Dynamic Spectrum Sharing (DSS) for 5G & LTE: Signal Generation and Analysis.

Products:

- R&S®FSW
- R&S®SMW200A

This Application Note supplements the video series, describing signal generation and signal analysis for Dynamic Spectrum Sharing (DSS) for LTE and 5G NR. Links to the videos are provided in the Literature section.

In this illustration, a four frame (40 subframes) long LTE sequence will be created, and exemplary MBSFN slots inserted, carrying 5G payloads. That signal sequence will be compiled and played by the SMW signal generator. The FSW signal analyzer LTE and 5G NR personalities are then used to analyze and verify the content of each subframe/slot.

Three methods are presented, (1) Manual Entry using the GUI, (2) SCPI command sequence/remote control and (3) configuration file. The latter variants require the download of various files, available from the provided link.

The configuration file approach offers the fastest time to initially setup. The SCPI command sequences provides some insight of the functionality and settings at each step, and the supplied MATLAB® script (only core license required) provides a prototype to illustrate the programming of successive slots or subframes. The Manual Entry approach, using the instrument's front panel GUI, provides a step-by-step set-up instruction, which can itself be augmented with SCPI recording, for easy modification and programming.

The R&S®SMW200A Signal Generator is herein after referred to as SMW.
The R&S®FSW Signal Analyzer is herein after referred to as FSW.

Note:

Please find the most up-to-date document on our homepage.

http://www.rohde-schwarz.com/appnote/GFM337

Application Note

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3.2020 – GFM337_0e

Table of Contents

1 Introduction

1.1 Background

Dynamic Spectrum Sharing (DSS) enables both LTE and 5G network operation, in a common frequency band, potentially re-using existing LTE infrastructure. In essence, this is achieved by inserting 5G subframes into existing LTE transmissions, using the MBSFN (multicast-broadcast single frequency network) transmission mode.

This application note, supporting the existing demonstration videos (see Literature), demonstrates exemplary DSS signal generation and signal analysis. This enables test and measurement, thus qualification, of complete transmission/reception systems as well as the radio frontend (RFFE) subsystems.

More information is widely available on the MBSFN topic, in the public domain.

1.2 Reader's Guide

The first part of this document addresses signal generation; the creation of a basic DSS LTE/5G signal.

The second part of the document presents the signal analysis of the LTE and 5G components of the DSS signal. As for the generator side, the three exemplary methods are presented.

Naturally, these building blocks may be modified by the user to create alternative scenarios within the DSS concept.

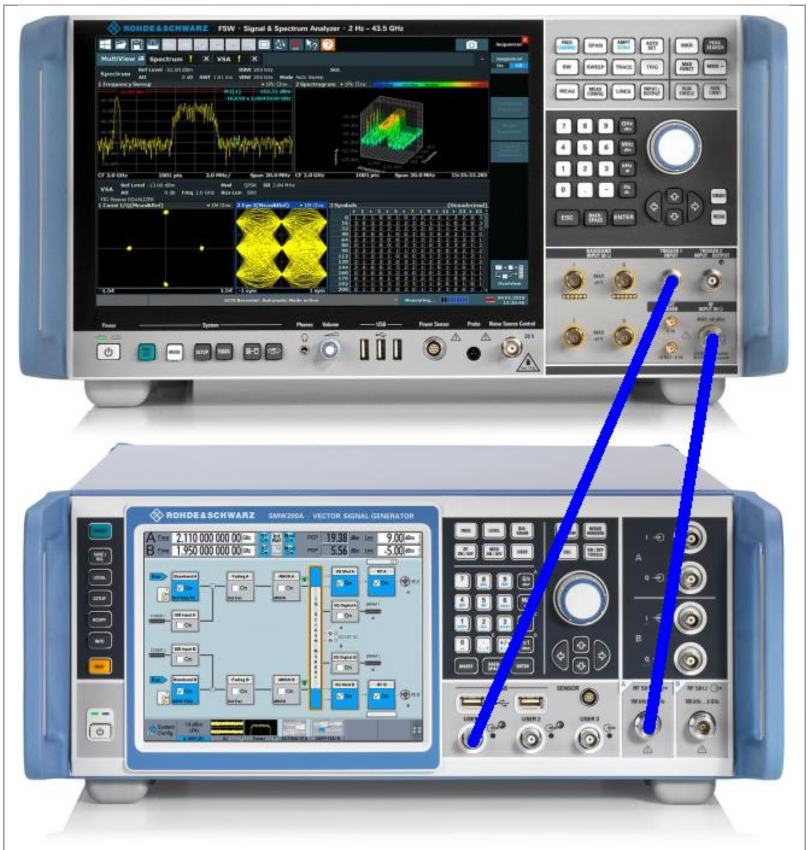
To that end, the third part of the document provides an exemplary MATLAB® script, functions and class, automating the set-up procedure completely, and may easily be modified or ported to automate the test scenarios. Note that only the core MATLAB® license is required to run the scripts.

2 Instrument Setup

2.1 Hardware

To replicate the illustrative measurement performed in this document, the following hardware and connections are used.

- FSW signal analyzer (FW revision 4.51 or higher)
- SMW signal generator (FW revision 4.65.007.30 or higher)
- The 'RF A' output of the SMW is connected, either with a cable or DUT, to the 'RF Input' of the FSW, e.g. with an RF coaxial cable (see Figure)
- Optionally, for better results, the 'User 1' front panel output of the SMW is connected with a BNC cable to the 'Trigger 1 Input' input port of the FSW (see Figure)
- Also optional, a PC or similar, for remote control of the SMW and FSW, with all three connected through a TCP/IP Router.



The SMW+FSW stack, showing Trigger and RF connections.
The recommended PC and LAN connections are not shown.

3 Signal Generator: SMW200A

3.1 Introduction

In line with Dynamic Spectrum Sharing protocol, in this example, a 4 frames long LTE structured signal will be created in a first SMW baseband generator. It will be filled incompletely with exemplary LTE payloads.

Those subframes that are empty, that are allocated to carry 5G payloads, specified by MBSFN, will have their 5G content created in the second SMW baseband generator.

Those two digital data streams, LTE and 5G, are added (in the instrument), and passed through a common output path.

The signal generator may be set up using one of several different methods, including:

- manual entry (front panel or remote)
- remote control using SCPI commands
- uploading a configuration file (.savrcltxt)

These three example methodologies are described for both instruments in this document.

The user may modify some or other of the parameters to suit their own specific test case needs.

3.2 Manual Entry using the GUI

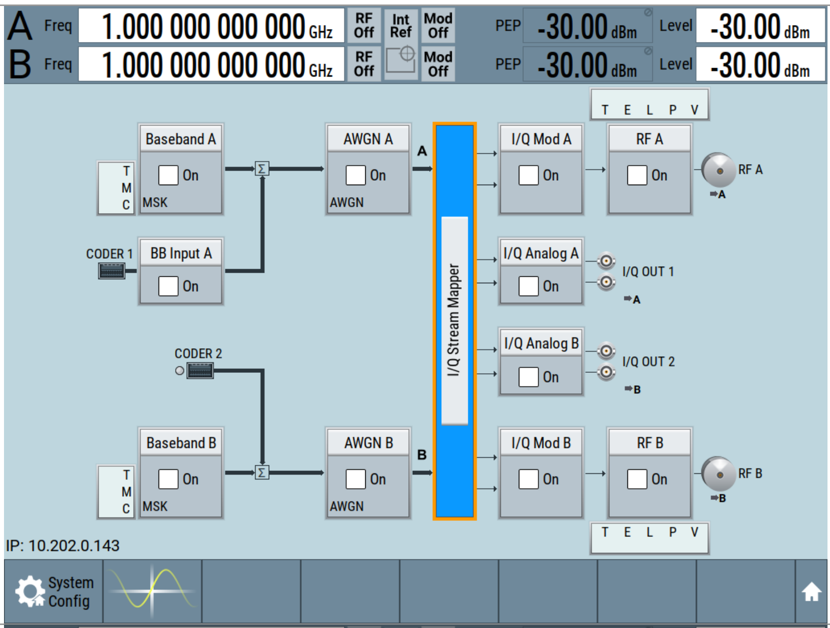
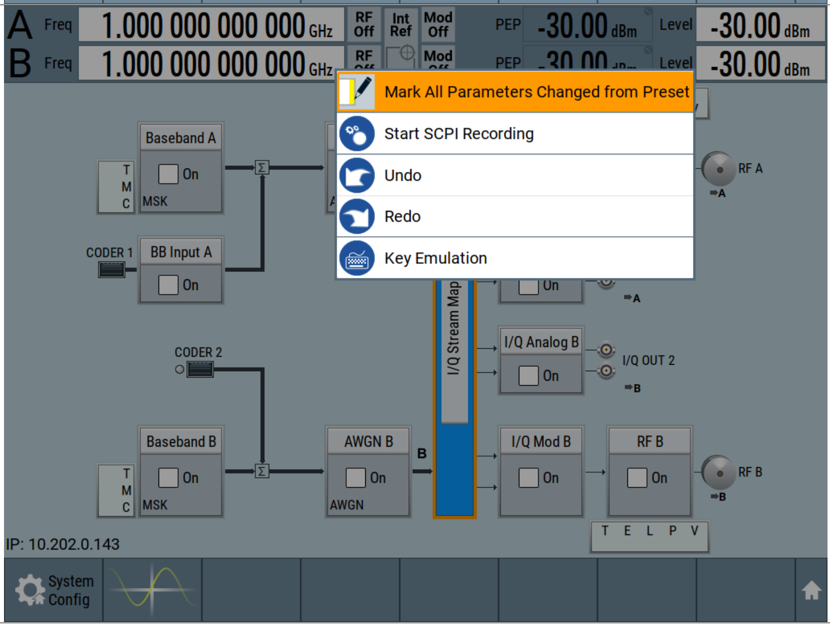
Before describing the manual set-up, it is worthwhile noting the existence of the SCPI recording feature, a productivity feature enabling faster, more repeatable testing.

This is especially so for relatively lengthy parameter setting processes, where one or more parameters might need to be changed.

Alternatively, if the intention is to migrate to a production testing, this feature will also come in useful.

The SCPI Recorder can be started, paused and stopped at any time, similarly the contents of the sequence viewed and exported for re-use.

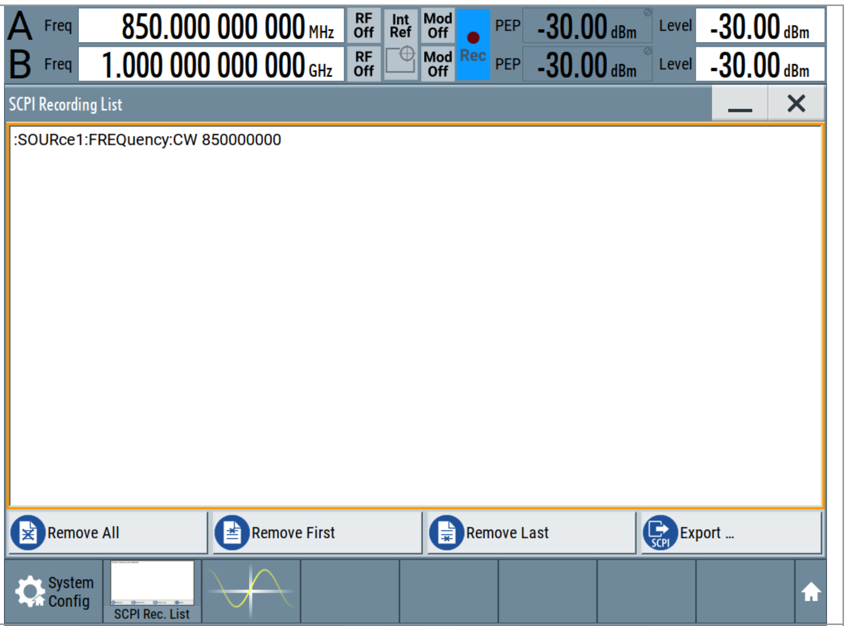
In the first step, the instrument will be configured such that the two baseband channels will be summed for use in one output path.

Start the instrument with a 'Preset', and press the 'I/Q Stream Mapper' block in the middle of the screen.	
At this point, the SCPI recorder can be invoked. Press and hold, in the instrument background, outside of one of the functional blocks. The pictured list will appear, select the 'Start SCPI Recording' option.	

A 'Rec' button appears, to indicate that SCPI recording is active.

Pressing this button will bring up the list of SCPI commands created, along with potential actions to take.

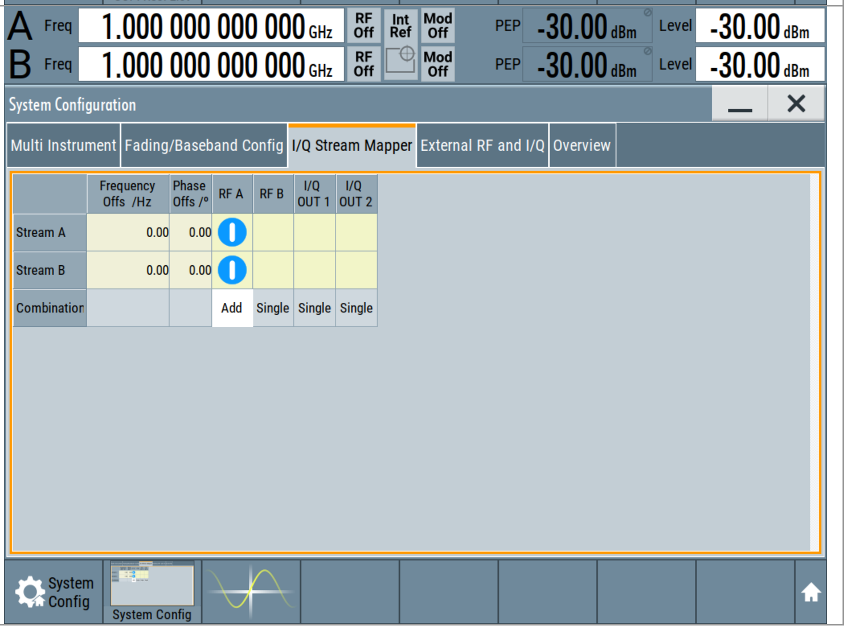
This feature only captures commands submitted manually. Remote commands will not appear in the recording list.



At the intersection of 'Combination' and 'RF A' press the button labeled 'Single', and change its state to 'Add'.

This will eventually provide a summation of the 5G and LTE signals in the digital domain.

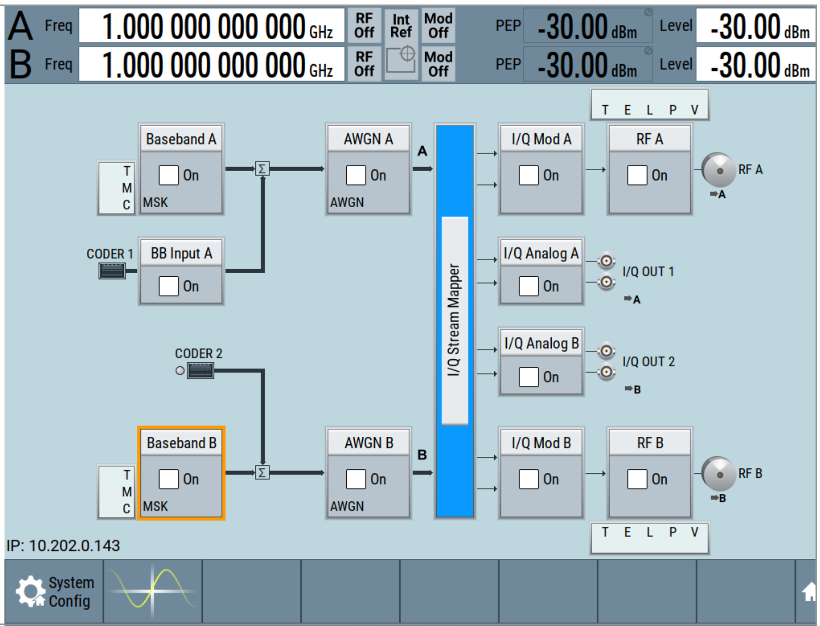
The frequency of operation, and generator output power level, may be changed at any point in the overall process.



Where necessary, select the desired operating frequency and output power and pressing each of those boxes and entering desired values (e.g. 850MHz and -6dBm).

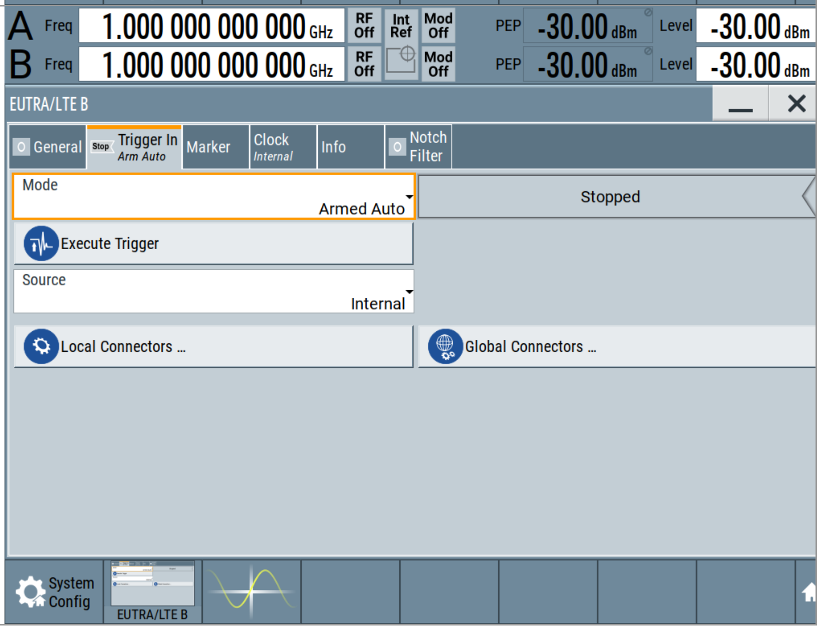
In the second phase, baseband B will be configured to generate the LTE kernel along with some empty subframes, into which 5G payloads will be inserted later.

Press 'Baseband B' (highlighted) and choose the EUTRA/LTE option



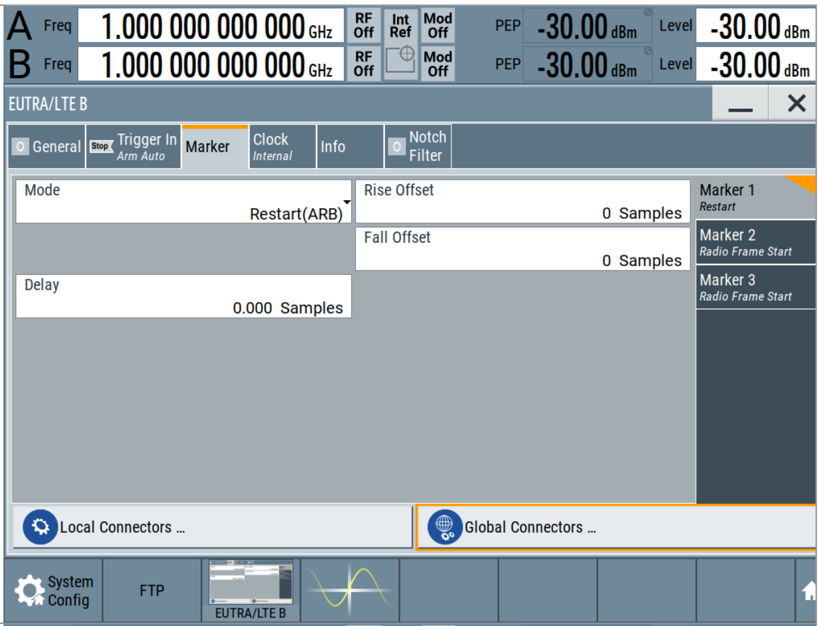
In the 'Trigger' tab, select 'Armed Auto' mode (highlighted).

