the M9410A.

1.2.1: Generating SCP files

1 For the Open RAN Studio software to gather data for BER / BLER measurements, you must configure the Carrier with the characteristics, which are shown in Figure 1.

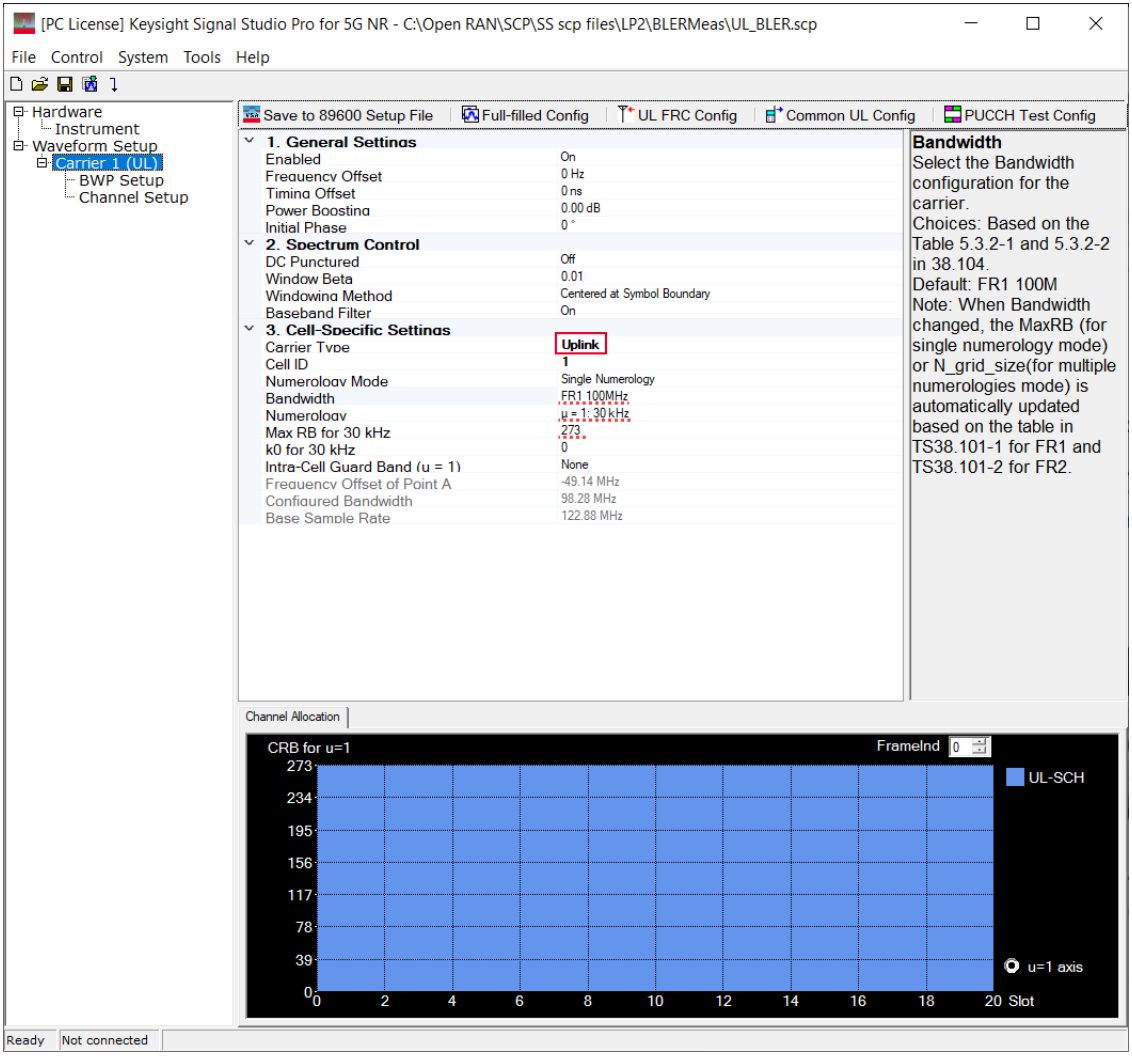

Figure 1 SCP file settings in Signal Studio

Carrier settings common for BER / BLER measurement:

- Carrier Type: Uplink (other carrier types are currently not supported for BER / BLER measurements)
- Data taken from SCP file for measurements
  - Bandwidth
  - Numerology
  - Max RB
- Channel Setup: UL-SCH
  - Payload Data: PN9

2 Configure the 'Channel Coding' for BER / BLER measurements as shown in Figure 2 and Figure 3.

- BLER – Channel Coding set to 'On'

Figure 2 Channel Setup settings for BLER

- BER – Channel Coding set to 'Off'

Figure 3 Channel Setup settings for BER

3 Click **File** > **Save As...** to generate an SCP file (**.scp*) each for BER and BLER, with their respective characteristics described above.

Note that for the purpose and ease of illustration, the SCP files generated in the Signal Studio software for BER and BLER have been saved in two separate folders named 'BER' and 'BLER' respectively, which were manually created, in the local disk (C:) of the PC. The entire folder path is required to define the file names during the BER/BLER measurements using the manual process, as is explained further.