Then, select the 'Marker' tab.



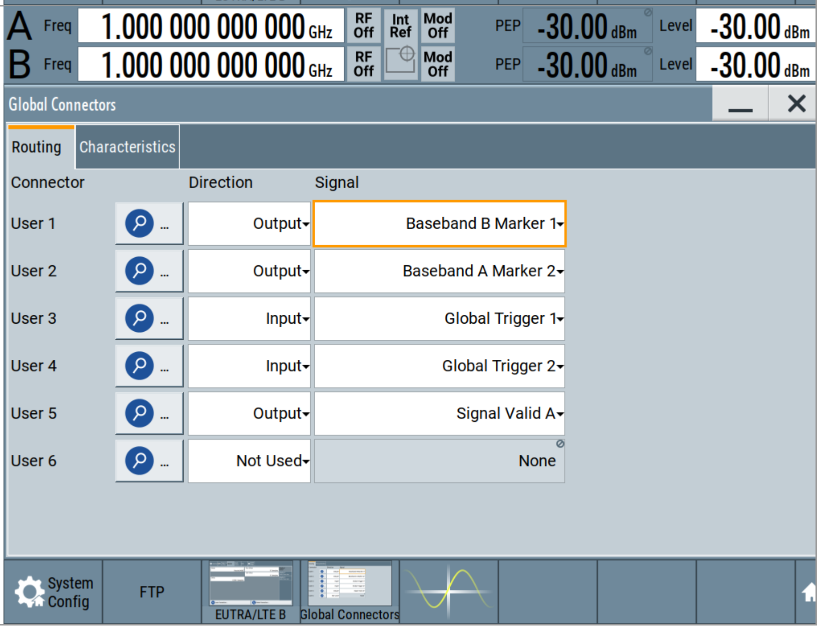
Select 'Restart (ARB)' from the 'Mode' scroll-box.

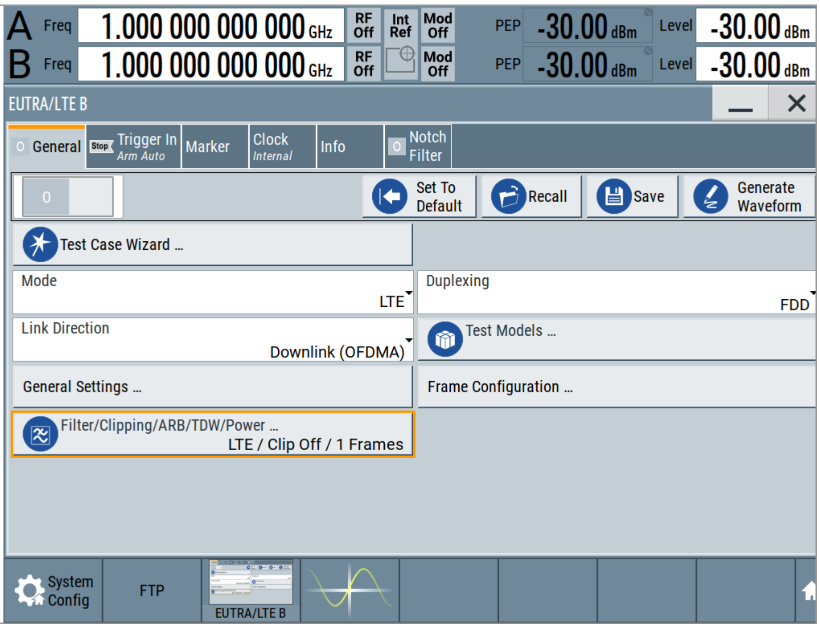
Press 'Global Connectors'

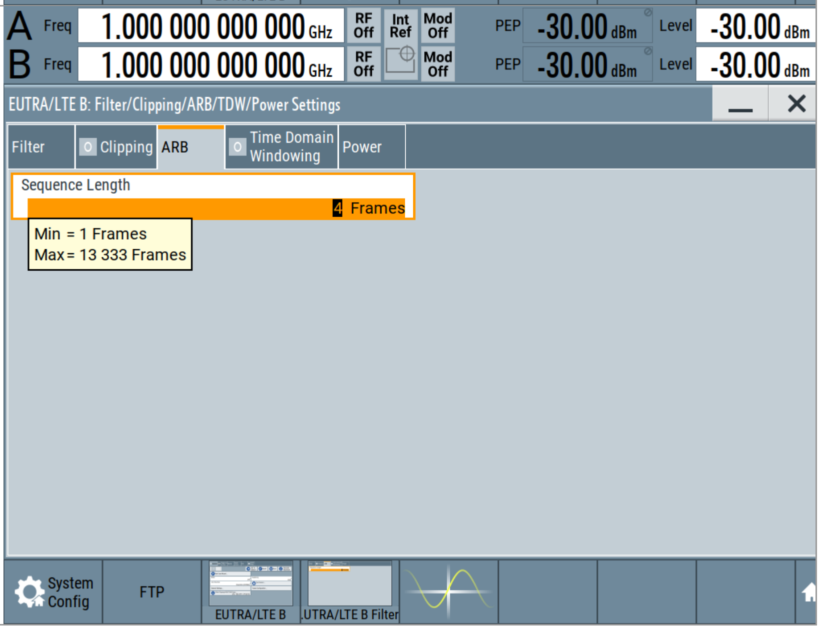


Select 'Baseband B Marker 1' from the 'User 1' connector, ensuring its direction is set to output.

This signal will be used to synchronize the generator and analyzer on the 4 frame basis.



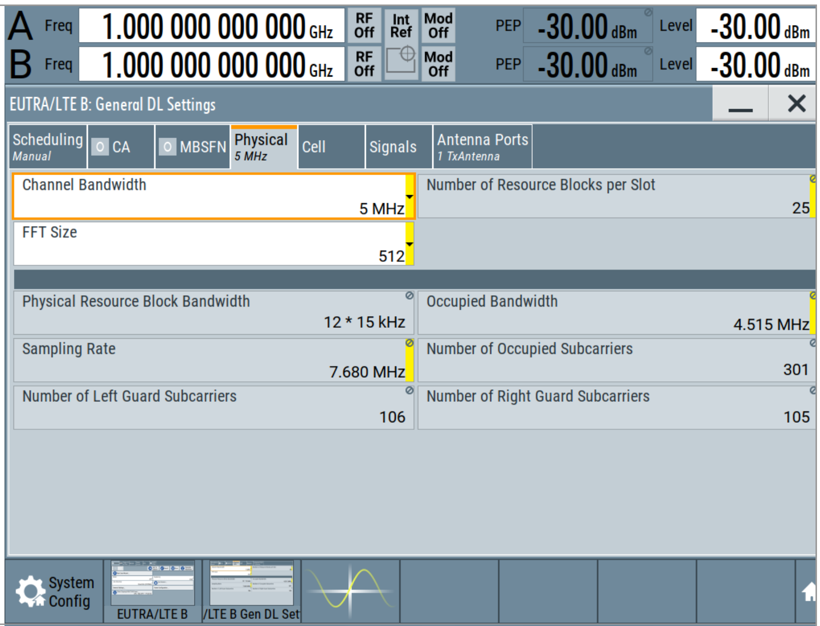
<table>
<tr>
<td>Press the 'Filter/Clipping/ARB/TDW/Power …' button</td>
<td>
</td>
</tr>
<tr>
<td>Select the 'ARB' tab, and enter '4 Frames' as the sequence length.

Close the window with the 'X'.</td>
<td>
</td>
</tr>
</table>

Within the 'General' tab, press the 'General Settings' button.

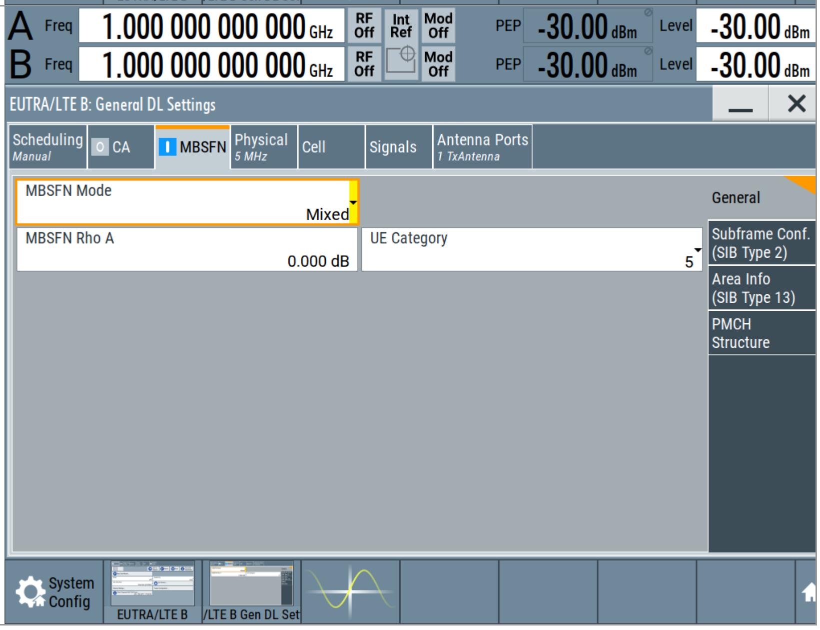
Select the 'Physical' tab, and in the 'Channel Bandwidth' option, select '5 MHz'.

Some other values will be automatically updated with new default values.



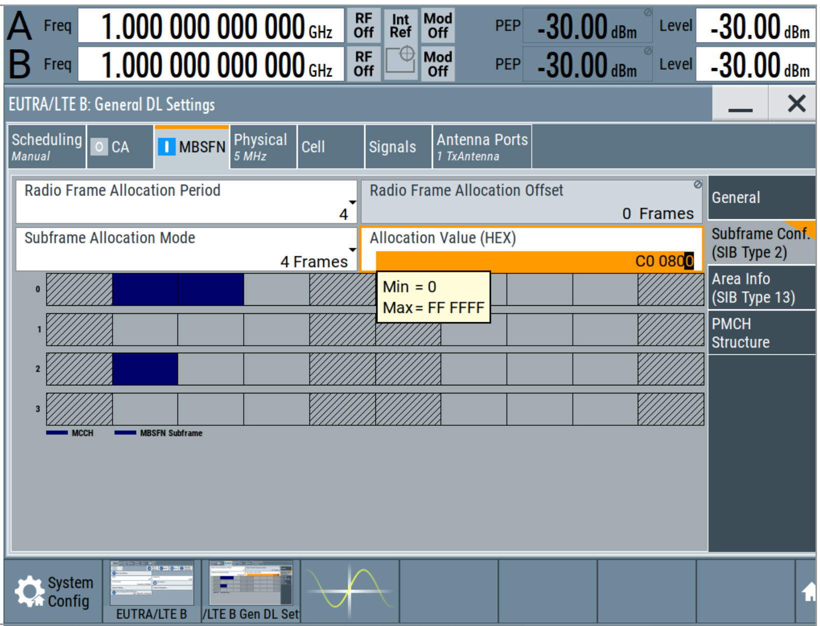
Select the 'MBSFN' tab, and for 'MBSFN Mode' select 'Mixed'

This is the most critical phase of the set-up process, creating space for the 5G payload to be inserted.

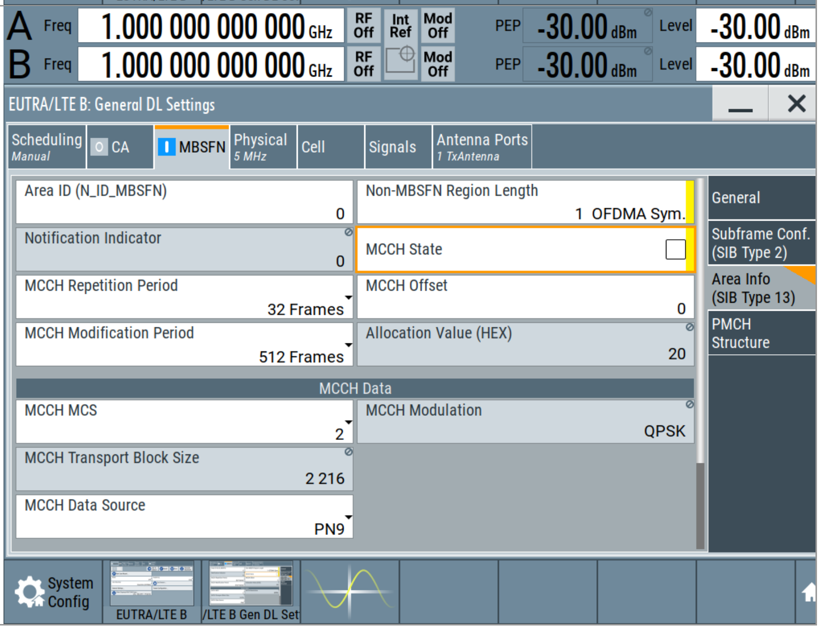


Using the tabs on the right hand side, select 'Subframe Conf. (SIB Type 2)'. Set the:
'Radio Frame Allocation Period' to '4'
'Subframe Allocation Mode' to '4 Frames'
'Allocation Value (HEX)' to 'C00800'.

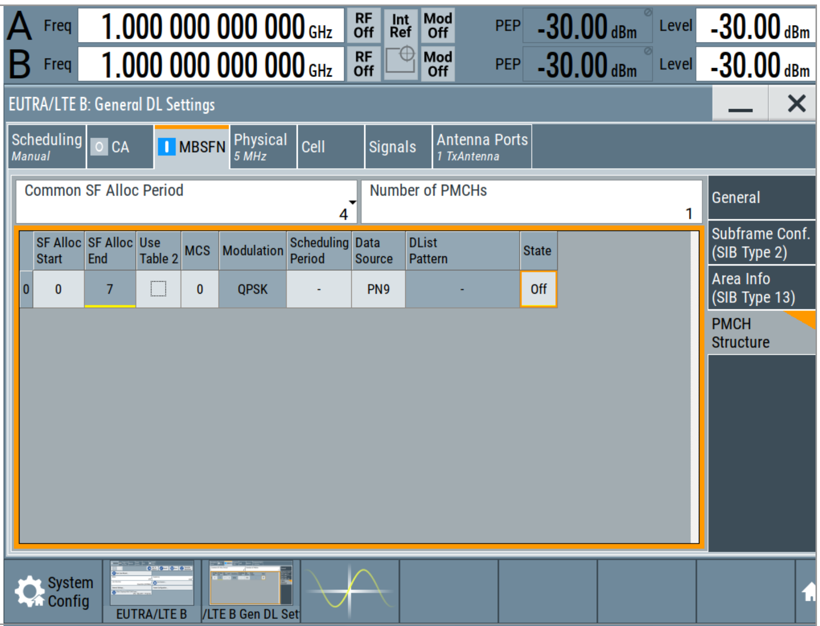
Note: This is just an example set-up pattern, which will be used through the document.
The 6-digit HEX value represents the binary presence of MBSFN subframes starting with Frame 0, Subframe 1 as MSB, and Frame 3 Subframe 8 as LSB.



In the next right hand side tab, 'Area Info (SIB Type 13)', modify two parameters:
'Non-MBSFN Region Length' to 1
'MCCH State' should be UN-checked.

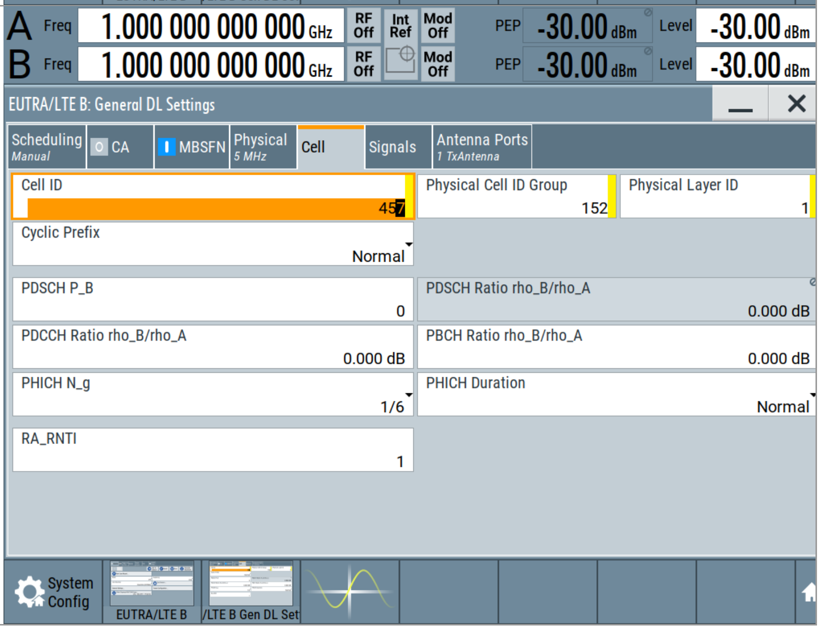


In the 'PMCH Structure' tab, switch the state to 'Off'



Finally, in the 'Cell' tab, enter a value of '457' for the 'Cell ID' variable. (for example)

Close the window, using the 'X' in the top right.

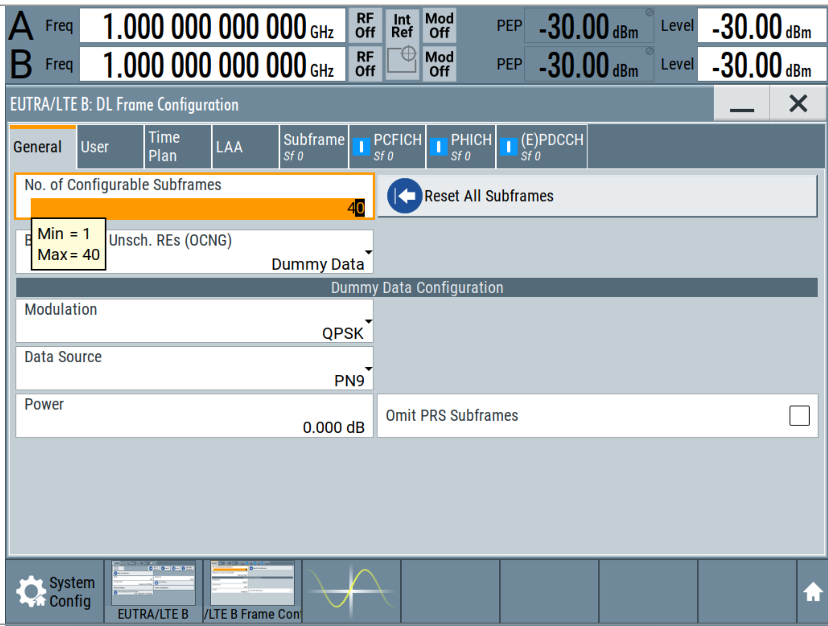


The 'General Settings' is now complete. The LTE frame has been defined for DSS operation. The next step is to define the LTE subframes within.

Press the 'Frame Configuration' button.

In the 'General' tab, set the 'No. of Configurable Subframes' parameter to '40'.

There are now 40 subframes which can be configured.

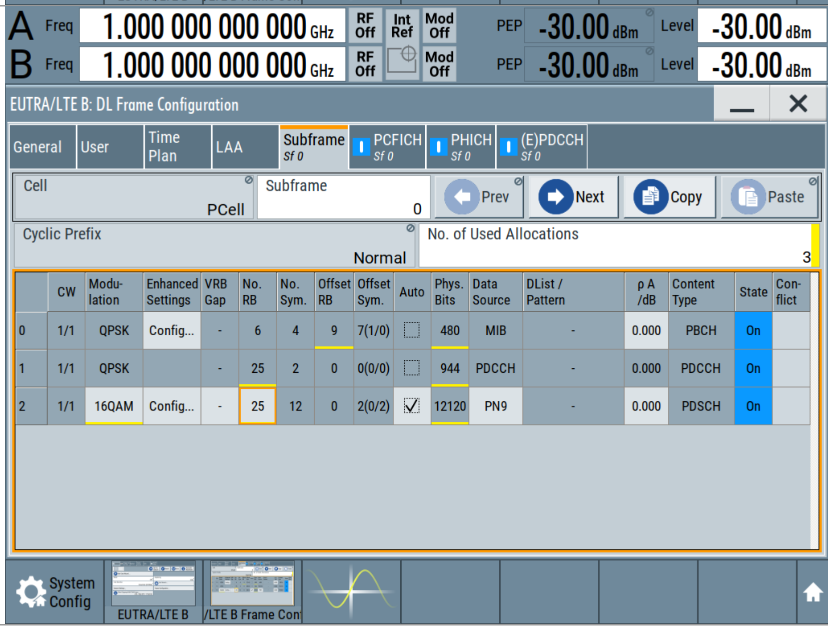


Select the 'Subframe' tab.

From here, the subframes can be programmed.

For 'Subframe 0', '… 10', '… 20' and '… 30'
Select '3' for 'No. Of Used Allocations'. A third row will appear.

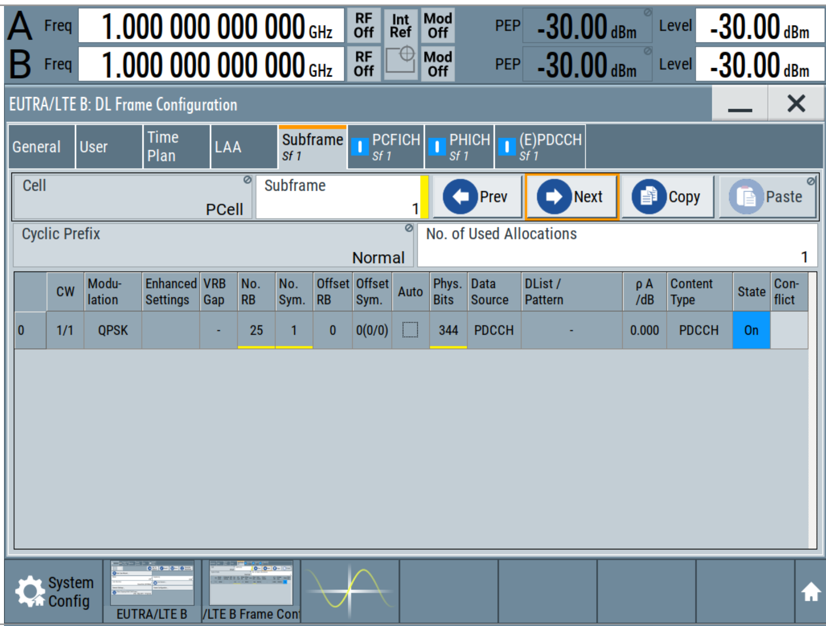
Within that third row, modify the 'QPSK' parameter to be '16QAM' and 'No. RB' should be set to '25'.



With Subframes 0, 10, 20, 30 configured, returning to subframe 1…

Leave subframes 1, 2 and 21 alone.

They will be filled with 5G payloads, later.



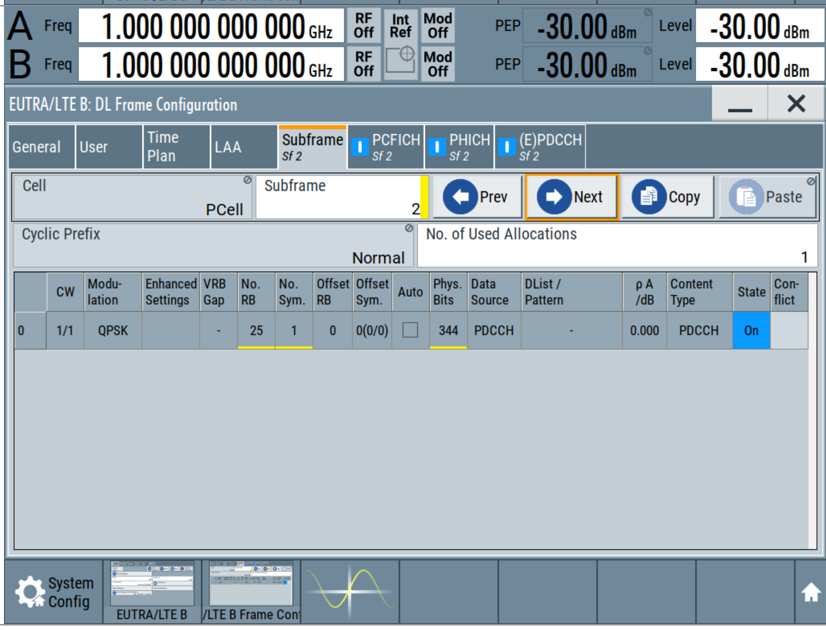
As a general instruction:

For the potential MBSFN subframes {1,2,3,6,7,8,11,12 … 38,39}; there are two options

(1) to allocate to 5G, in which case leave with the default settings; do not make any changes.

(2) to allocate to LTE, in which case use the next step

Use 'Next' and 'Prev' to move between the subframes.



To create an LTE payload, in this case starting with Subframe 3:

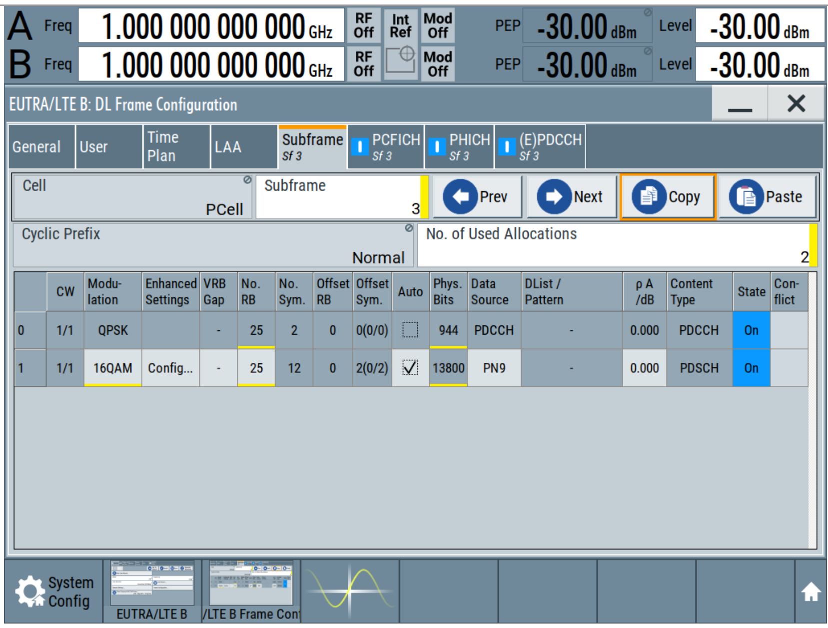
Set the 'No. of Used Allocations' to '2'.

A second row will appear.

In the second row modify:
'Modulation' to 16QAM
'No. RB' to 25

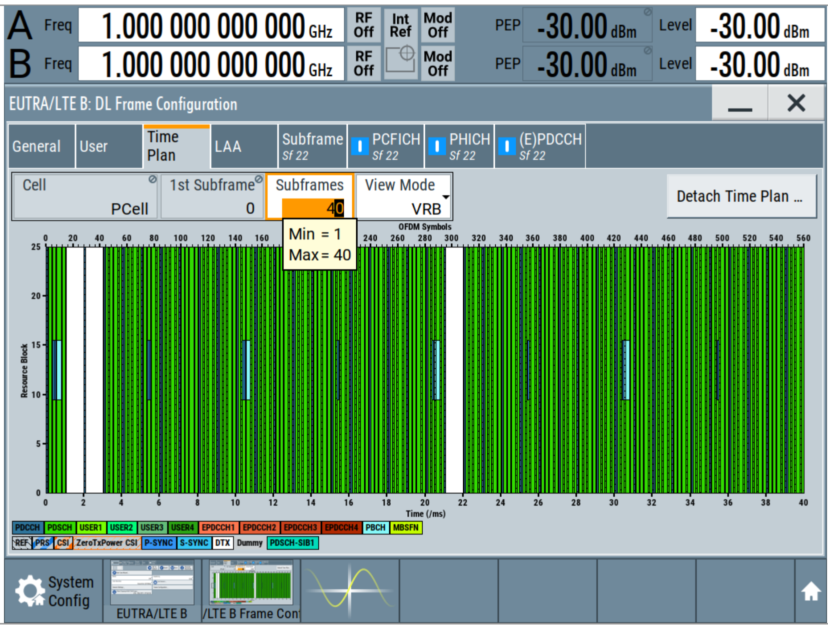
Press 'Copy', enabling a faster replication into the remainder of the LTE subframes.

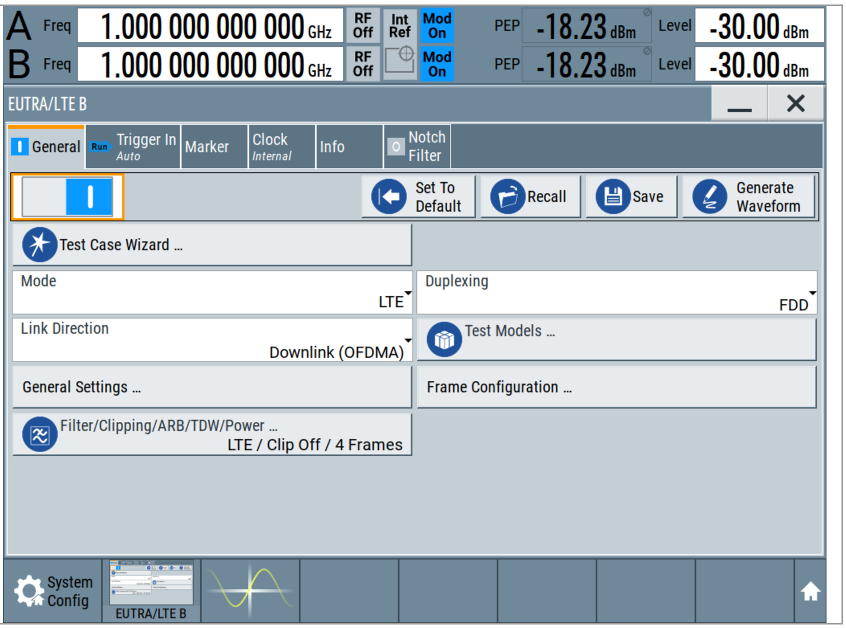
To follow this example, copy subframe 3 and paste into {4,5,6,7,8,9, 11,12,13,14,15,16,17,18,19, 22,23,24,25,26,27,28,29, 31,32,33,34,35,36,37,38,39}



Selecting the 'Time Plan' tab, and entering a value of '40' for 'Subframes' shows the 40 subframes, 10 of which are not highlighted or yet filled.

Close the 'Frame Configuration' window.



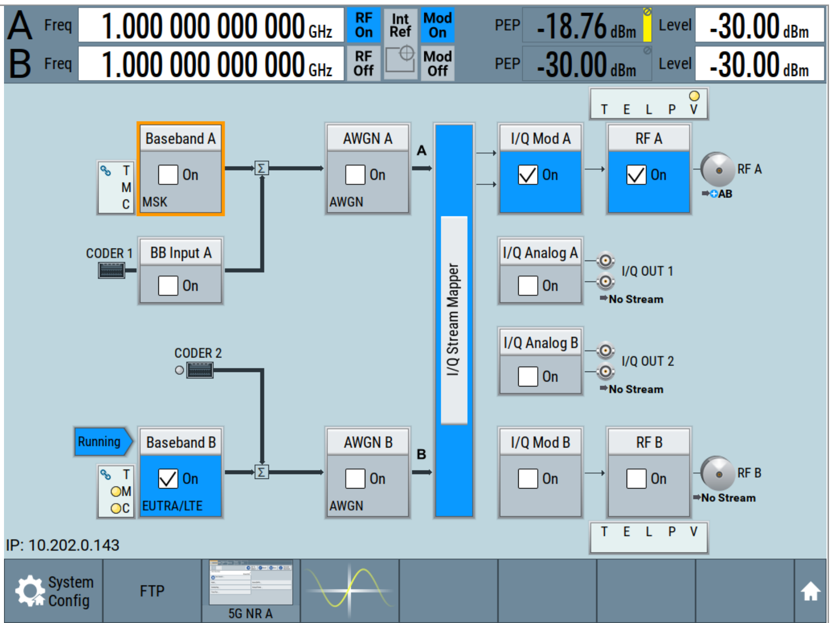
Switch On the LTE modulation, at which point the Trigger will be automatically activated. RF may also be switched on at this point.	

The EUTRA/LTE kernel set-up is now complete. If the SCPI recording feature was active, the returned sequence would look something like:

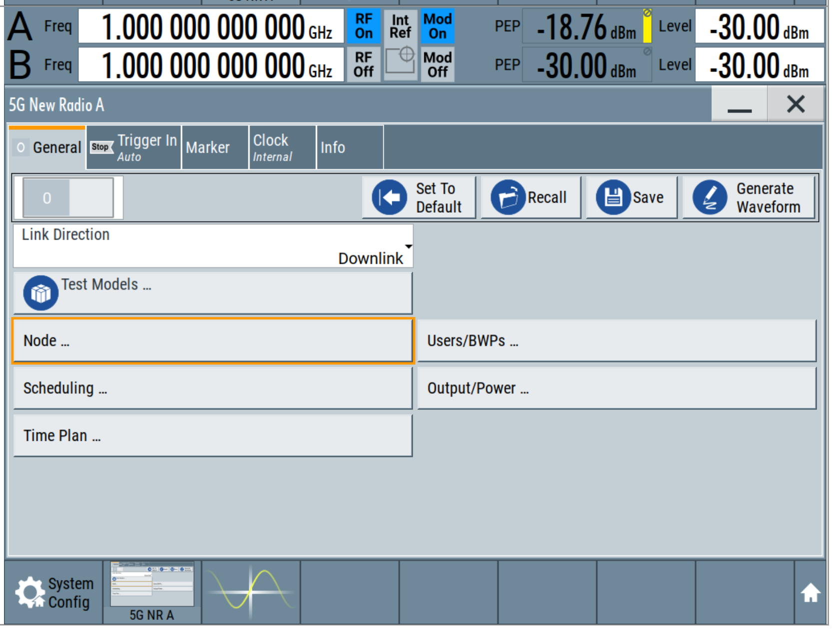
```
*RST
:SCONfiguration:APPLy
:SCONfiguration:OUTPut:MAPPing:RF1:MODE Add
:SCONfiguration:OUTPut:MAPPing:RF1:STReam2:STATe 1
:SOURce2:BB:ARBitrary:NOTCh1:APPLy
:SOURce2:BB:EUTRa:TRIGger:OUTPut1:MODE REST
:OUTPut1:USER1:SIGNal MARKB1
:SOURce2:BB:EUTRa:TRIGger:SEQuence AAUT
:SOURce2:BB:EUTRa:SLENgth 4
:SOURce2:BB:EUTRa:DL:BW BW5_00
:SOURce2:BB:EUTRa:DL:MBSFn:MODE MIX
:SOURce2:BB:EUTRa:DL:MBSFn:SC:APER AP4
:SOURce2:BB:EUTRa:DL:MBSFn:SC:AMODe F4
:SOURce2:BB:EUTRa:DL:MBSFn:SC:AVAL 12584960
:SOURce2:BB:EUTRa:DL:MBSFn:AI:NMRL 1
:SOURce2:BB:EUTRa:DL:MBSFn:AI:MCCH:STATe 0
:SOURce2:BB:EUTRa:DL:MBSFn:PMCH0:STATe 0
:SOURce2:BB:EUTRa:DL:PLCI:CID 457
:SOURce2:BB:EUTRa:DL:CONSubframes 40
:SOURce2:BB:EUTRa:DL:SUBF0:ALCount 3
:SOURce2:BB:EUTRa:DL:SUBF0:ALLoc2:CW1:MODulation QAM16
:SOURce2:BB:EUTRa:DL:SUBF0:ALLoc2:CW1:RBCount 25
:SOURce2:BB:EUTRa:DL:SUBF10:ALCount 3
:SOURce2:BB:EUTRa:DL:SUBF10:ALLoc2:CW1:MODulation QAM16
:SOURce2:BB:EUTRa:DL:SUBF10:ALLoc2:CW1:RBCount 25
:SOURce2:BB:EUTRa:DL:SUBF3:ALCount 2
:SOURce2:BB:EUTRa:DL:SUBF3:ALLoc1:CW1:MODulation QAM16
:SOURce2:BB:EUTRa:DL:SUBF3:ALLoc1:CW1:RBCount 25
:SOURce2:BB:EUTRa:STATe 1
```

Example SCPI recording from following the documented sequence. Note that the copy-paste commands are not supported.

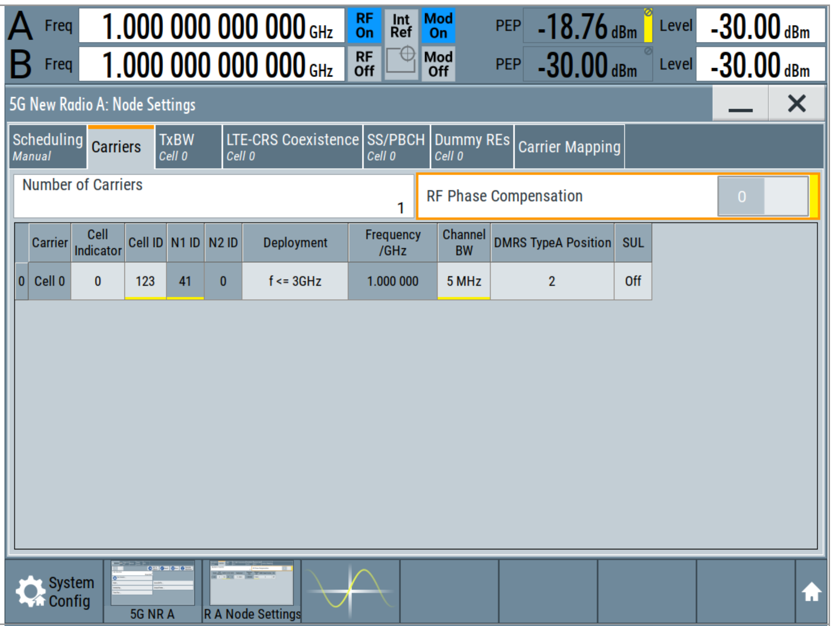
It just remains to add the 5G payload to be inserted, using baseband A of the generator.