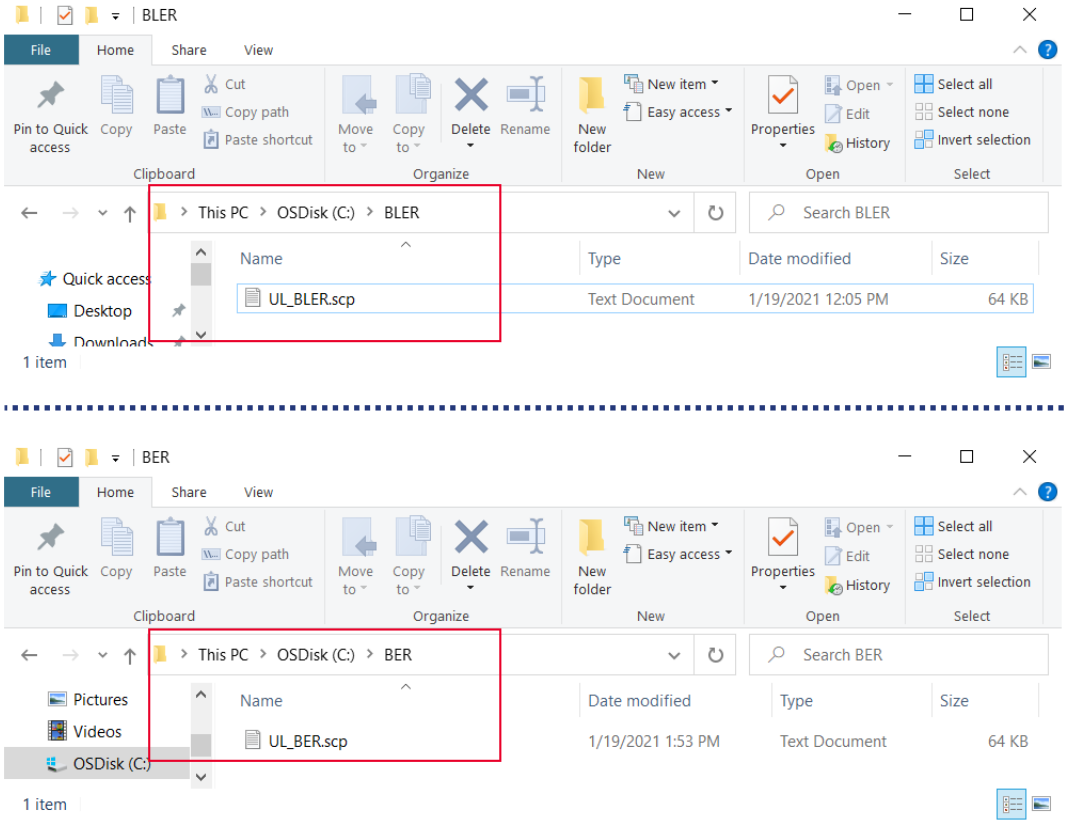

Figure 4 Manually created folders to save files for BER/BLER measurements

1.2.2: Generating Waveform Files

1 Click **File** > **Export Waveform Data** to generate a Waveform file (*.*wfm*) each for BER and BLER, with their respective characteristics described in the previous section.

2 Save the waveform files for BER and BLER in their respective folders, where the corresponding SCP files are located.

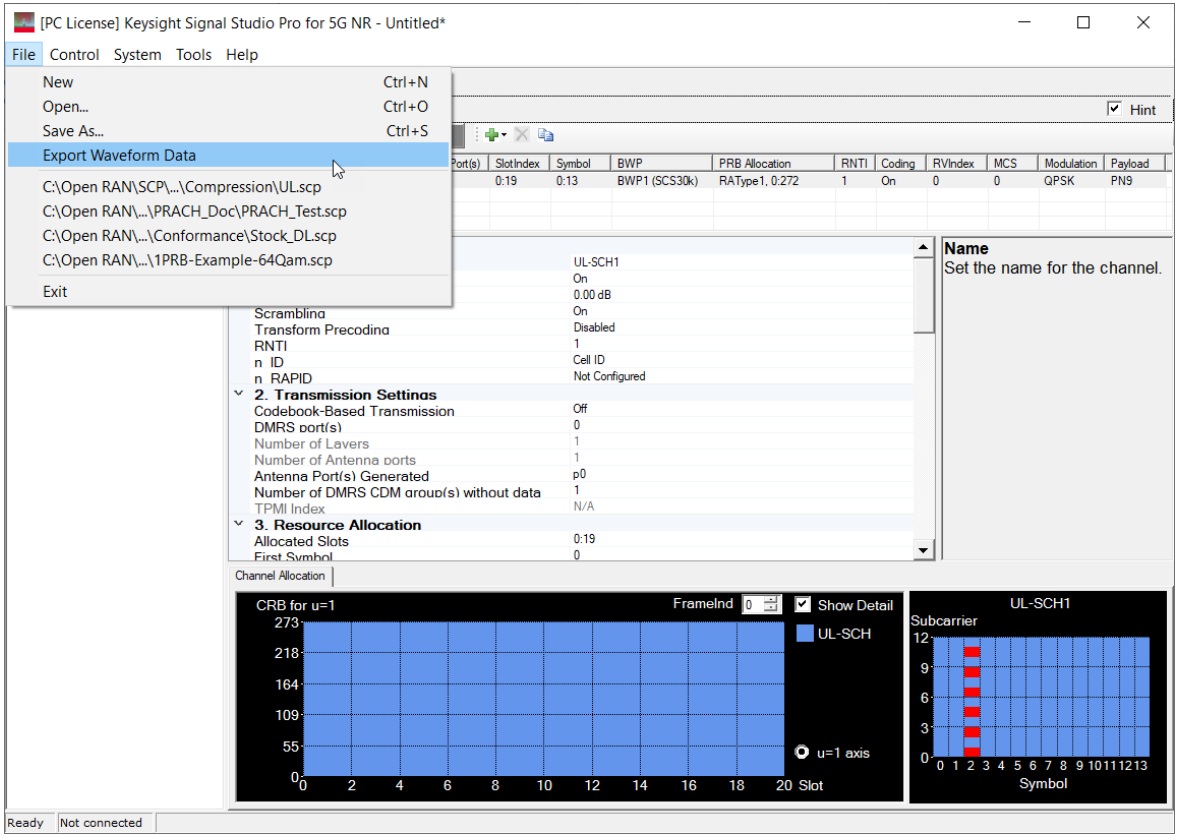

Figure 5 Waveform file generation in Signal Studio

NOTE Waveform files (**.wfm*) are not required when measuring BER / BLER using the manual process, which has been explained further.

Section 1.3: Generating files with Open RAN Studio

The following example displays the steps to generate the ORSTX and PCAP files, followed by generating the XML file using the U5040A Open RAN Studio software. These files are required to measure BLER. The flow to generate files for BER measurement is the same with some differences, which are explained along.