<table>
<tr>
<td>Select Baseband 'A'</td>
<td>
</td>
</tr>
<tr>
<td>Scroll to the '5G NR' option and select.

Within that 5G NR option, the following is presented.

Press the 'Node…' button.</td>
<td>
</td>
</tr>
</table>

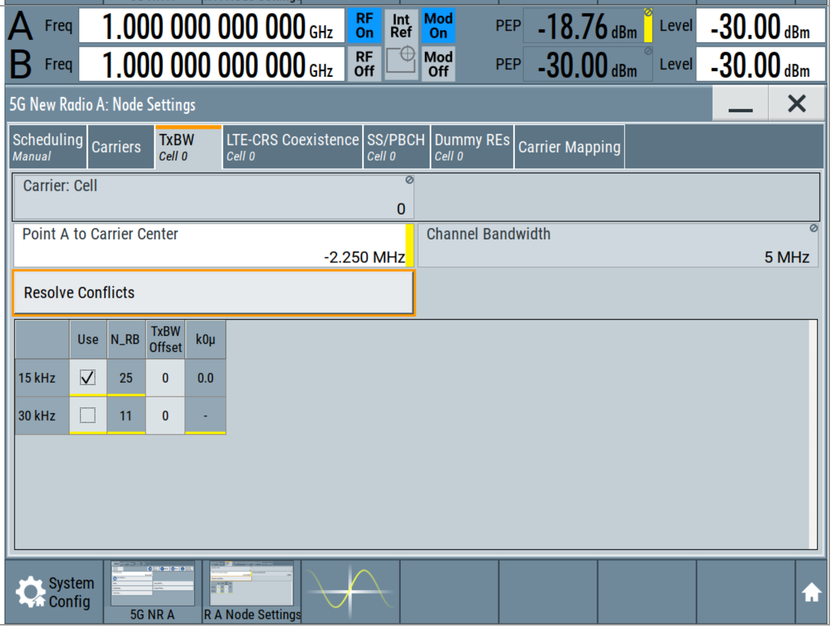
In the 'Carriers' tab make the following modifications:
'RF Phase Compensation' to OFF
'Cell ID' variable to '123' (for example)
'Channel BW' to '5MHz'



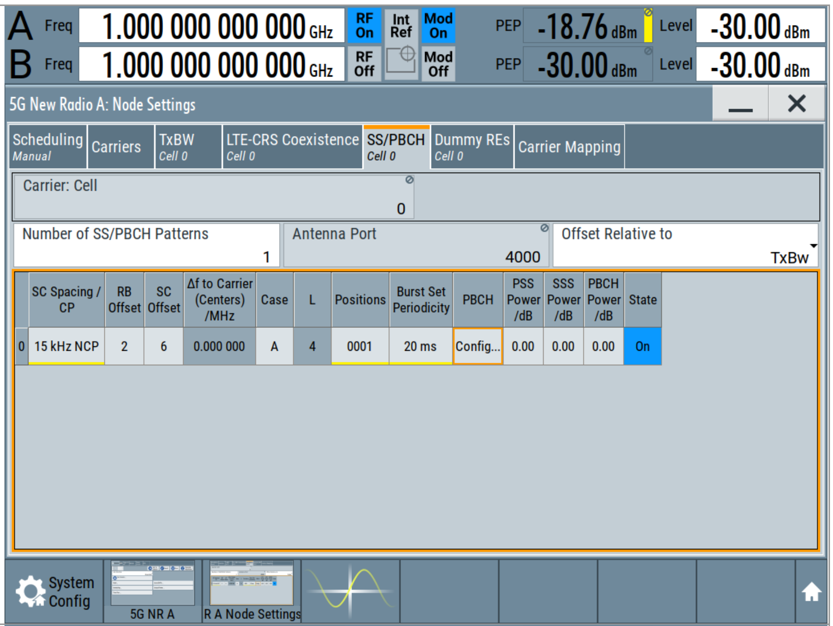
Next, select the 'TxBW' tab.

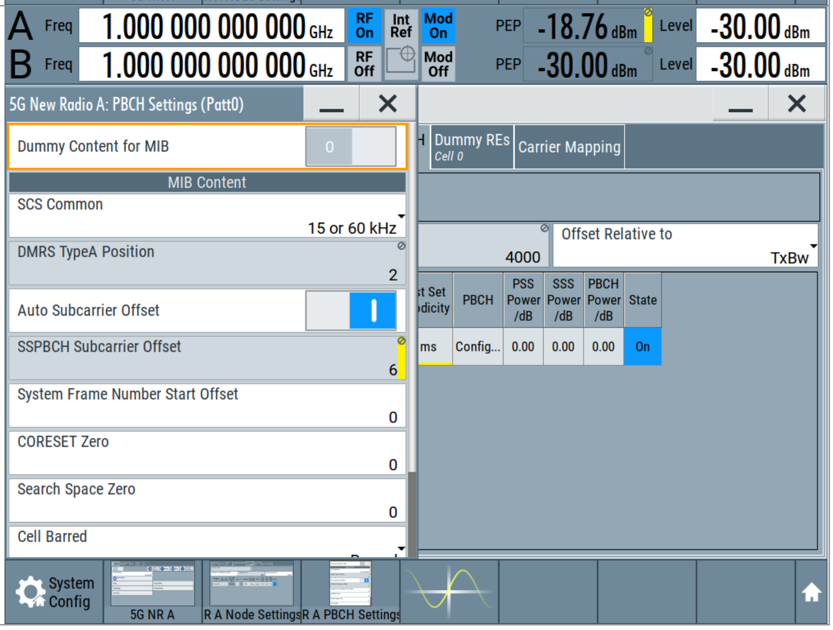
Make the following changes:
In the 'Use' column, deselect '30 kHz'
Select '15 kHz'.
Press 'Resolve Conflicts'

This resolution will modify the 'Point A to Carrier Center' value.

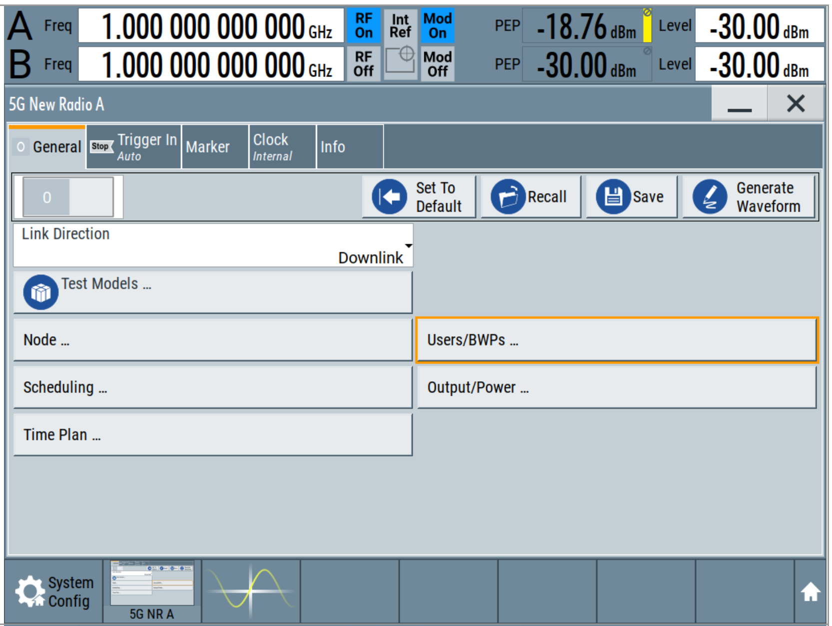
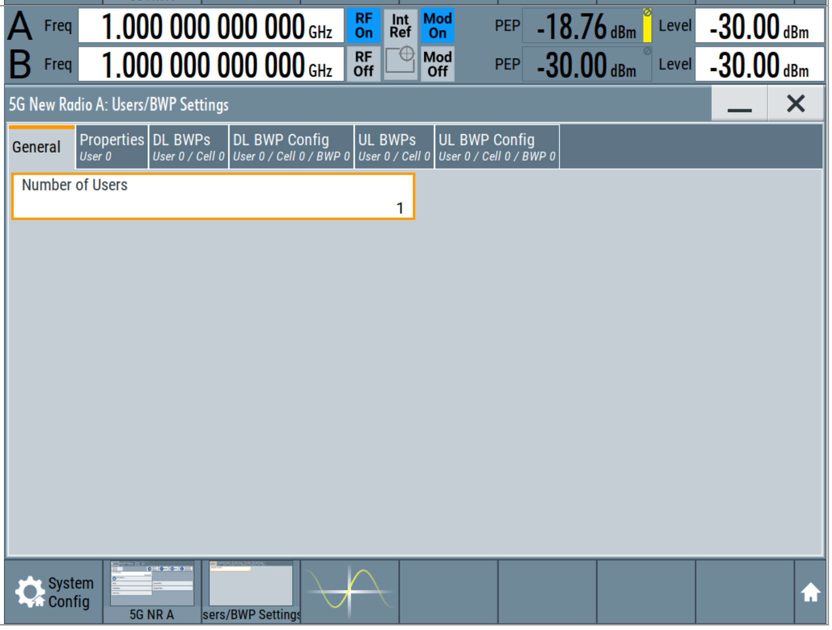


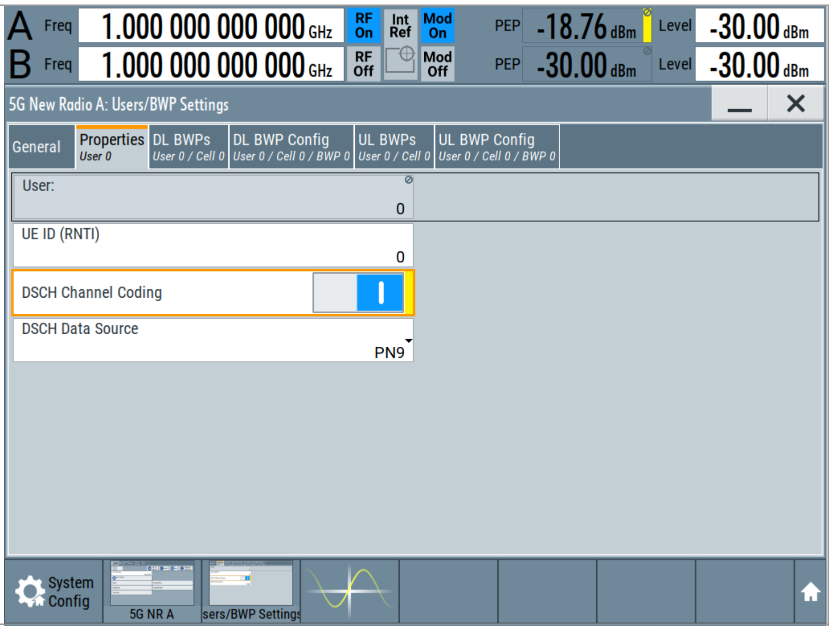
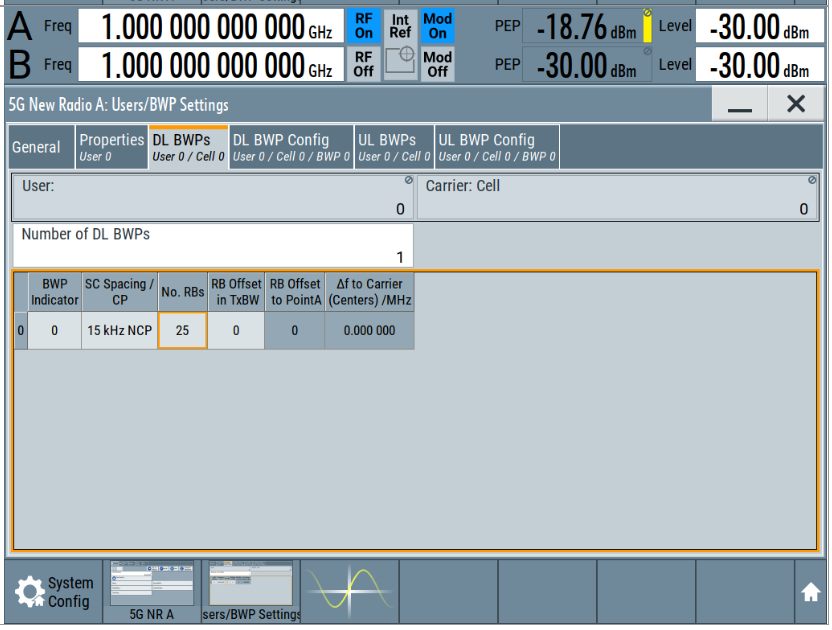
<table>
<tr>
<td>In the 'SS/PBCH' tab, make the following changes:
Set 'Number of SS/PBCH Patterns' to 1
'SC Spacing/CP' to '15 kHz'
Positions to '0001'
'Burst Set Periodicity' to '20 ms'
Ensure the State is set to 'On'.

Select the 'Config…' option under 'PBCH'…</td>
<td>


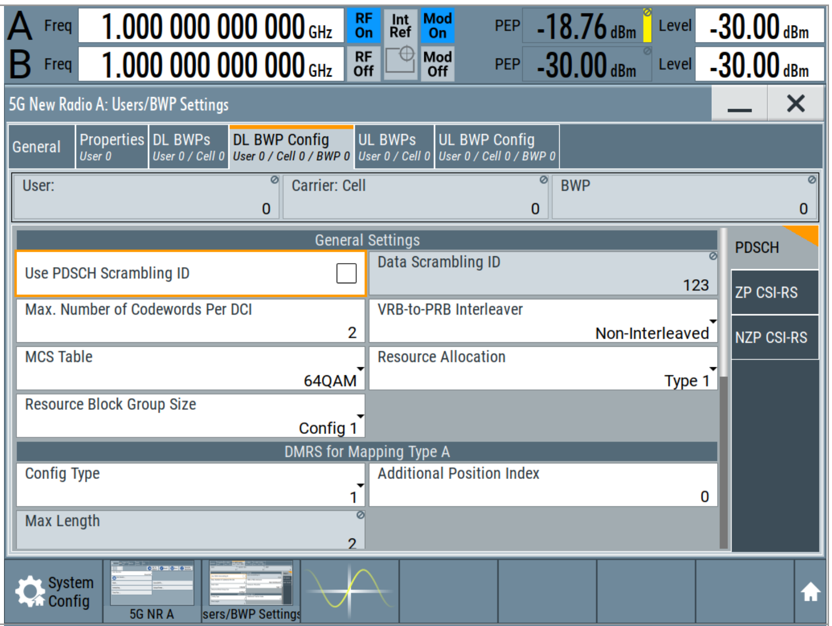
</td>
</tr>
<tr>
<td>… and ensure that 'Auto Subcarrier Offset' is switched to 'On'</td>
<td>


</td>
</tr>
</table>

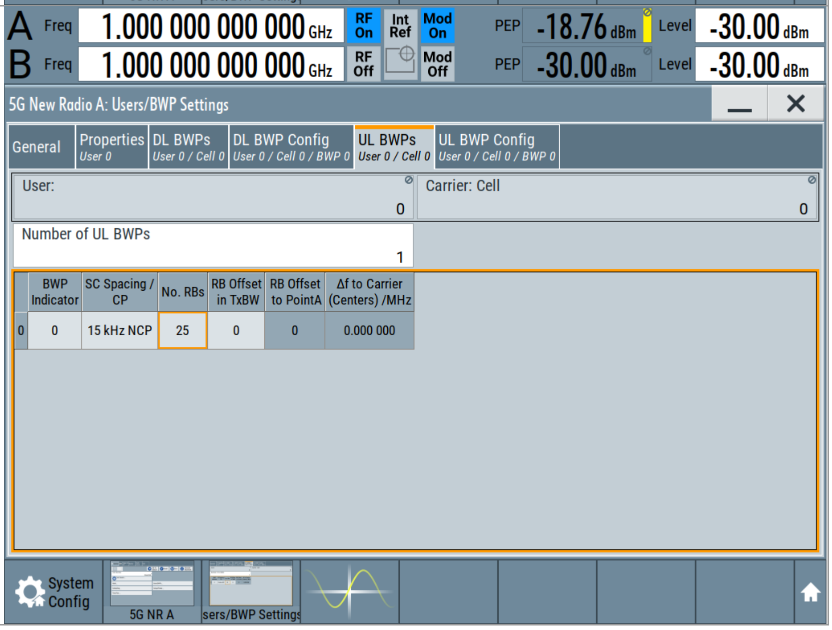
Close the 'Node …' window and press the 'Users/BWPs …' button.	
In the 'General' tab, verify that 'Number of Users' is set to '1'.	

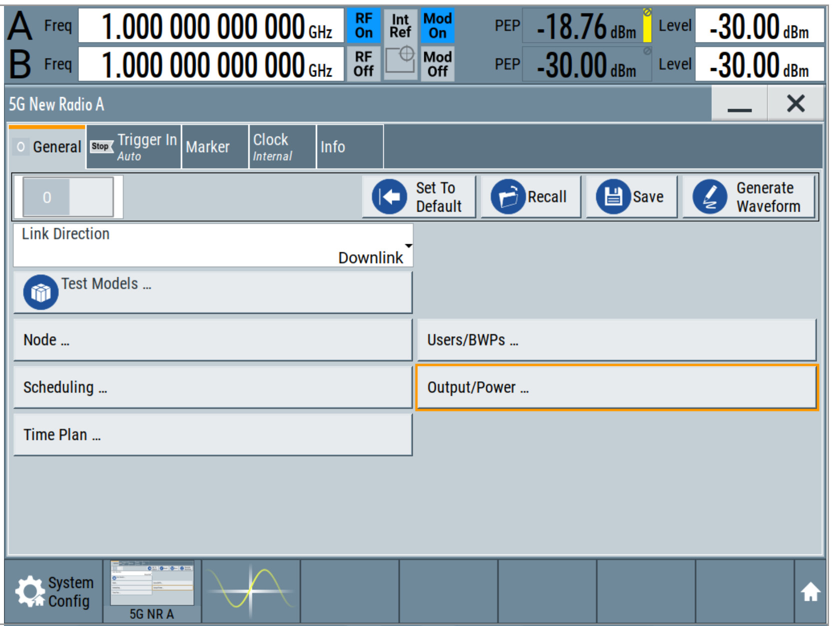
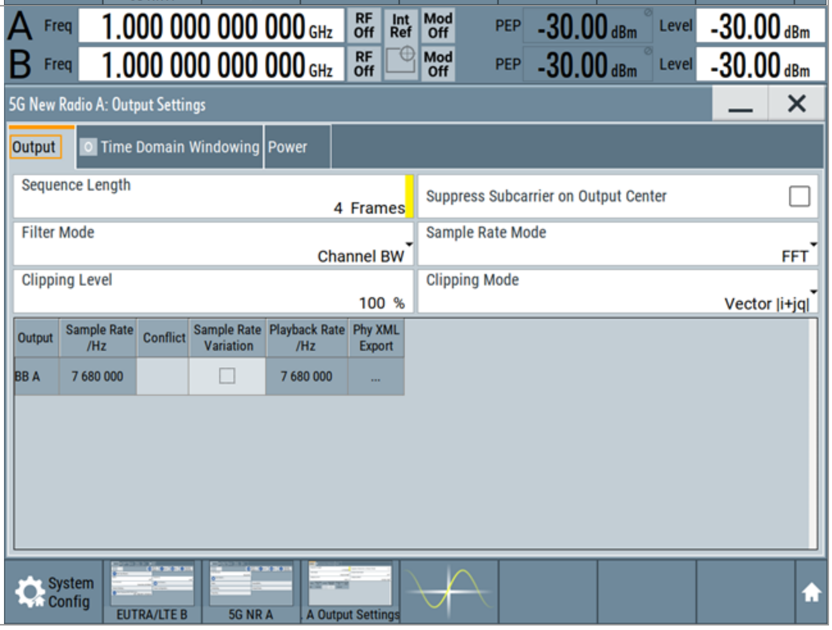
<table>
<tr>
<td>In the 'Properties' tab, switch on 'DSCH Channel Coding'</td>
<td>
</td>
</tr>
<tr>
<td>In 'DL BWPs', enter '25' for 'No. RBs'</td>
<td>
</td>
</tr>
</table>

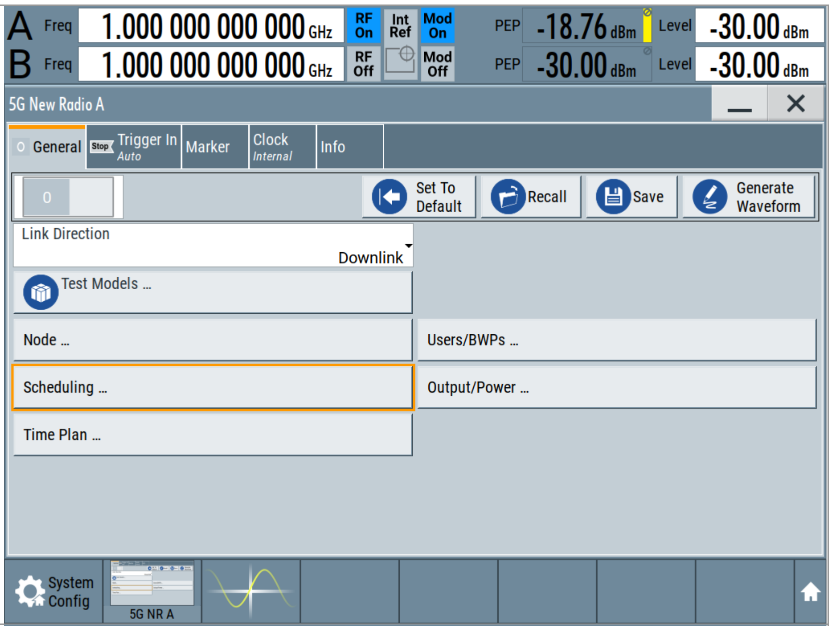
In 'DL BWP Config', ensure 'MCS Table' is set to '64QAM' and 'Resource Block Group Size' is set to 'Config 1'



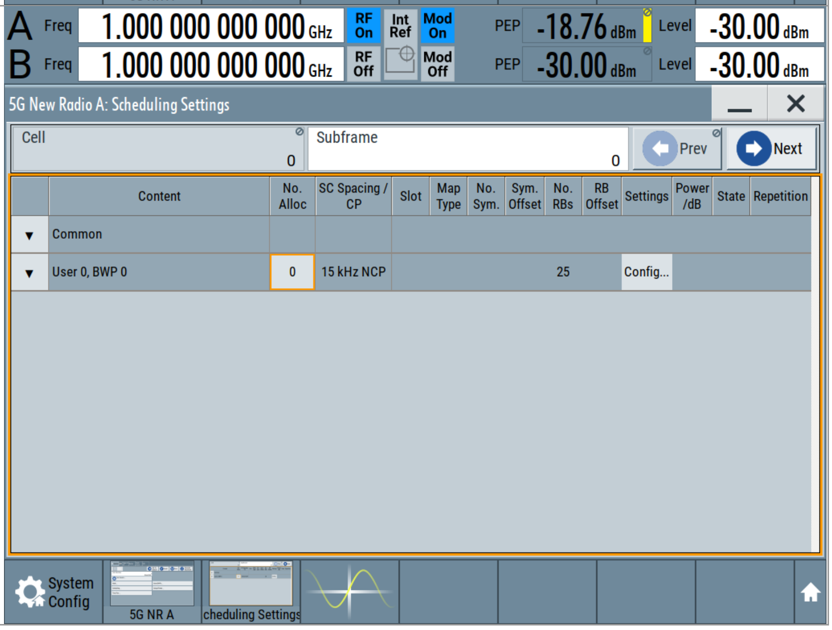
In 'UL/BWPs' select '25' for 'No. RBs'



Close the 'Users/BWPs…' window and select 'Output Power…'	
Set the 'Sequence Length' parameter to '4 Frames'	

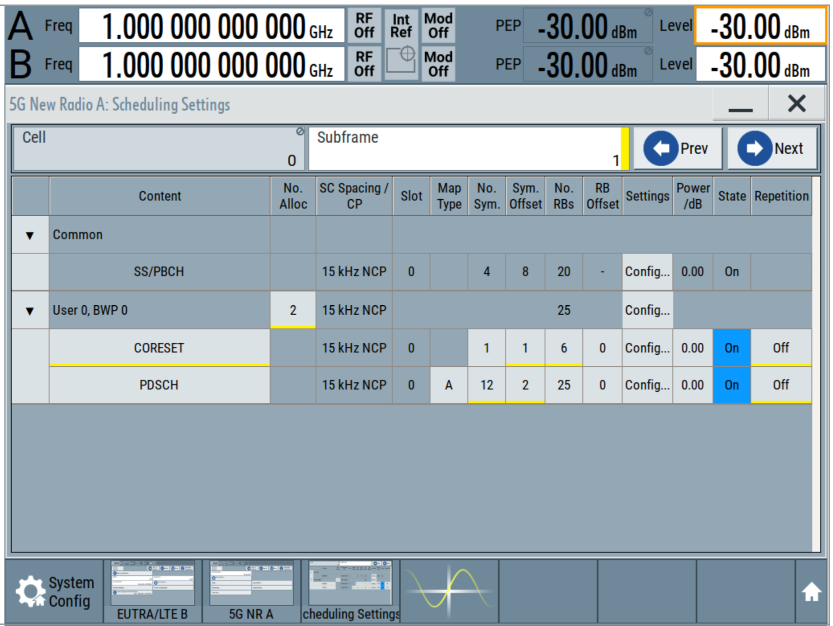
<table>
<tr>
<td>Close the 'Output Power…' window and select 'Scheduling…'</td>
<td>
</td>
</tr>
<tr>
<td>In Subframe 0, ensure a value of '0' is entered for 'No. Alloc.'.

Ensure that is the case also for Subframes {0,3,4,5,6,7,9, 10,11,12,13,14,15,16,17,18,19, 20,22,23,24,25,26,27,28,29,30, 31,32,33,34,35,36,37,38,39}

Go to Subframe 1.</td>
<td>
</td>
</tr>
</table>

In Subframe 1, make the following parameter changes:
'No. Alloc' to '2'
Select 'CORESET' in the first block.
Set 'No. Sym.' to 1
Set 'Sym. Offset' to 1
Set 'No. RBs' to '6'
Set 'Repetition' to 'Off' option

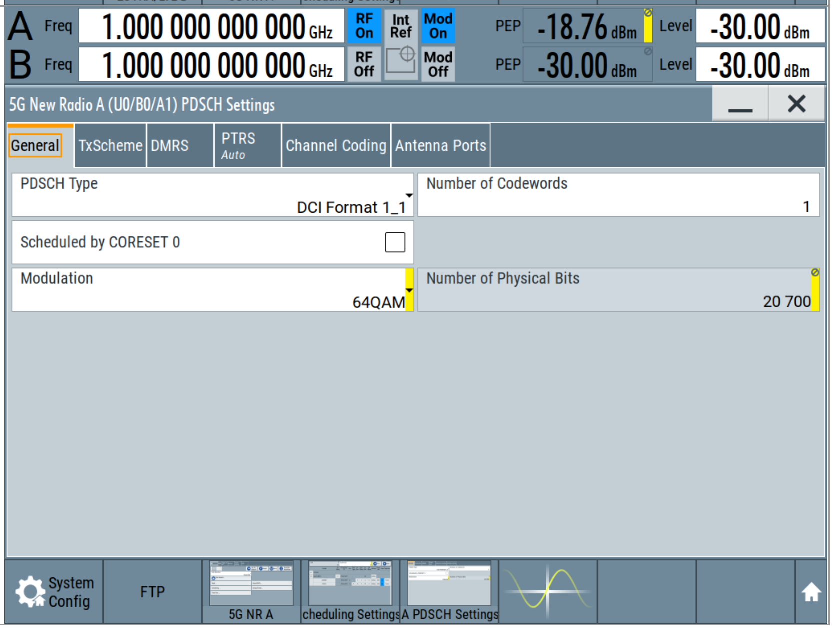
In the second row, select 'PDSCH', and modify the parameters to the values shown.



Under 'Settings', press 'Config…' for the PDSCH option and select '64QAM'.

Close the 'PDSCH Settings' tab.

Repeat these settings into 'Subframe 21'.

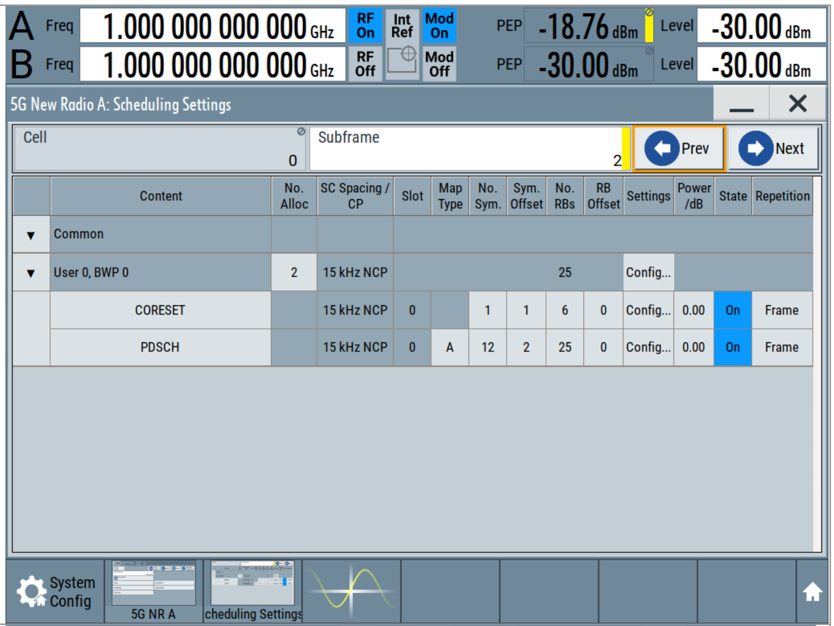


Enter a value of '2' for the 'Subframe' parameter.

Copy the settings as shown in the picture.

Again, press the 'Config' button at the intersection of 'PDSCH' and 'Settings', and select 64QAM.

Close the 'Config…' tab, to return to the screen shown.



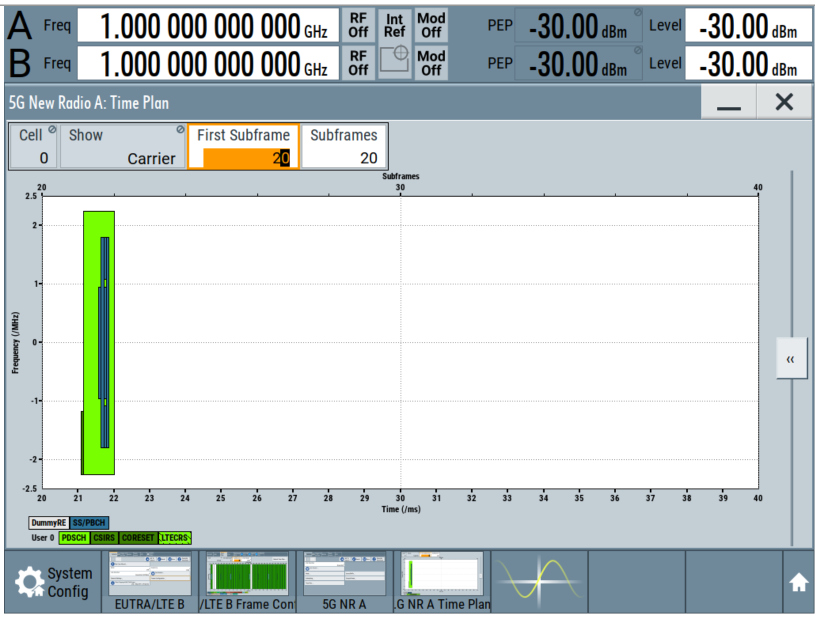
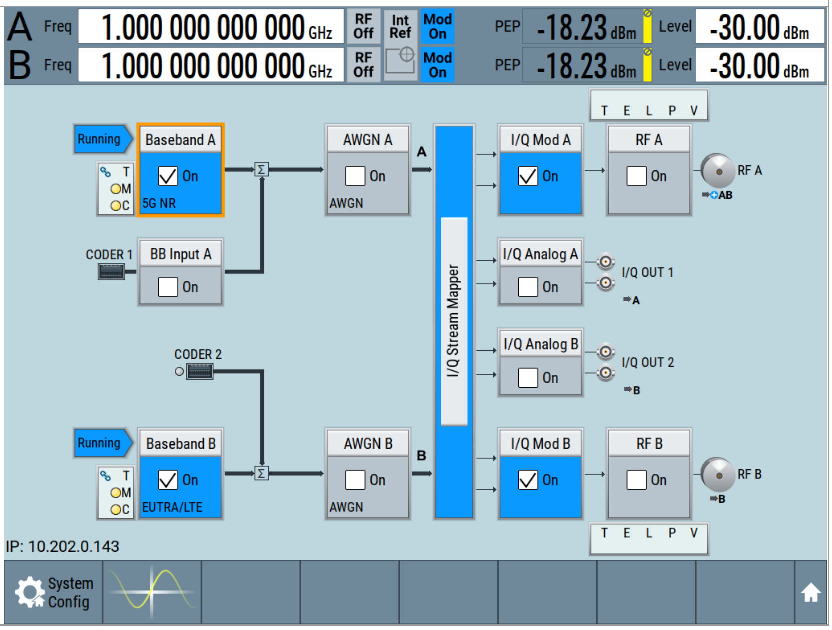
Close the 'Output/Power' tab, and select 'Time Plan'.

Enter '0' for 'First Subframe' and a value of '20' for 'Subframes'.

Assuming the process was successful, the opposite is presented in the Time Plan display of the 5G NR generator.

Similarly, a 'First Subframe' value of '20' should yield the second graphic.

Finally, return to the main '5G NR' window by closing the tab.

<table>
<tr><td></td><td>
</td></tr>
<tr><td>Returning to the Home screen, and ensuring 'On' is selected for 'Baseband A' and 'Baseband B', something similar to the picture should be shown.</td><td>
</td></tr>
</table>

Again, in case the SCPI recording was active during this session, the returned command sequence would look something like:

```
:SOURce1:BB:NR5G:TRIGger:SEQuence AAUT
:SOURce1:BB:NR5G:NODE:CELL0:CELLid 123
:SOURce1:BB:NR5G:NODE:CELL0:CBW BW5
:SOURce1:BB:NR5G:NODE:CELL0:TXBW:S15K:USE 1
:SOURce1:BB:NR5G:NODE:CELL0:TXBW:S30K:USE 0
:SOURce1:BB:NR5G:NODE:CELL0:TXBW:RESolve
:SOURce1:BB:NR5G:NODE:CELL0:NSSPbch 1
:SOURce1:BB:NR5G:NODE:CELL0:SSPBch0:SCSPacing N15
:SOURce1:BB:NR5G:NODE:CELL0:SSPBch0:POSition #H1,4
:SOURce1:BB:NR5G:NODE:CELL0:SSPBch0:BSPeriodicty BS20
```

```
:SOURce1:BB:NR5G:UBWP:USER0:DSCH:CCODing:STATe 1
:SOURce1:BB:NR5G:UBWP:USER0:CELL0:DL:BWP0:RBNumber 25
:SOURce1:BB:NR5G:UBWP:USER0:CELL0:UL:BWP0:RBNumber 25
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF0:USER0:BWPart0:NALLoc 0
:SOURce1:BB:NR5G:OUTPut:SEQLen 4
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF1:USER0:BWPart0:NALLoc 2
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF1:USER0:BWPart0:ALLoc0:CONTent COR
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF1:USER0:BWPart0:ALLoc0:SYMoffset 1
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF1:USER0:BWPart0:ALLoc0:RBNumber 6
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF1:USER0:BWPart0:ALLoc0:REPetitions OFF
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF1:USER0:BWPart0:ALLoc1:SYMNumber 12
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF1:USER0:BWPart0:ALLoc1:SYMoffset 2
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF1:USER0:BWPart0:ALLoc1:REPetitions OFF
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF1:USER0:BWPart0:ALLoc1:CW0:MOD QAM64
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:USER0:BWPart0:NALLoc 2
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:USER0:BWPart0:ALLoc0:CONTent COR
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:USER0:BWPart0:ALLoc0:SYMoffset 1
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:USER0:BWPart0:ALLoc0:RBNumber 6
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:USER0:BWPart0:ALLoc0:REPetitions OFF
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:USER0:BWPart0:ALLoc1:REPetitions OFF
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:USER0:BWPart0:ALLoc1:SYMNumber 12
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:USER0:BWPart0:ALLoc1:SYMoffset 2
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:USER0:BWPart0:ALLoc1:CW0:MOD QAM64
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF2:USER0:BWPart0:NALLoc 2
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF2:USER0:BWPart0:ALLoc0:CONTent COR
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF2:USER0:BWPart0:ALLoc0:SYMoffset 1
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF2:USER0:BWPart0:ALLoc0:RBNumber 6
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF2:USER0:BWPart0:ALLoc0:REPetitions OFF
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF2:USER0:BWPart0:ALLoc1:SYMNumber 12
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF2:USER0:BWPart0:ALLoc1:SYMoffset 2
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF2:USER0:BWPart0:ALLoc1:REPetitions OFF
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF2:USER0:BWPart0:ALLoc1:CW0:MOD QAM64
```

Example SCPI recording from following the documented sequence.

3.3 SCPI Command Method

The SCPI sequences required to complete the instrument set-up is as follows.

The first sequence sets up the instrument generally, for frequency, output power, etc.

```
*RST
:SCONfiguration:APPLy
:SCONfiguration:OUTPut:MAPPing:RF1:MODE Add
:SCONfiguration:OUTPut:MAPPing:RF1:STReam2:STATe 1
:OUTPut1:STATe 1
:SOURce1:FREQuency:CW 850000000
:SOURce1:POWer:POWer -10
```

Step 1: SCPI command sequence to prepare the Generator's general settings.