1 Load the SCP file into the Open RAN Studio software.

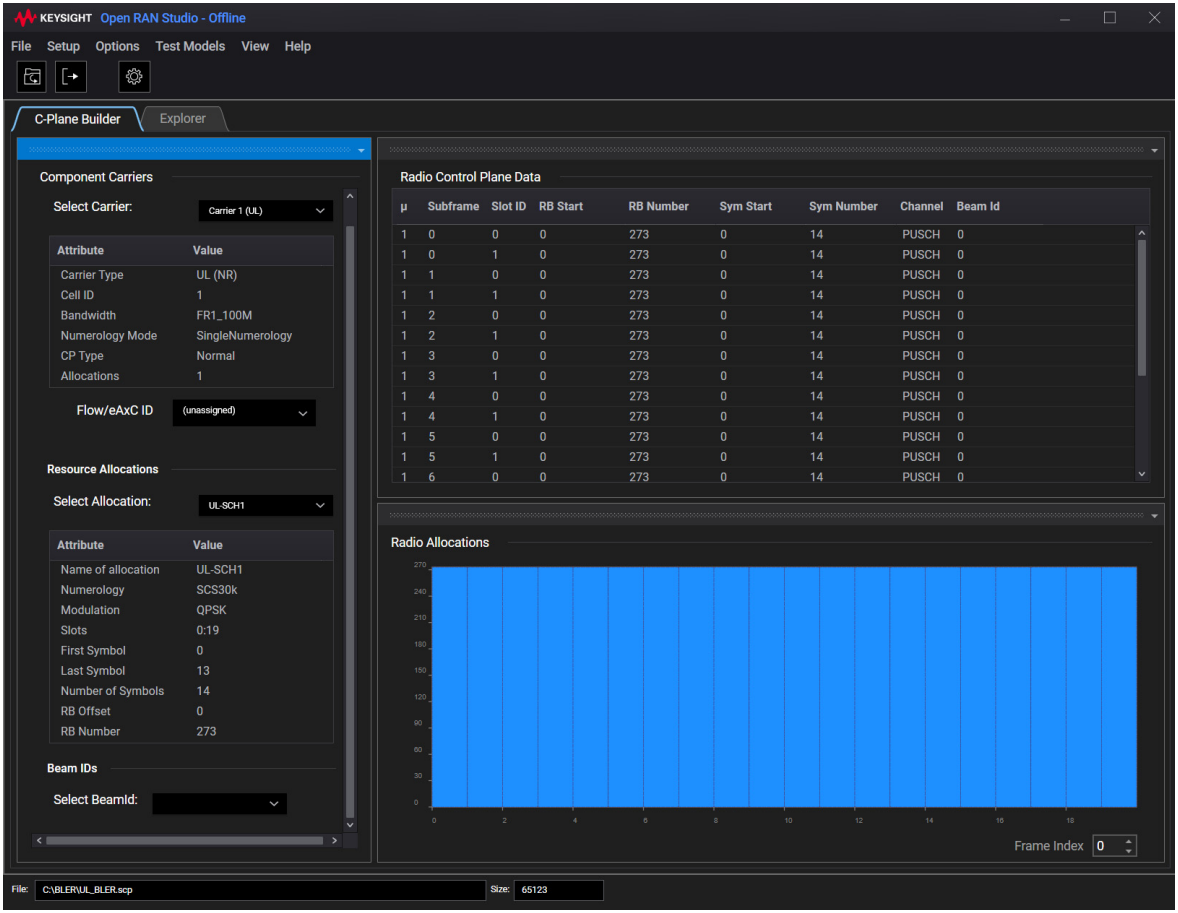

Figure 6 SCP file loaded in O-RAN Studio

2 Assign a **Flow/eAxC ID** to the selected carrier.

3 Launch the **C/U-Plane Builder Configuration Tool** window.

4 In the **Options** tab, select the **Create Uplink U-Plane** check box in the **U-Plane Package** area.

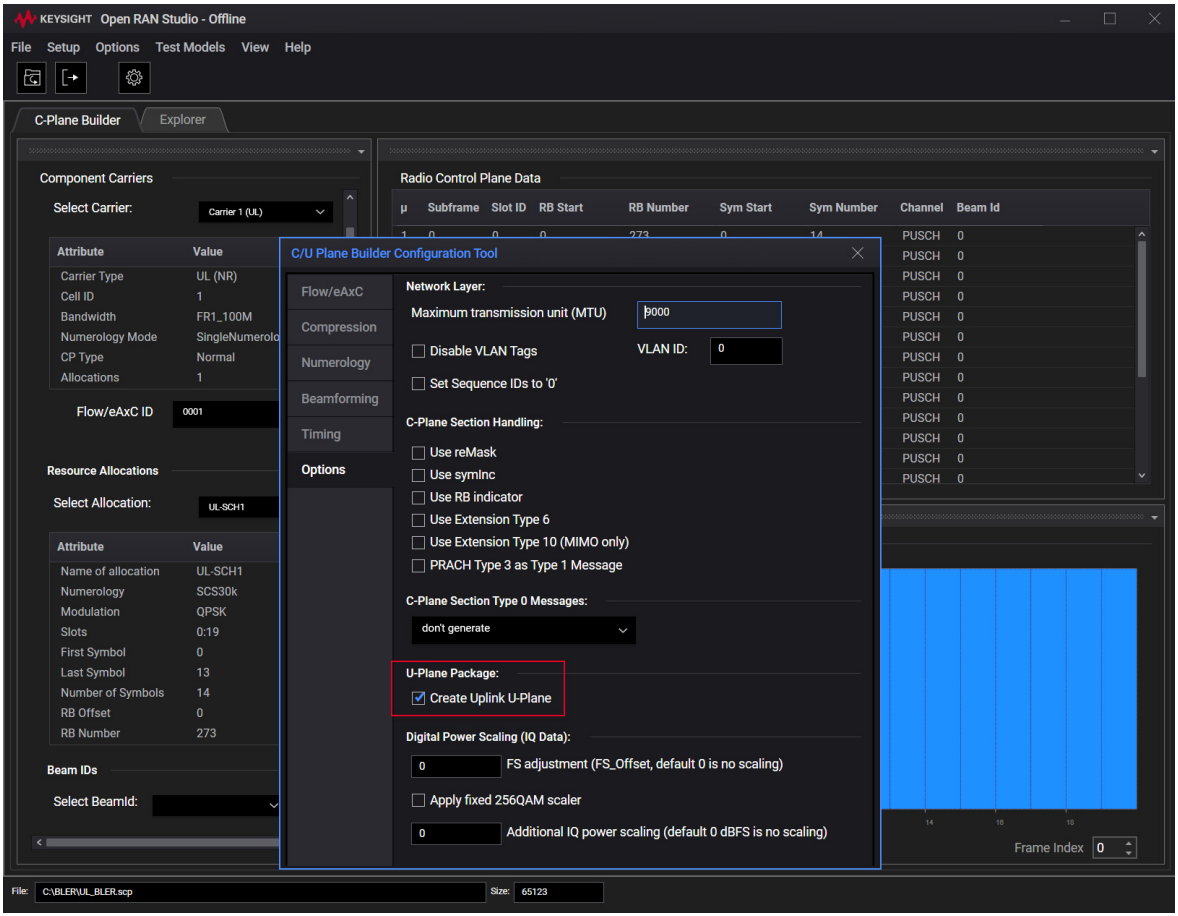

Figure 7 Modifying configuration of the loaded file

5 Close the **C/U-Plane Builder Configuration Tool** window.

6 From the main menu, click **File** > **Export** > **Generate Stimulus file** to generate the corresponding PCAP file, with the '_UL' suffix (which shall contain the U-Plane messages in the Uplink data). Note that the ORSTX file is also generated in this step.