The second part of the sequence creates an empty LTE kernel, .ready for loading with LTE subframes (and later, 5G subframes).

Critically, this sequence contains the (exemplary) command:
`:SOURce2:BB:EUTRa:DL:MBSFn:SC:AVAL 12584960`

The value transmitted with this command (e.g. 12584960) configures the MBSFN subframes in the four frames.

Up to six subframes of MBSFN content, per frame may be transmitted, meaning 24 subframes within a four frame signal. The MBSFN allowed subframes are {1, 2, 3, 6, 7, 8, 11, 12 … 36, 37, 38}.

The subframes allocated to MBSFN are communicated by SCPI using a decimal quantity. In this example case, 12584960 is the decimal representation of the binary '110000000000100000000000', where Frame 0, Subframe 1 is the MSB and Frame 3 Subframe 8 is the LSB.

Note that front panel or manual entry of this quantity is performed in HEX, 'C00800'.

```
:SOURce2:BB:EUTRa:STATe 0
:SOURce2:BB:EUTRa:PRESet
:SOURce2:BB:EUTRa:TRIGger:OUTPut1:MODE REST
:OUTPut1:USER1:SIGNal MARKB1
:SOURce2:BB:EUTRa:DL:BW BW5_00
:SOURce2:BB:EUTRa:DL:MBSFn:MODE MIX
:SOURce2:BB:EUTRa:DL:MBSFn:SC:APER AP4
:SOURce2:BB:EUTRa:DL:MBSFn:SC:AMODe F4
:SOURce2:BB:EUTRa:SLENgth 4
:OUTPut1:USER1:SIGNal MARKB1
:SOURce2:BB:EUTRa:TRIGger:OUTPut1:MODE REST
:SOURce2:BB:EUTRa:DL:MBSFn:SC:AVAL 12584960
:SOURce2:BB:EUTRa:DL:MBSFn:AI:NMRL 1
:SOURce2:BB:EUTRa:DL:MBSFn:AI:MCCH:STATe 0
:SOURce2:BB:EUTRa:DL:MBSFn:PMCH0:STATe 0
:SOURce2:BB:EUTRa:DL:CONSubframes 40
:SOURce2:BB:EUTRa:DL:DUMD:OPSubframes 1
:SOURce2:BB:EUTRa:DL:SUBF0:ALCount 3
:SOURce2:BB:EUTRa:DL:SUBF0:ALLoc2:CW1:MODulation QAM16
:SOURce2:BB:EUTRa:DL:SUBF0:ALLoc2:CW1:RBCount 25
```

Step 2: SCPI command sequence, to prepare the LTE MBSFN feature with 4 frames, ready for LTE payload entry.

The third sequence prepares the 5G personality, in baseband A, as with LTE, ready for payload creation.

```
:SOURce1:BB:NR5G:STATe 0
:SOURce1:BB:NR5G:PRESet
:SOURce1:BB:NR5G:TRIGger:SEQuence AAUT
:SOURce1:BB:NR5G:NODE:CELL0:CELLid 457
:SOURce1:BB:NR5G:NODE:CELL0:CBW BW5
:SOURce1:BB:NR5G:NODE:RFPHase:STATe 0
:SOURce1:BB:NR5G:NODE:CELL0:TXBW:S15K:USE 1
:SOURce1:BB:NR5G:NODE:CELL0:TXBW:S30K:USE 0
:SOURce1:BB:NR5G:NODE:CELL0:TXBW:RESolve
:SOURce1:BB:NR5G:NODE:CELL0:NSSPbch 2
:SOURce1:BB:NR5G:NODE:CELL0:NSSPbch 1
:SOURce1:BB:NR5G:NODE:CELL0:SSPBch0:SCSPacing N15
```

```
:SOURce1:BB:NR5G:NODE:CELL0:SSPBch0:POSition #H1,4
:SOURce1:BB:NR5G:NODE:CELL0:SSPBch0:BSPeriodicty BS20
:SOURce1:BB:NR5G:UBWP:USER0:DSCH:CCODing:STATe 1
:SOURce1:BB:NR5G:UBWP:USER0:CELL0:DL:BWP0:RBNumber 25
:SOURce1:BB:NR5G:UBWP:USER0:CELL0:UL:BWP0:RBNumber 25
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF0:USER0:BWPart0:NALLoc 0
:SOURce1:BB:NR5G:OUTPut:SEQLen 4
```

Step 3: SCPI command sequence for creating the 5G NR signal frame sequence, ready for payload programming

Into each of the 40 frames now created, and with MBSFN subframes allocated, the LTE or 5G payloads can be inserted.

Again, note that in a sequence of 0~39 subframes, {0, 4, 5, 9, 10, 14 … 35, 39} must be LTE, and {1, 21} must be 5G. The content of the other subframes is defined by the MBSFN declaration. Into every subframe (MBSFN or not), an LTE PDCCH must be inserted. Into every 10th frame {0, 10, 20, 30}, a PBCH allocation is required.

For each subframe in turn, we program one of the following three scenarios.

The suffix to `:SUBF10:` denotes the subframe (e.g. 10), and needs to be modified/incremented to a value in the range 0~39.

In an automated script, this might be most efficiently performed using a '`for… next`' loop (or equivalent). Indeed, in the supplied MATLAB® example, that is how it is presented.

```
:SOURce2:BB:EUTRa:DL:SUBF7:ALCount 2
:SOURce2:BB:EUTRa:DL:SUBF7:ALLoc1:CW1:MODulation QAM16
:SOURce2:BB:EUTRa:DL:SUBF7:ALLoc1:CW1:RBCount 25
```

```
:SOURce2:BB:EUTRa:DL:SUBF10:ALCount 3
:SOURce2:BB:EUTRa:DL:SUBF10:ALLoc2:CW1:MODulation QAM16
:SOURce2:BB:EUTRa:DL:SUBF10:ALLoc2:CW1:RBCount 25
```

```
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:NALLoc 2
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:ALLoc0:CONTent COR
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:ALLoc0:SYMoffset 1
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:ALLoc0:RBNumber 6
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:ALLoc0:REPetitions OFF
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:ALLoc1:SYMNumber 12
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:ALLoc1:SYMoffset 2
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:ALLoc1:REPetitions OFF
:SOURce1:BB:NR5G:SCHed:CELL0:SUBF21:ALLoc1:CW0:MOD QAM64
```

Step 4: Three potential, and example, payload programming sequences for (1) LTE subframes other than {0,10,20,30}, (2) for LTE subframes {0, 10, 20, 30}, and finally for MBSFN 5G subframes.

Finally, with command sequences for initialization, MBSFN frame creation, payload programming already performed, the last step is to switch on the modulation, enabling the sequence to be generated.

```
:SOURce2:BB:EUTRa:STATe 1
:SOURce1:BB:NR5G:STATe 1
:SOURce1:BB:NR5G:TRIGger:EXECute
```

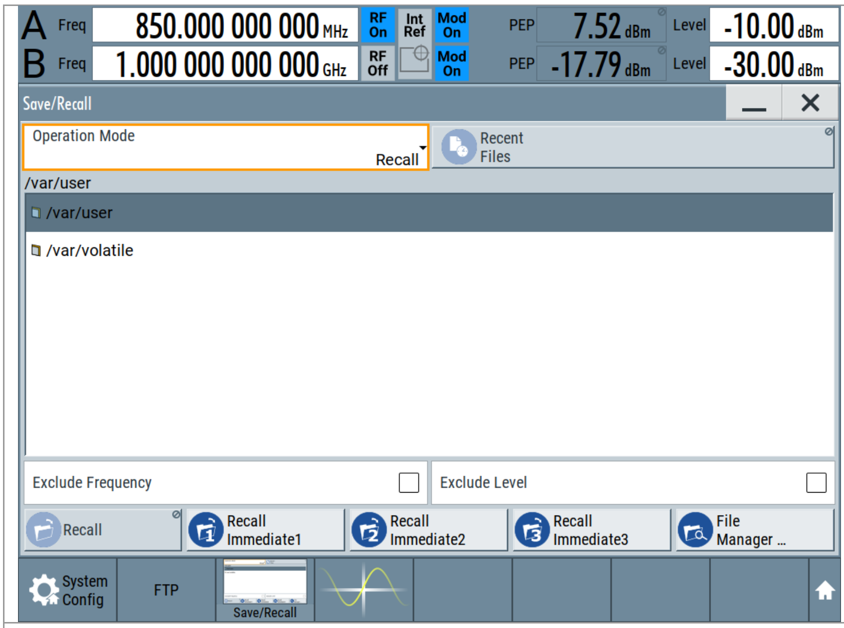
Step 5: Compile the signals defined in both basebands and trigger.

3.4 Configuration File Method

The configuration file is provided as a separate download. Please visit the Application Note webpage (address provided on the front cover).

The configuration file may be transferred to the instrument using a network protocol (e.g. SMB or FTP) or a USB memory stick.

Once the file is made available to the instrument, simply press the 'Save/Rcl' hard-key, select the 'Recall' option from the 'Operation Mode' scrollbar. Then, point the to the file's location.



Press the 'Save/Rcl' hard-key, select 'Recall' from the 'Operation Mode' scroll-box and point to the setup file location.

4 Signal Analyzer: FSW

4.1 Introduction

This example assumes a 10 subframe long LTE signal partially loaded with two 5G subframes, as defined in the previous section.

The two components of the DSS signal, LTE and 5G, are analyzed independently using their measurement personalities.

The signal analyzer may be set-up in several ways. Three exemplary ways demonstrated here are:

- manual entry (front panel, real or virtual)
- remote control using SCPI commands
- uploading a configuration file (.dfl)

Regardless of which set-up methodology is shown, the end result is the same.

The user may modify some or other of the parameters to suit their own specific test case needs.

4.2 Manual Entry using the GUI

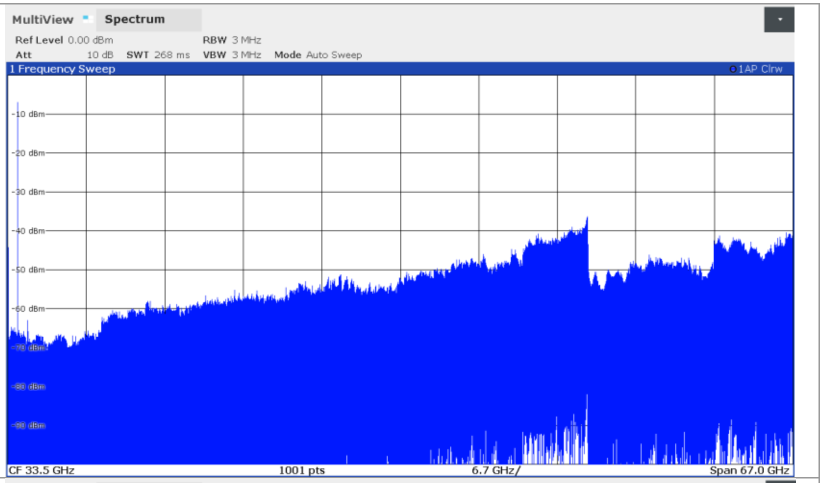
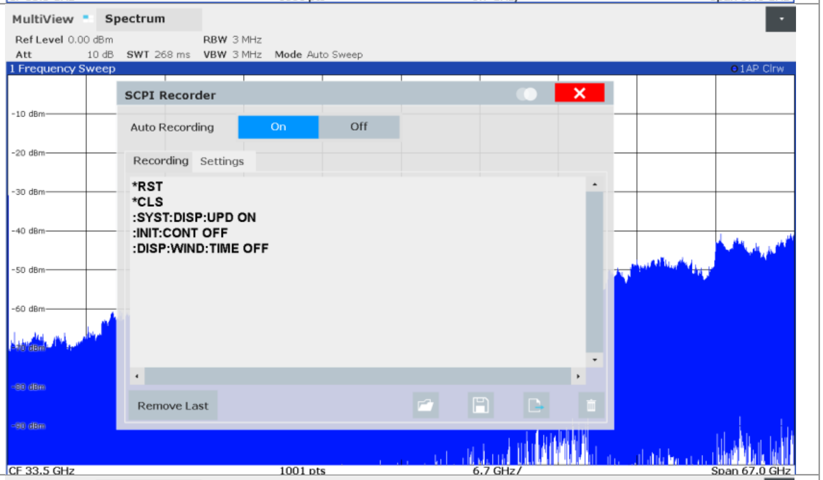
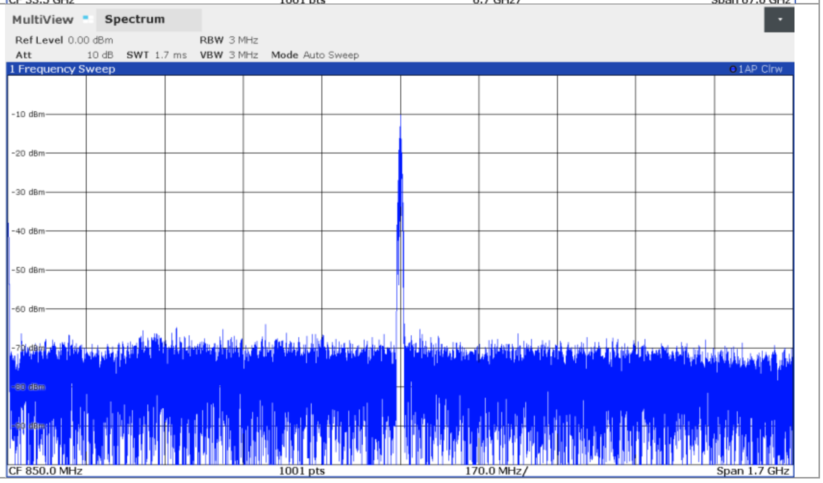
Before describing the manual set-up, it is worthwhile noting the existence of the SCPI recording feature, a productivity feature enabling faster, more repeatable testing.

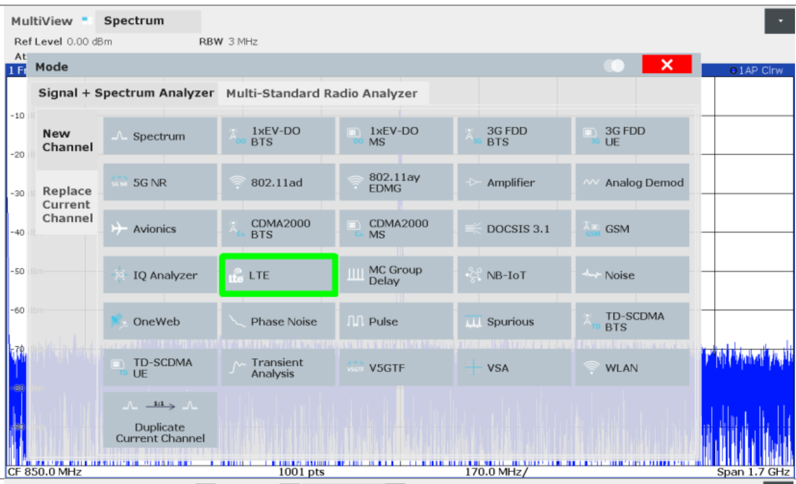
This is especially so for relatively lengthy parameter setting processes, where one or more parameters might need to be changed.

Alternatively, if the intention is to migrate to a production testing, this feature will also come in useful.

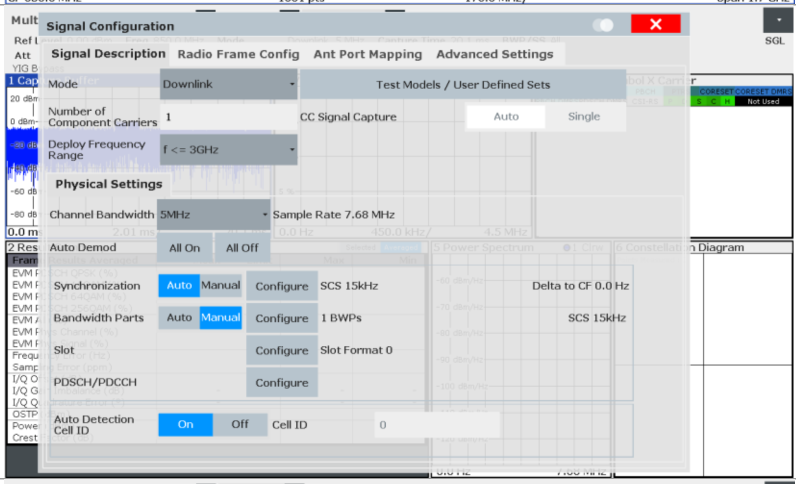
The SCPI Recorder can be started, paused and stopped at any time, similarly the contents of the sequence viewed and exported for re-use.

Set up of the FSW using the touchscreen or web interface is as follows.

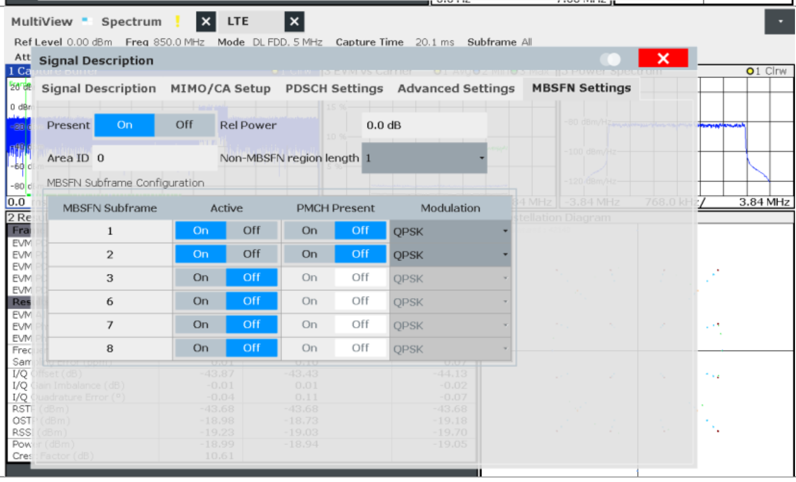
Start with the Analyzer in its Preset state.	
Optionally, invoke the SCPI recorder, to capture the command sequences used. At the end of the process, the instrument state may also be saved, in a proprietary file format.	
Select the common features (e.g. frequency, attenuation, etc.) For this example, press the 'Frequency' hard-key and enter a value of 850MHz.	