7 From the main menu, click **File** > **Export** > **Generate BLER XML File**.

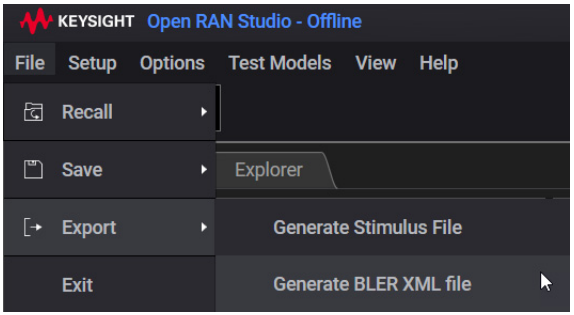

Figure 8 Generating XML file for BER/BLER measurement

8 Click **Ok** on the Progress Dialog, after the Activity Progress reaches '100%', which indicates that the XML file required for BLER measurement has been generated.

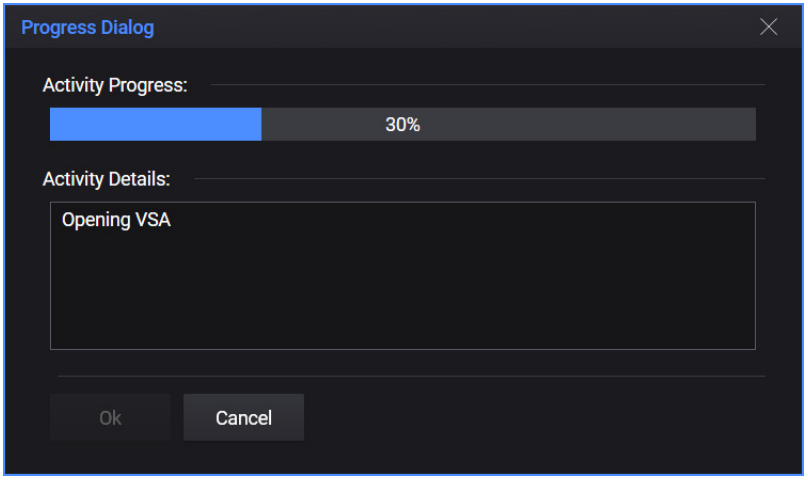

Figure 9 Activity progress for XML file generation for BLER

The folders, where the SCP and the corresponding uplink U-Plane message PCAP (with the UL suffix) and ORSTX files are located, shows an XML file with the same name as the SCP file.

The folder in Figure 10 shows the files required for BLER measurement.

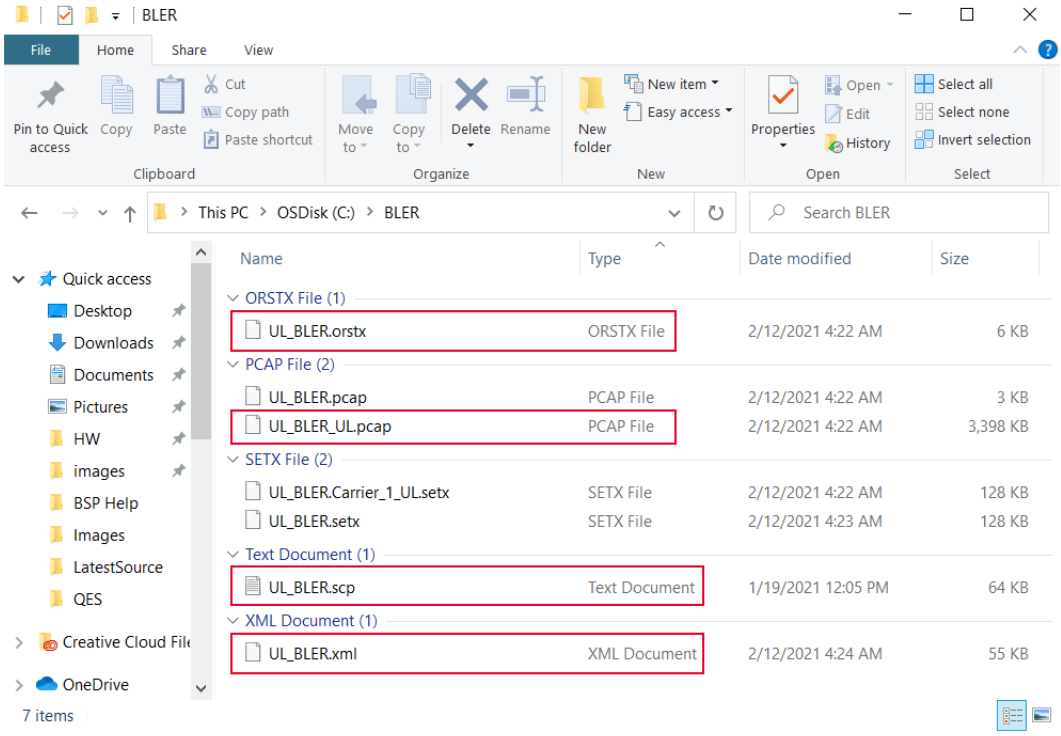

Figure 10 Folder for BLER containing all files reqd. for measurement

If measuring BER, the file set will be similar, as shown in Figure 11.

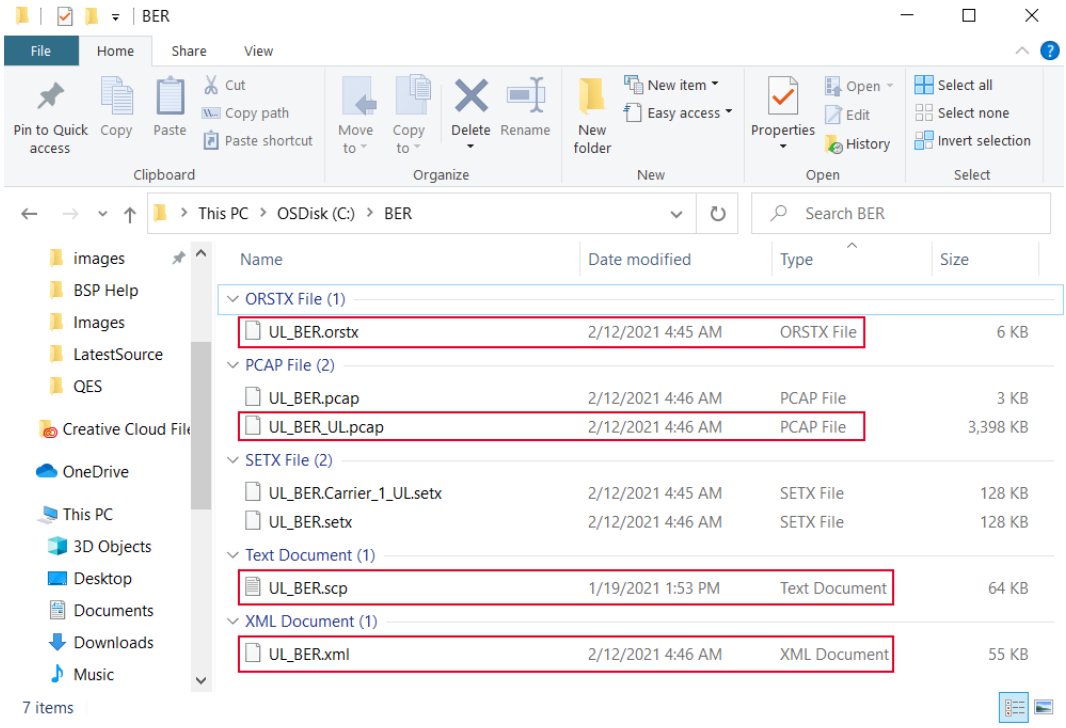

Figure 11 Folder for BER containing all files reqd. for measurement

The set of files generated previously (SCP and WFM) and the stimulus file generated in this section (PCAP_UL) are used as inputs to a BittWare system, with triggering and automation enabled.

Section 1.4: Generating Recording PCAP files

Consider a BittWare system, as depicted in Figure 12, where the following devices are connected:

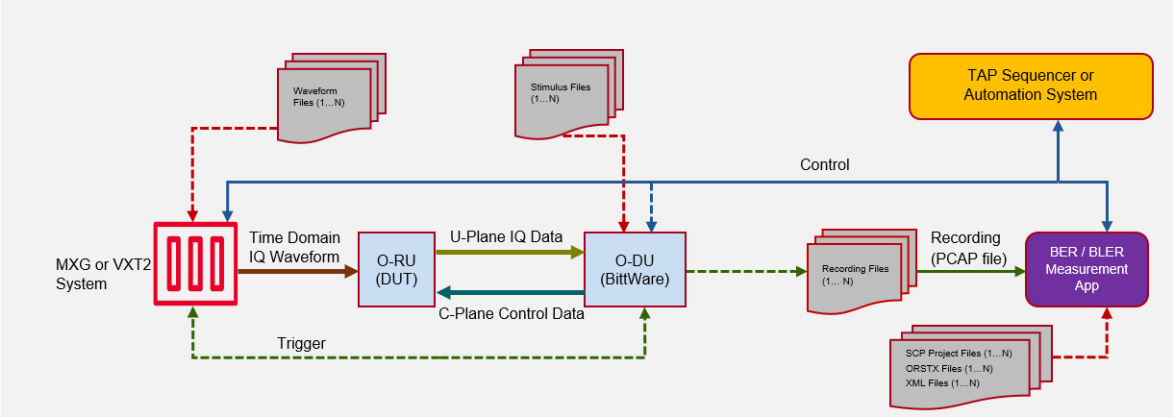

Figure 12 Block diagram illustration of a BittWare system

- an O-DU (BittWare server)
  - the U5040A Open RAN Studio software and the U5040MULA license must be installed on the server
- an O-RU (Device under test)
- a triggering mechanism, with one of the following instrument set:
  - N5182B MXG, or
  - M9019A PXIe 18-Slot Chassis, M9037A PXIe Embedded Controller, M9410A VXT PXI Vector Transceiver, and M9300A PXIe Reference Module

NOTE **You must install the N7631EMBC license per-chassis for the M9410A VXT instrument or on each N5182B MXG.**

- a PC for automation using either TAP or your own automation system. This step is optional as you may manually perform BER / BLER measurements, as explained further.

Figure 13 illustrates how the instruments are connected to each other using one or more cables listed in Table 1. This setup uses the VXT instrument set for the purpose of triggering and to aid the BittWare server in generating the required PCAP file. The SCP and WFM files are input to the VXT whereas the PCAP_UL file is loaded into the Open RAN Studio software on the BittWare server to capture the Recording PCAP file, which is required for the BER/BLER measurements.

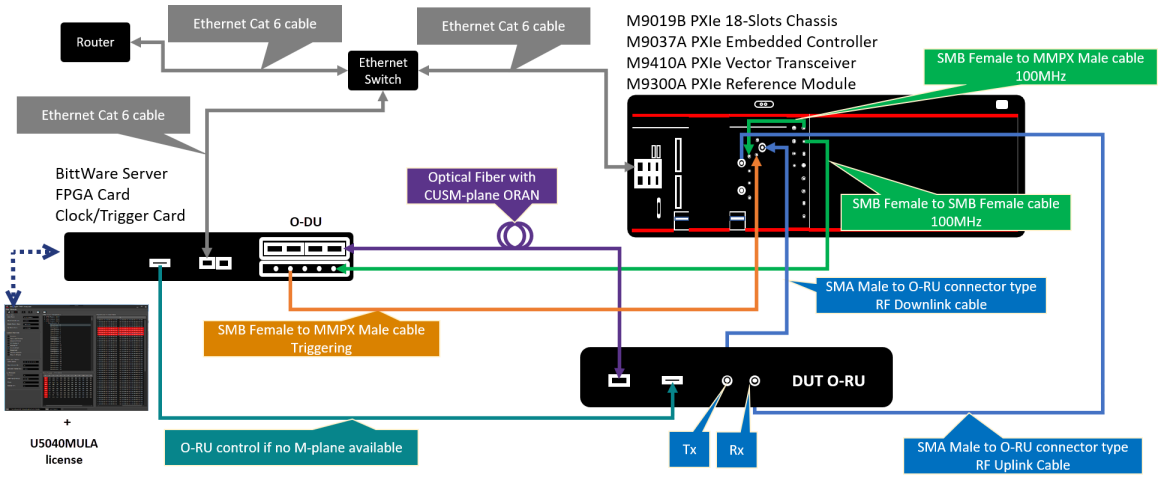

Figure 13 BittWare system setup for BER/BLER measurement

Figure 14 illustrates the flow of data in the system using various software components:

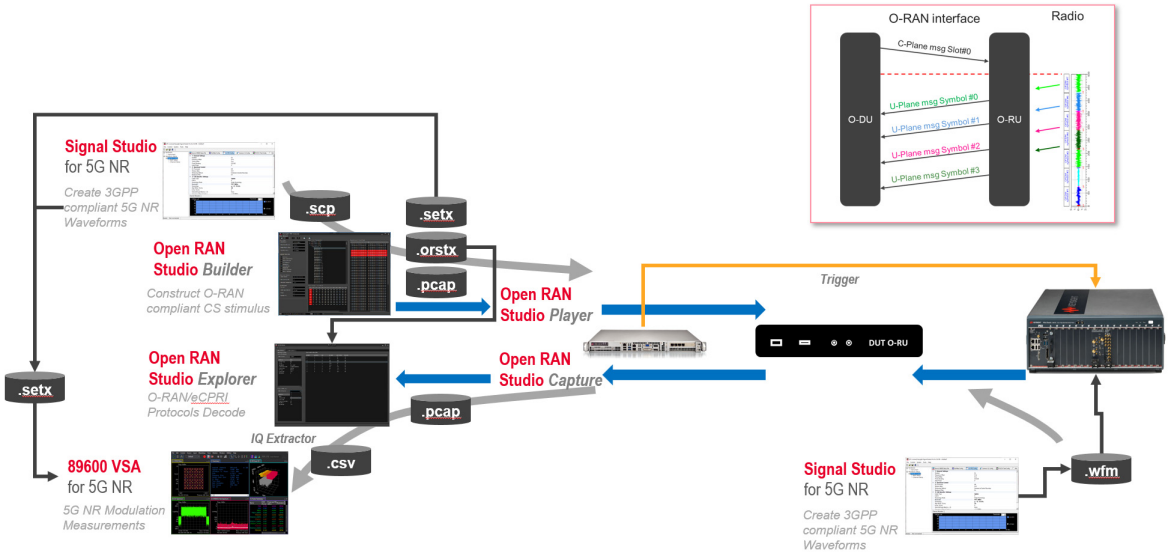

Figure 14 Data flow (for Uplink signal) in the BittWare system

1.4.1: Delay in triggering mechanism for Uplink signal

Let us consider the scenario, where the Trigger comes out of the Trigger Out from the O-RU with the Delay set to 0s on the Open RAN Studio software, as the stimulus file starts.

If no trigger is applied, the Uplink signal/waveform/radio frame will arrive at the Radio's antenna port after a few milliseconds (say, 30µs) after triggering.

This causes misalignment between the arrival of the waveform and the expected radio frame boundaries at the Radio and makes the extracted IQ data to be invalid. If loaded in the 89600 VSA, it is unable to sync and demodulate such IQ data.

If you connect an Oscilloscope, you shall find that the time passed between triggering of the M9410A to the moment the RF signal is received is about 30µs

This means that, if we want the signal to be received about 10ms after we trigger (so it will be aligned with the 10ms radio frame boundaries), we must add about 9.97ms of delay in the Signal Source (MXG or VXT). This scenario is illustrated in Figure 15.

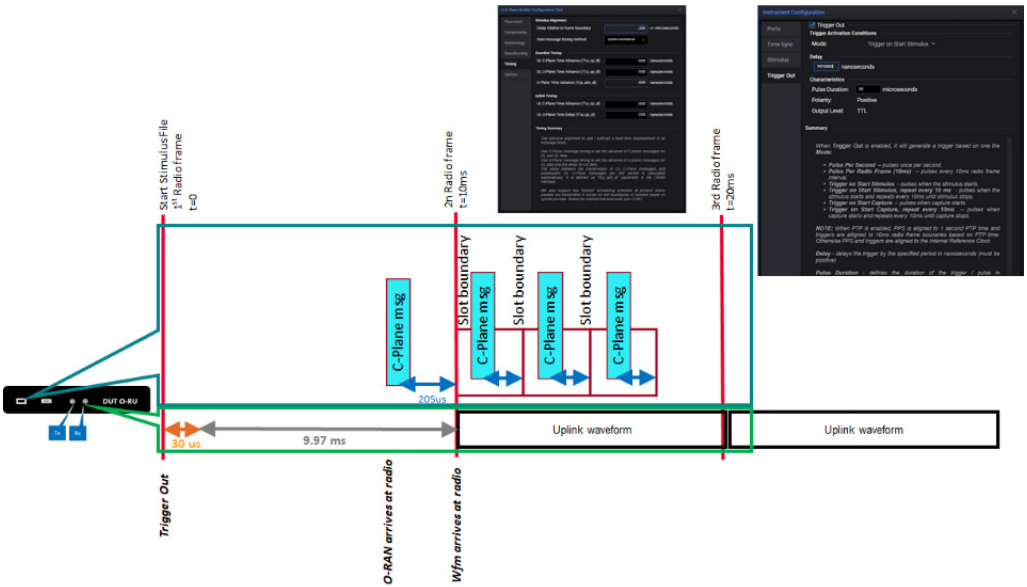

Figure 15 Trigger with 9.97ms delay applied

Section 1.5: BER / BLER Measurement Options

After the files required for BER/BLER measurement are generated, you may perform either “Option 1”, which involves an OpenTAP automated process to generate the PCAP file for measurement of BER/BLER on the BittWare server or “Option 2”, which involves a manual process or using your own automation application to generate the JSON files that contain the measurement data.

1.5.1: Using Keysight OpenTAP application’s automation

1 Prepare the PCAP file for the BER / BLER measurement on the O-DU (BittWare server).

2 Make sure that the U5040MULA license is installed.

3 Install the KS8400A PathWave Test Automation application, if not installed already.

4 Make sure that the Test Automation application is not running. Run the installer for the BLER/BER application. To download the BER/BLER installer package for TAP, click BER_BLER.1.0.0.TapPackage.