<table>
<tr>
<td>
Press the 'Mode' hard-key and invoke the LTE personality.
</td>
<td>


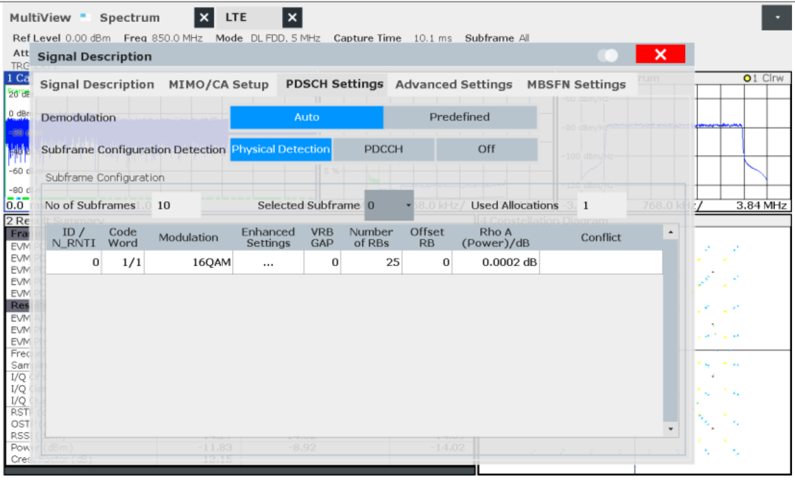
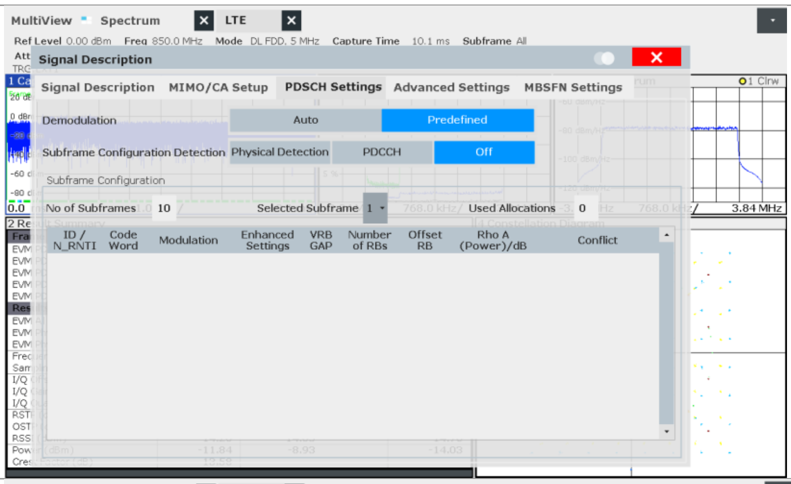
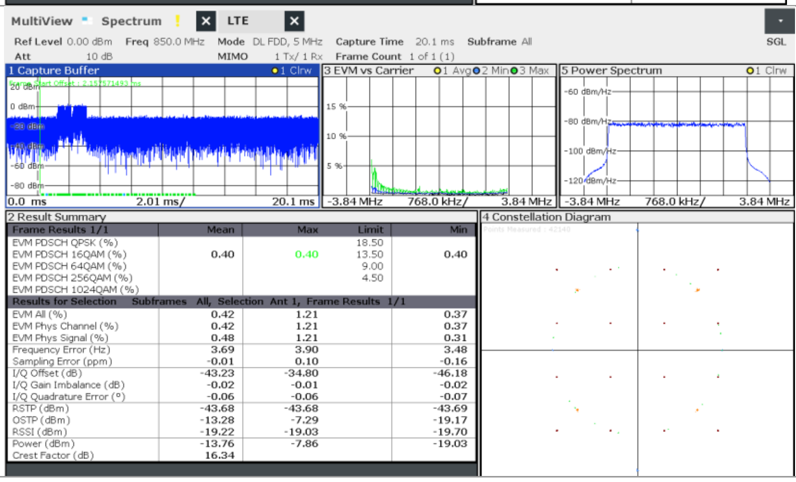
</td>
</tr>
<tr>
<td>
Press 'Signal Description' in the top right.

From the scroll-box of 'Channel Bandwidth', select '5MHz'
</td>
<td>


</td>
</tr>
<tr>
<td>
Select the 'MBSFN Settings' tab.

Set up the values as shown, i.e.;
'Present' to 'On'
'Non-MBSFN region length' set to '1'
'MBSFN Subframe' 1 and 2 set to 'Active'
</td>
<td>


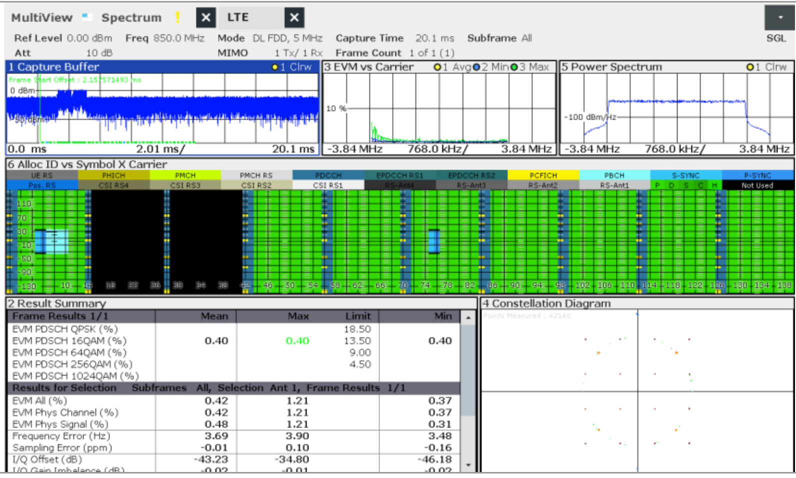
</td>
</tr>
</table>

Meanwhile, in the PDSCH tab, the default value will have detected the presence of modulation types. Switch Demodulation to 'Predefined' and 'Subframe Configuration Detection' to 'Off'. Ensure that values for 'Modulation' and 'Number of RBs' for Subframe '0' are as shown. Open the scroll-box for 'Selected Subframe', and verify the same settings have been automatically detected for subframes {0, 3, 4, 5, 6, 7, 8, 9}	
Choose a value of '1' for 'Selected Subframe' and modify 'Used Allocations' to '0'. Recall that Subframes 1 and 2 will be packed with 5G NR payloads. Repeat for 'Selected Subframe' case '2', ensure that 'Used Allocations' is set to '0'.	
A first set of measurement results should now be visible, on closing the 'Signal Description' window.	

Those results may be augmented, for example, by pressing 'Meas. Config' hard-key, and dragging 'Alloc ID vs Symbol X Carrier'.

The 2 empty MBSFN subframes, configured earlier, are clearly visible.

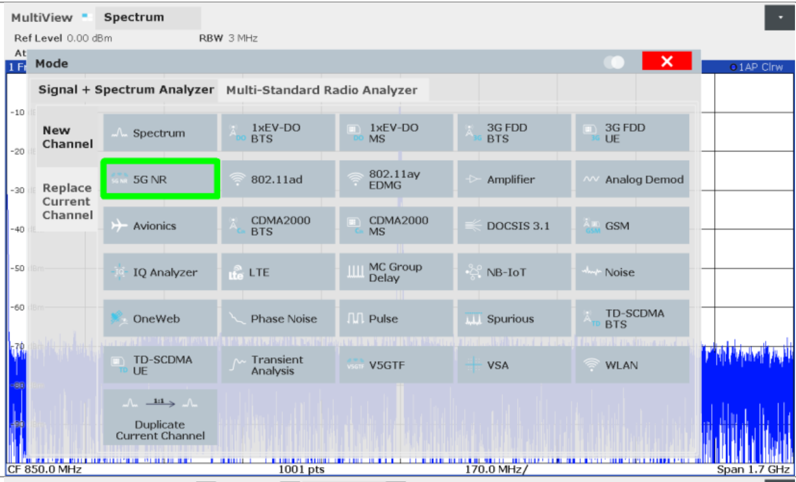
Metrics for, and constellation diagram of, the 16QAM LTE payloads are reported.



Measurement of the LTE part of the DSS scenario is now complete.

The three 5G NR subframes spread across the four frame long DSS signal are measured in the 5G NR personality.

Press the 'Mode' hard-key and select the 5G NR personality.

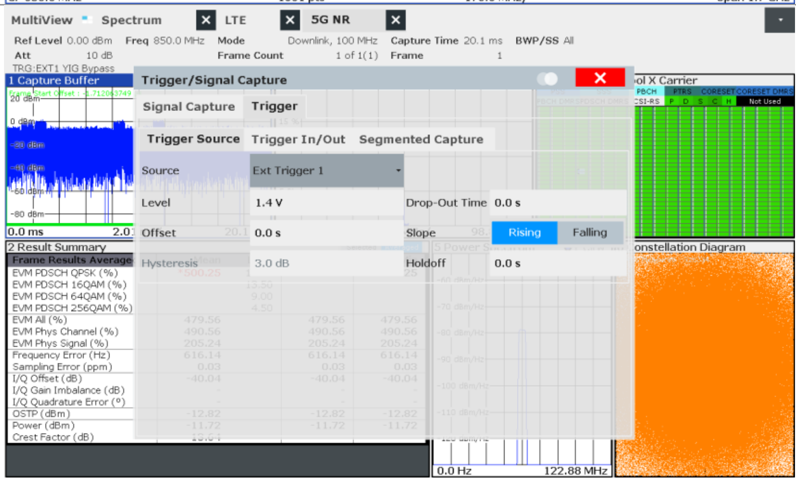


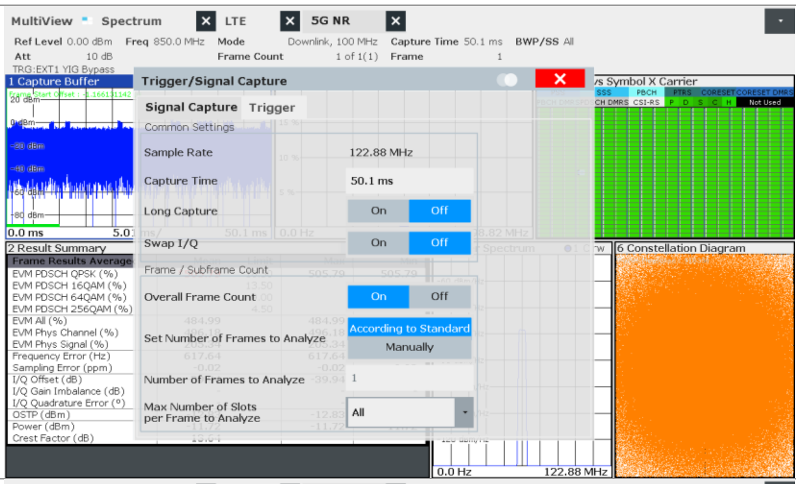
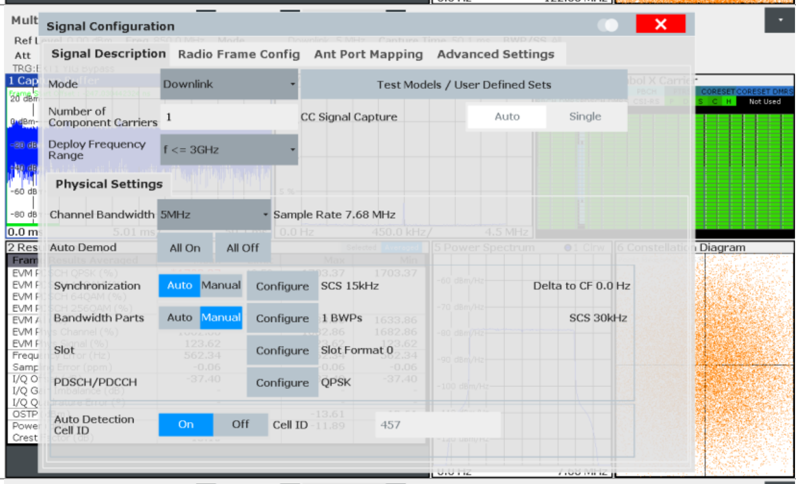
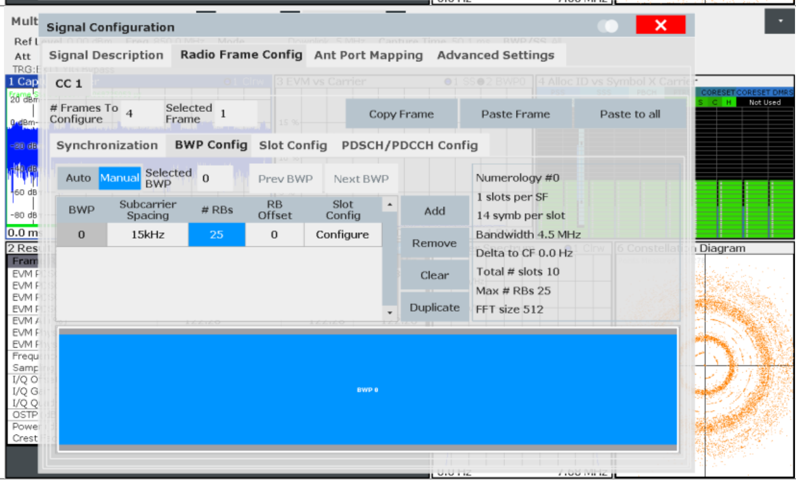
Firstly, the triggering and capture length are set-up.

In the 'Trigger' tab, select 'Ext Trigger 1', ensure that offset is set to zero.

In the 'Signal Capture' tab, select a value great than 40ms, which corresponds to 4 frames. In this case, 50.1ms is used.

'Set Number of Frames to Analyze' should be set to 'Manually' and '4' entered for 'Number of Frames to Analyze'.



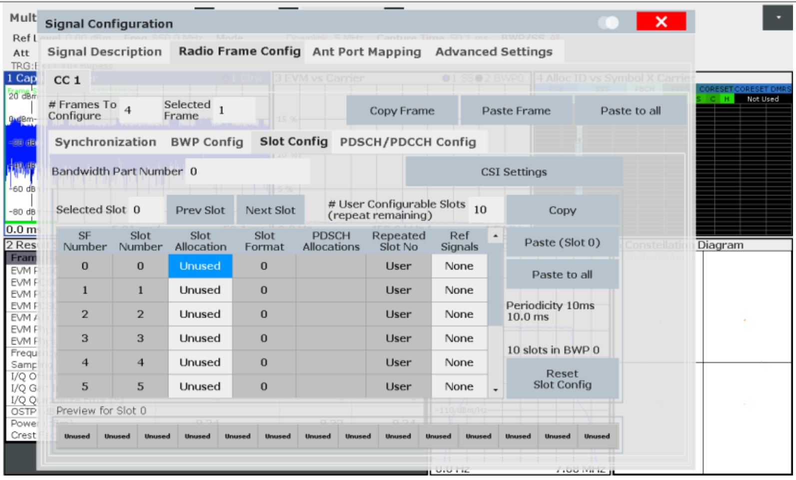
	
Select the 'Signal Description' menu. From the 'Signal Description' tab, enter '5MHz' for the 'Channel Bandwidth'	
Select the 'Radio Frame Config.' tab, and the 'BWP Config' subtab. Modify the 'Subcarrier Spacing' and '#RBs' parameters as shown. Change the '#Frames To Configure' to '4' There is now a repository of 40 subframes, which can be configured individually, or in bulk.	

In the example case, there are more LTE than 5G payloads to analyze, It is more efficient to create bulk 'Unused' (i.e. LTE) slots.

To enable bulk copy-pasting, enter a value 10 in '# User Configurable Slots'

In slot '1', choose 'Unused' from the scroll-box.
Then hit 'Copy' (not 'Copy Frame') and 'Paste to all'.

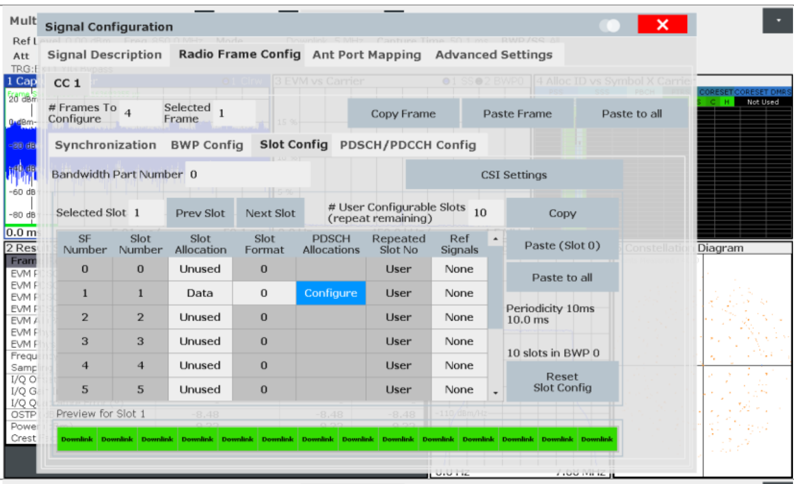
At this point, the completely blank frame, comprising 10 'Unused' slots, may itself be copied and pasted into the 4 frames (use the 'Copy Frame' and 'Paste to all')



Then, the 10 individual 5G NR loaded slots can be programmed.

For 'SF Number' 1, choose 'Data' from 'Slot Allocation'.

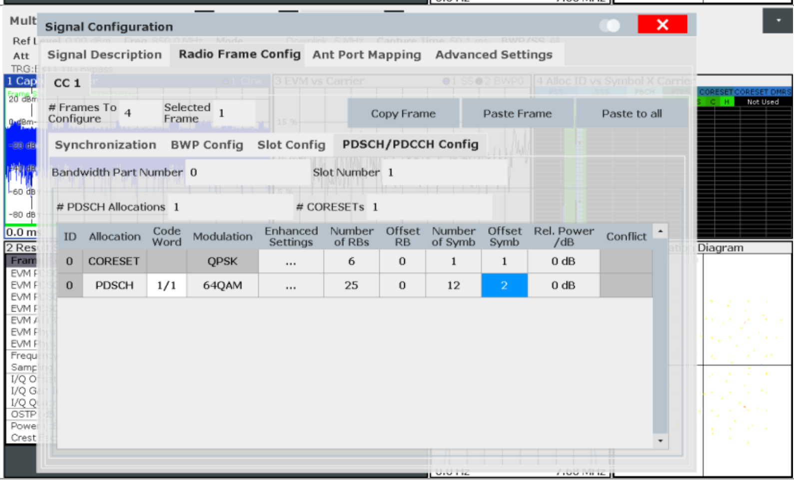
Press the 'Configure' button that appears.



The payload of the 5G slot must now be defined.

Copy the values shown for 'Modulation', 'Number of RBs', 'Number of Symb.' And 'Offset Symb'.

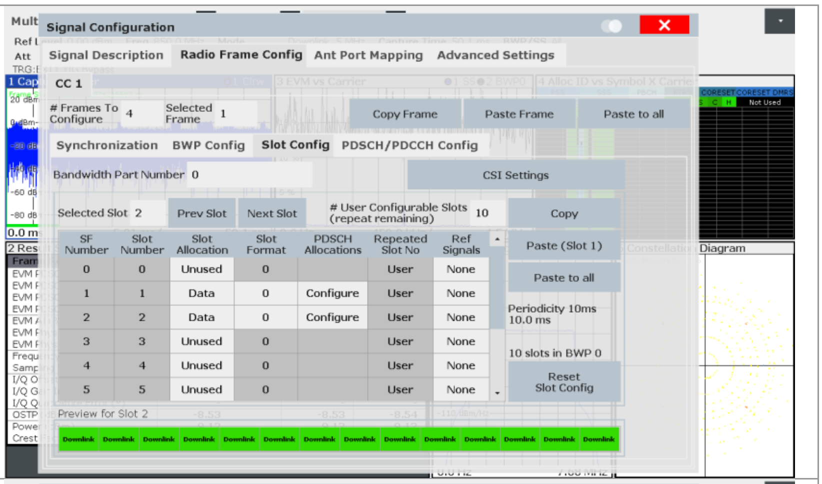
Press the 'Slot Config' sub-tab when complete, to go back.