5 Launch the PathWave Test Automation application and create a new Test Plan.

6 Add the BLER/BER measurement to the test by clicking on the '+' button at the top left corner.

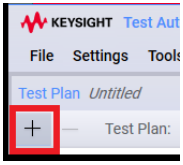

Figure 16 Adding a test plan to TAP Automation

7 On the “Test Steps” dialog that appears, navigate to the ‘BER and BLER’ option and click “Add”.

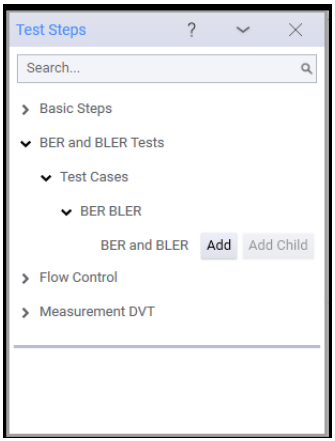

Figure 17 Adding automation steps for BER and BLER to TAP

8 Populate the required fields and run the test.
   - The JSON file is generated, which can be used for analysis.

1.5.2: Using manual process or custom automation

Note that before proceeding with either the manual or your own automation process for BER/BLER measurements, you must automate the captured O-RU response using the setup illustrated in Figure 12 and Figure 13. This requires coordination of the O-DU and the signal generator to make sure that it sends the signal when the O-RU expects it. Once the captured file has been created, save it in the same folder where the other files (SCP, ORSTX and XML) are placed for BER or BLER measurements. Proceed with the measurements either manually or through your own automation system.

1 From the **Start** menu on your machine, launch the Command Prompt window.
2 Set the root folder as "*C:\Program Files\Keysight\Open RAN Studio*".

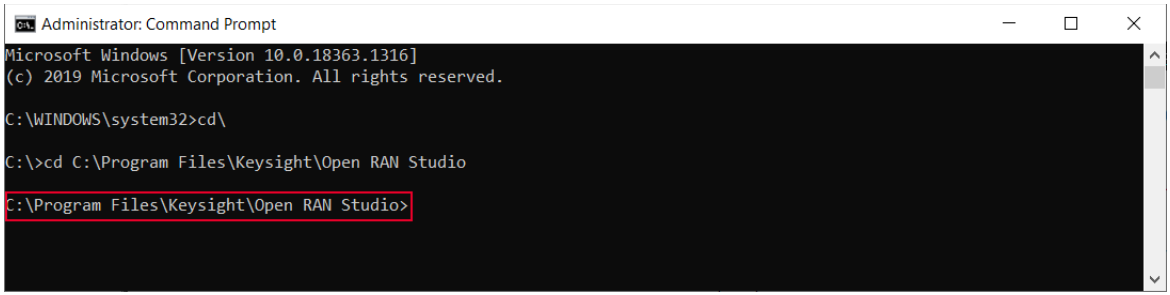

Figure 18 Setting default installation folder as root

3 Type the following syntax and press **Enter**.

ErrorRatioAnalyzer BER|BLER <scpFilename> <xmlFilename> <pcapFilename> <orstxFilename>

Here:

- *ErrorRatioAnalyzer* is the executable file that is installed in the folder "*C:\Program Files\Keysight\Open RAN Studio*" along with Open RAN Studio software ver. 1.2 or higher.
- BER or BLER must be entered to indicate the measurement you are performing
- <scpFilename>: enter full path for the SCP file
- <xmlFilename>: enter full path for the XML file
- <orstxFilename>: enter full path for the ORSTX file
- <pcapFilename>: enter full path for the PCAP file captured in Generating Recording PCAP files on page 21.

For BLER:

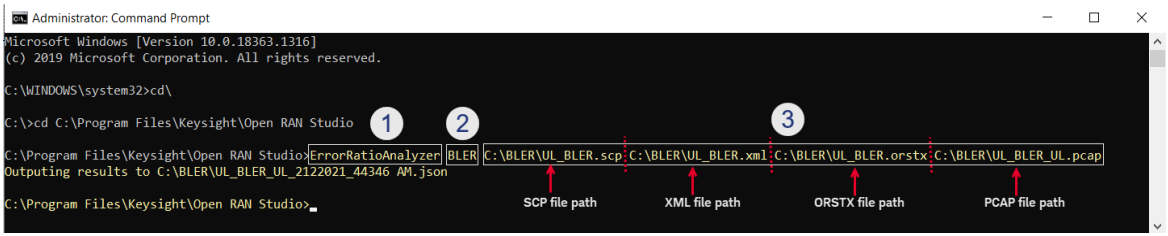

Figure 19 Entering command for BLER measurement

For BER:

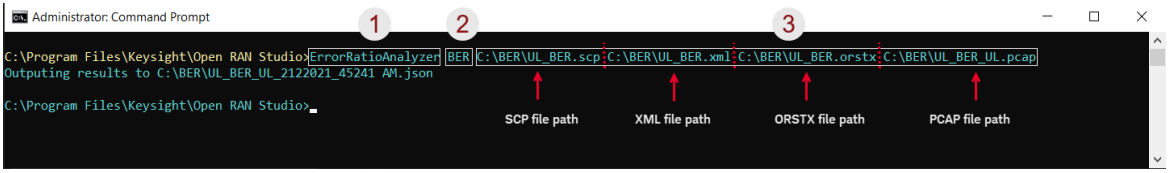

Figure 20 Entering command for BER measurement

where,

1 – ErrorRatioAnalyzer

2 – BER or BLER, depending on what you are measuring

3 – Full paths to the SCP, PCAP, XML and ORSTX files (in any order) separated by a single space. Note that in the examples above, the complete folder location for each file is shown, such as *C:\BLER\UL_BLER.scp* and so on.

If successful, the command prompt window displays the message *Outputing results to <JSON file name>*.

In both cases, the measurement result is written to a file in JSON format. File name of this JSON is of the format (name of PCAP file + date + time).

The folder, where the SCP, PCAP, XML and ORSTX files are located, now shows the JSON file generated.

JSON file in the BLER folder

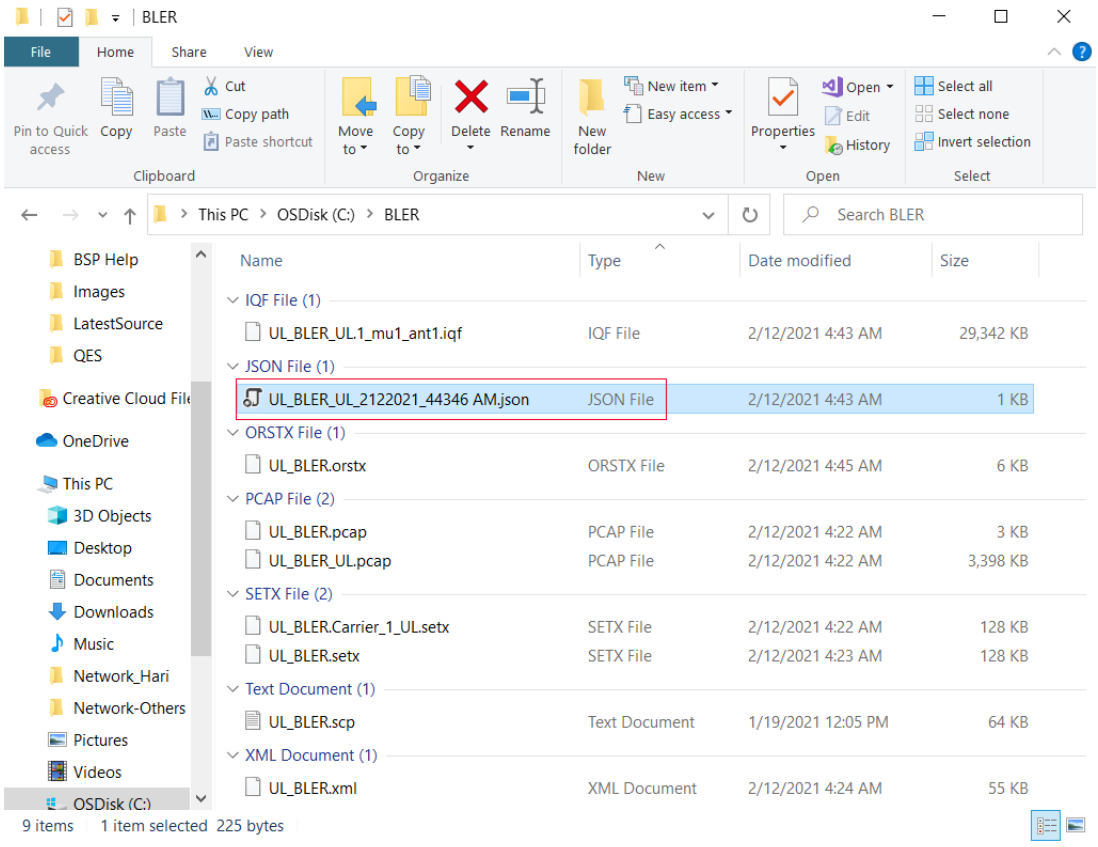

Figure 21 Generated JSON file containing BLER measurement data

JSON file in the BER folder

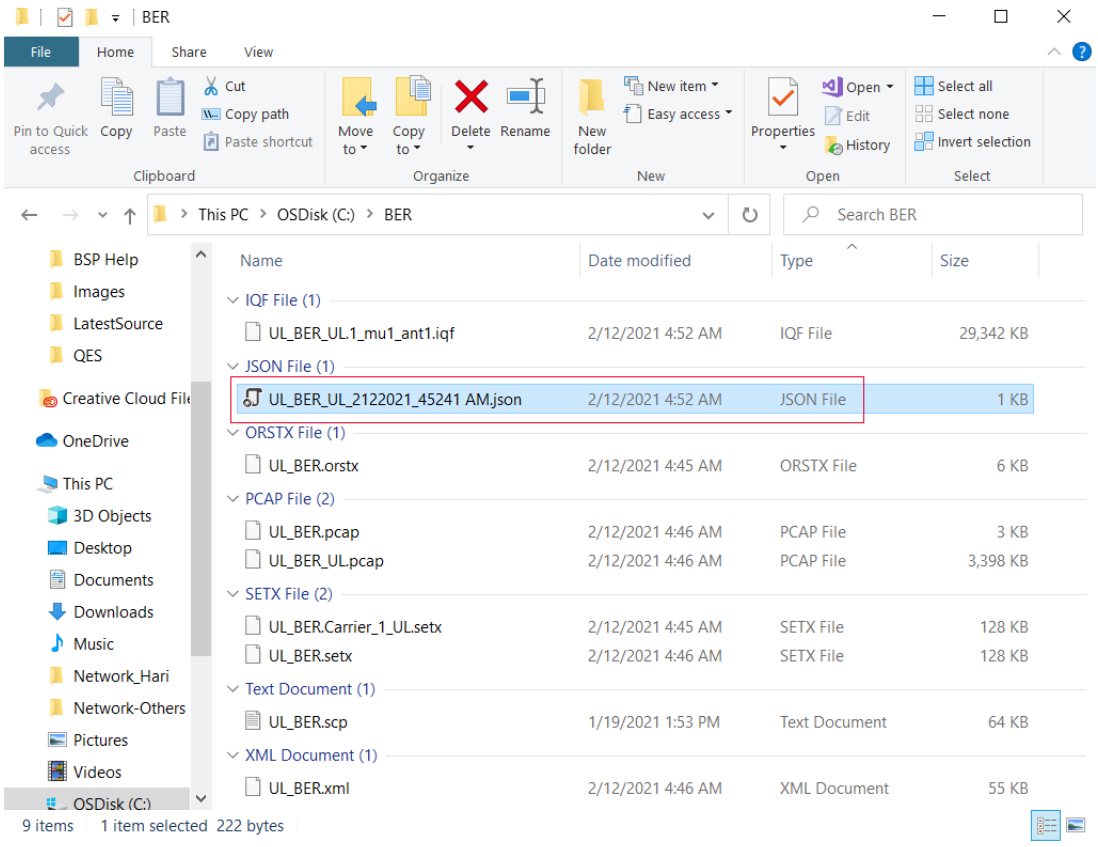

Figure 22 Generated JSON file containing BER measurement data

Section 1.6: Structure of the JSON file

To analyze the measured BER / BLER data, let us understand the JSON file structure.

JSON file for BER measured with 4 Frames in the recording


```
{
  "MeasurementType": "BER",
  "FileName": "4frames.pcap",
  "FinishedAt": "2021-01-11T19:46:18.4342047+02:00",
  "Frames": [
    {
      "ErrorRatioInPercent": 2.1526929860263193,
      "FrameNumber": 1
    },
    {
      "ErrorRatioInPercent": 2.1526929860263193,
      "FrameNumber": 2
    },
    {
      "ErrorRatioInPercent": 2.1526929860263193,
      "FrameNumber": 3
    },
    {
      "ErrorRatioInPercent": 2.1526929860263193,
      "FrameNumber": 4
    }
  ]
}
```


Figure 23 Structure of the JSON file for BER

The JSON file structure contains:

- Measurement type
- File name of recording
- Date and time when the measurement was finished
- Error ratio in percentage and frame number for each frame

Each frame has PN9 sequence with 11 bits altered. The Bit Error Ratio (BER) is calculated as 11/511 ~ 2.15%.

Section 1.7: Contact us

For more information on Keysight Technologies' products, applications or services, contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus.

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Edition 1.0, April 2021

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