Press 'Copy', to copy this prototype 5G slot.

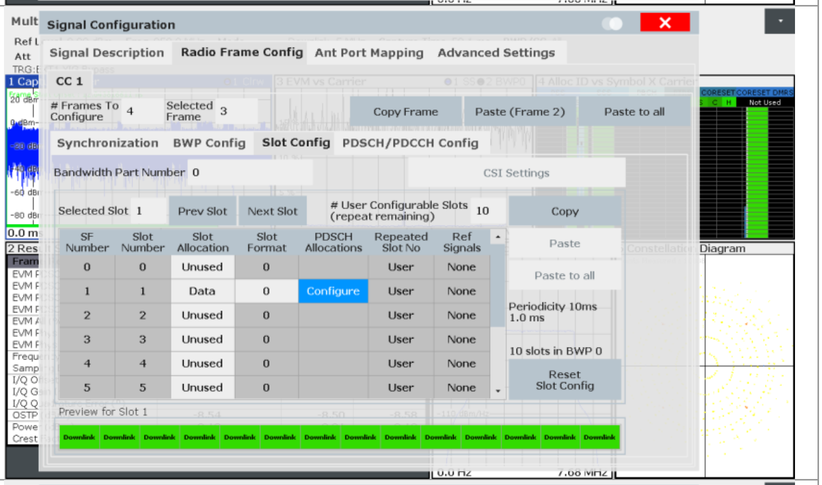
Select 'SF Number' 2, and press 'Paste'.

It just remains to configure the remaining slot, in subframe 21.

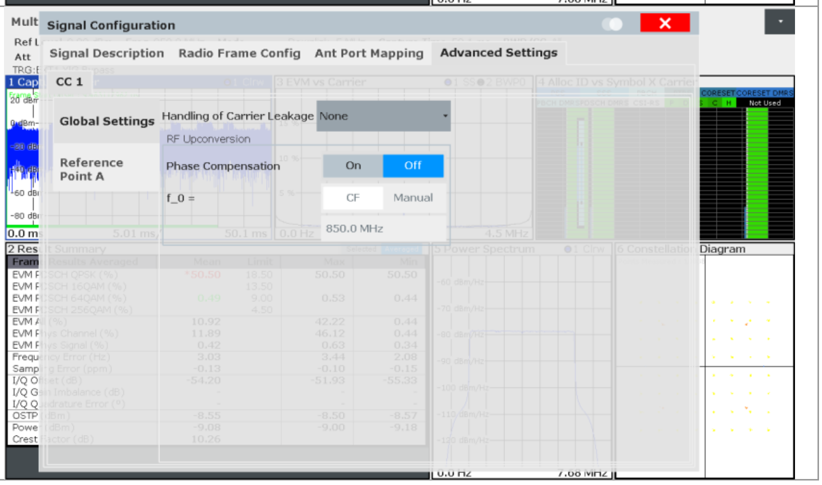


Enter a value '3' for 'Selected Frame'.

In Slot 1, repeat the configuration steps detailed previously.

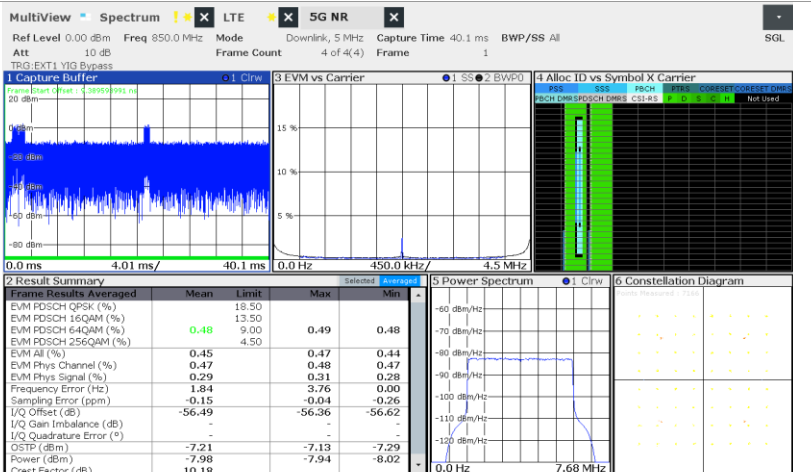


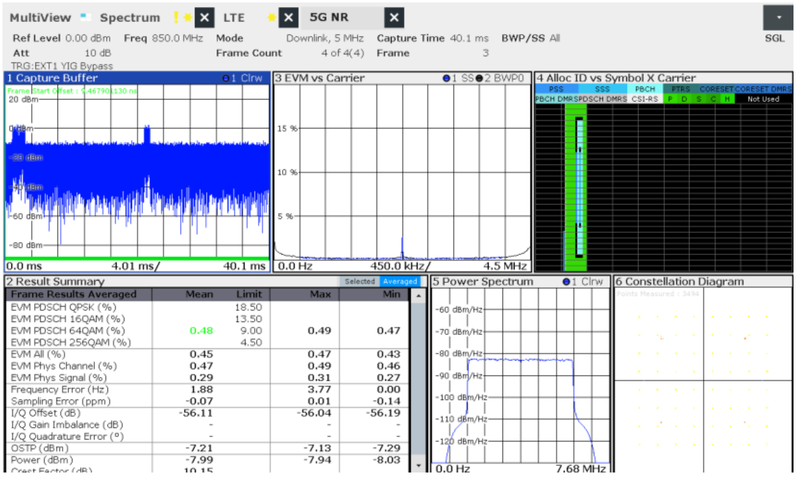
Finally, in the 'Advanced Settings' tab, set 'Phase Compensation' to 'Off'.



The 4 frames, containing 3 slots of 5G payloads may now be individually inspected.

Press 'Evaluation Range' to choose the current frame of analysis (1~4)





Following the documented procedure, with the SCPI Recorder feature invoked from the start would yield a command sequence similar to…

```
*RST
*CLS
:SYST:DISP:UPD ON
:INIT:CONT OFF
:INST:CRE:NEW LTE, 'LTE'
:INIT:CONT OFF
:SENS:SWE:TIME 0.0101
:TRIG:SEQ:SOUR EXT
:CONF:LTE:DL:CC:BW BW5_00
:CONF:LTE:DL:CC:MBSF:STAT ON
:CONF:LTE:DL:CC:MBSF:AI:NMRL 1
:CONF:LTE:DL:CC:MBSF:SUBF1:STAT ON
:CONF:LTE:DL:CC:MBSF:SUBF2:STAT ON
:CONF:LTE:DL:CC:MBSF:SUBF8:STAT ON
:SENS:LTE:DL:DEM:AUTO OFF
:SENS:LTE:DL:FORM:PSCD OFF
:CONF:LTE:DL:CC:SUBF1:ALC 0
:CONF:LTE:DL:CC:SUBF2:ALC 0
:CONF:LTE:DL:CC:SUBF8:ALC 0
:INST:CRE:NEW NR5G, '5G NR'
```

```
:INIT:CONT OFF
:SENS:SWE:TIME 0.0501
:SENS:NR5G:FRAM:COUN:AUTO OFF
:SENS:NR5G:FRAM:COUN 4
:TRIG:SEQ:SOUR EXT
:CONF:NR5G:DL:CC1:BW BW5
:CONF:NR5G:DL:CC1:RFUC:STAT OFF
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SSP SS15
:CONF:NR5G:DL:CC1:FRAM1:BWP0:RBC 25
:CONF:NR5G:DL:CC1:FRAM1:BWP0:CSL 10
:CONF:NR5G:DL:CC1:FTC 4
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT0:ATYP UNUS
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT0:COPY
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT:PAST:ALL
:CONF:NR5G:DL:CC1:FRAM1:COPY
:CONF:NR5G:DL:CC1:FRAM:PAST:ALL
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:ATYP DATA
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:ALL0:CW:MOD QAM64
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:COR0:RBC 6
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:COR0:SOFF 1
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:ALL0:SCO 12
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:ALL0:SOFF 2
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:COPY
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT2:PAST:SLOT
:CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT8:PAST:SLOT
:CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:ATYP DATA
:CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:ALL0:CW:MOD QAM64
:CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:COR0:RBC 6
:CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:COR0:SOFF 1
:CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:ALL0:SCO 12
:CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:ALL0:SOFF 2
:CONF:NR5G:DL:CC1:FRAM2:COPY
:CONF:NR5G:DL:CC1:FRAM3:PAST:FRAM
:CONF:NR5G:DL:CC1:FRAM4:PAST:FRAM
:CONF:NR5G:DL:CC1:FRAM4:BWP0:SLOT1:COPY
:CONF:NR5G:DL:CC1:FRAM4:BWP0:SLOT2:PAST:SLOT
:CONF:NR5G:DL:CC1:FRAM4:BWP0:SLOT6:PAST:SLOT
:CONF:NR5G:DL:CC1:FRAM4:BWP0:SLOT7:PAST:SLOT
:CONF:NR5G:DL:CC1:FRAM4:BWP0:SLOT8:PAST:SLOT
:SENS:NR5G:CC1:BWP:SEL 2
:SENS:NR5G:CC1:BWP:SEL 3
:SENS:NR5G:CC1:BWP:SEL 4
```

SCPI command sequence created by the FSW analyzer, following the manual entry flow.

4.3 SCPI Command Method

Measurement of the DSS signal uses LTE and 5G personalities separately. As each personality is invoked, it inherits the salient features of the instrument state (for example, center frequency and front end attenuation). Therefore, it is advantageous to set-up the basic features of the analyzer first, then invoke the personalities, ensuring consistency of settings.

A sequence of approximately 40 SCPI commands is required from the Preset state to create a basic, but illuminating, measurement results report, analyzing both the LTE and 5G subframes.

```
*RST
:SYST:DISP:UPD OFF
:INIT:CONT OFF
:SENS:FREQ:CENT 850e6
:INST:CRE:NEW LTE, 'DSS_LTE'
:SYST:DISP:UPD OFF
:INIT:CONT OFF
:TRIG:SEQ:SOUR EXT
:CONF:LTE:DL:CC:BW BW5_00
:CONF:LTE:DL:CC:MBSF:STAT ON
:CONF:LTE:DL:CC:MBSF:AI:NMRL 1
:CONF:LTE:DL:CC:CSUB 10
:SENS:SWE:TIME 0.0101
:INST:CRE:NEW NR5G, 'DSS_5G_NR'
:SYST:DISP:UPD OFF
:INIT:CONT OFF
:TRIG:SEQ:SOUR EXT
:CONF:NR5G:DL:CC1:BW BW5
:CONF:NR5G:DL:CC1:FTC 4
:SENS:SWE:TIME 0.0401
:SENS:NR5G:FRAM:COUN:AUTO OFF
:SENS:NR5G:FRAM:COUN 4
:CONF:NR5G:DL:CC1:RFUC:STAT OFF
```

Simple setup SCPI sequence.

Each of the personalities, 5G and LTE, may now be configured to measure their contents.

The generated signal is four frames, i.e. 40 ms, long. The 5G personality will be capture the full 40ms and analyze all 40 subframes, on a frame-by-frame basis. With all frames defined from the outset, the current frame of analysis may be selected manually from a scroll box, or remote command.

The LTE personality analyses one frame at a time. The frame to be analyzed is defined as and when needed. The content of that one frame may also be defined manually or by remote command.

This process will describe the measurement set-up, subframe-by-subframe, of 4 frames of DSS 5G and 1 frame of LTE, on the FSW.

Frame 0, Subframe 0 This is an LTE subframe, loaded (exemplarily) with 16QAM/25RB. Subframe 0 (along with 4,5 and 9) cannot contain 5G payloads. The opportunity is taken to preset all subframes to empty as default.	:INST:SEL "DSS_5G_NR" :CONF:NR5G:DL:CC1:FRAM1:BWP0:SSP SS15 :CONF:NR5G:DL:CC1:FRAM1:BWP0:RBC 25 :CONF:NR5G:DL:CC1:FRAM1:BWP0:CSL 10 :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT:PAST:ALL :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT0:ATYP UNUS :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT0:COPY :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT:PAST:ALL
The LTE content measurement is setup for QAM16 across 25RBs.	:INST:SEL "DSS_LTE" :CONF:LTE:DL:CC:MBSF:SUBF0:STAT OFF :CONF:LTE:DL:CC:SUBF0:ALC 1

	:CONF:LTE:DL:CC:SUBF0:ALL0:CW1:MOD QAM16 :CONF:LTE:DL:CC:SUBF0:ALL0:RBC 25 :CONF:LTE:DL:CC:SUBF0:ALL0:RBO 0 :CONF:LTE:DL:CC:SUBF0:ALL0:POW 0
The subframe is specifically programmed to be unused for 5G.	:INST:SEL "DSS_5G_NR" :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT0:ATYP UNUS

Frame 0, Subframe 1 Subframe 1 is a member of potential MBSFN subframes. Its specific status ('On' or 5G present, for subframe 1) will be written by instructing the LTE personality to ignore it.	:INST:SEL "DSS_LTE" :CONF:LTE:DL:CC:MBSF:SUBF1:STAT ON :CONF:LTE:DL:CC:SUBF1:ALC 0
The 5G personality is instructed to look for a 64QAM payload.	:INST:SEL "DSS_5G_NR" :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:ATYP DATA :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:ALL0:CW:MOD QAM64 :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:ALL0:SCO 12 :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:ALL0:SOFF 2 :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:COR0:RBC 6 :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT1:COR0:SOFF 1

Frame 0, Subframe 2 Subframe 2 is also a MBSFN subframe, occupied with a 5G payload. It is a copy and paste of the previous step, with an increment of the SUBF and SLOT indices, for LTE and 5G respectively.	:INST:SEL "DSS_LTE" :CONF:LTE:DL:CC:MBSF:SUBF2:STAT ON :CONF:LTE:DL:CC:SUBF2:ALC 0
	:INST:SEL "DSS_5G_NR" :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT2:ATYP DATA :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT2:ALL0:CW:MOD QAM64 :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT2:ALL0:SCO 12 :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT2:ALL0:SOFF 2 :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT2:COR0:RBC 6 :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT2:COR0:SOFF 1

Frame 0, Subframe 3 Subframe 2 is also a MBSFN subframe, but is NOT occupied with a 5G payload. It is an LTE payload. Thus, while SUBF and SLOT indices are incremented, the command sequences sent are different.	:INST:SEL "DSS_LTE" :CONF:LTE:DL:CC:MBSF:SUBF3:STAT OFF :CONF:LTE:DL:CC:SUBF3:ALC 1 :CONF:LTE:DL:CC:SUBF3:ALL0:CW1:MOD QAM16 :CONF:LTE:DL:CC:SUBF3:ALL0:RBC 25 :CONF:LTE:DL:CC:SUBF3:ALL0:RBO 0 :CONF:LTE:DL:CC:SUBF3:ALL0:POW 0
	:INST:SEL "DSS_5G_NR" :CONF:NR5G:DL:CC1:FRAM1:BWP0:SLOT3:ATYP UNUS

For the remaining 6 subframes in the first frame, the following command sequences apply:

- Subframes 4,5,6,7,8,9 are copies of Subframe 3.

The measurement configuration, for both LTE and 5G, in the first frame (comprising 10 subframes) is now complete.

For the remaining 3 frames, only the 5G personality needs to be configured, and on a subframe by subframe basis (up to subframe number 39).

The first subframe, or slot, of each frame will be programmed with the default payload configuration (15kHz spacing, etc.)

Note that only subframes 1,2,3 and 6,7,8 may contain 5G payloads. Of those, in this working example, subframe 21 remains with a 5G payload.

The first subframe in each frame (e.g. those numbered {10, 20, 30}), set the 5G defaults.

Frame 1, Subframe 0 The FRAM index is incremented (to 2) The potential contents of each MBSFN subframe as set to a default value (15Khz spacing, etc.)	:INST:SEL "DSS_5G_NR" :CONF:NR5G:DL:CC1:FRAM2:BWP0:SSP SS15 :CONF:NR5G:DL:CC1:FRAM2:BWP0:RBC 25 :CONF:NR5G:DL:CC1:FRAM2:BWP0:CSL 10 :CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT:PAST:ALL :CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT0:ATYP UNUS :CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT0:COPY :CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT:PAST:ALL

For other subframes/slots, set either 'Unused' for slots in the range {10~20, 22~39}

Frame 1, Subframe (Slot) 0	:CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT0:ATYP UNUS

… or 'Data' for slot {21}

Frame 1, Subframe (Slot) 1	:CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:ATYP DATA :CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:ALL0:CW:MOD QAM64' :CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:ALL0:SCO 12 :CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:ALL0:SOFF 2 :CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:COR0:RBC 6 :CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT1:COR0:SOFF 1

4.4 Configuration File Method

The configuration file may be transferred to the instrument using a network protocol (e.g. SMB or FTP) or a USB memory stick.

Once the file is made available to the instrument, simply press the 'File Open' icon, select the 'Recall' tab, and point the software to the file's location.

5 Remote Control Script

Proprietary set-up files which can be loaded directly into the instruments, are provided as separate downloads at the Application Note homepage (see the front page for the address).

In addition, MATLAB® script files are also provided (as-is, without warranty), intended as a start point for the development of remote control environs. The material may easily be ported to other platforms (e.g. Python). The files are provided in an archive.

After extracting the archive, to run this example, only the core MATLAB license is required. The MATLAB® Instrument Control Toolbox is NOT needed to replicate this application.

Remote control of the instruments is enabled using the R&S MATLAB® class, described in the Application Note "How to use Rohde & Schwarz Instruments in MATLAB". Complete the simple installation steps outlined before proceeding. Note that a valid VISA install is required (e.g. R&S VISA).

All nine files provided in the archive are needed, and all should at least be stored on the MATLAB® path.

Note that the compiling of the LTE and 5G signal files may take several seconds on the SMW. Increase the `obj.SetTimeoutMilliseconds` parameter in the VISA_Instrument.m file to a suitable value, if necessary.

Firstly, three .m MATLAB® script files.

- setup_4frames_MBSFN_Prepare.m
  - this script sets up general variables, including the preferred MBSFN slots
- setup_4frames_MBSFN_SMW.m
  - this completes the SMW signal generator set-up, calling on the supplied SCPI command files (ASCII format)
- setup_4frames_MBSFN_FSW.m
  - this completes the SMW signal generator set-up, calling on the supplied SCPI command files (ASCII format)

Modify the resource strings of the SMW and FSW instruments in the '…Prepare.m' file, then **just run the three scripts in sequence** to complete the exercise (ensuring all nine files are on the path).

Secondly, three .m MATLAB® function files, which are called from within the three scripts. Note that the VISA_Instrument class is supported by a separate Application Note (see Literature section), and may itself be subject to updates.

- VISA_Instrument.m

- sendSCPIcmd.m
- parseSCPIFile.m

Three additional ASCII files containing SCPI command sequences. These are simply SCPI command sequences, stored in ASCII format.

- setup_4framesMBSFN_SMW_1.scpi
- setup_4framesMBSFN_SMW_2.scpi
- setup_4framesMBSFN_FSW.scpi

6 Literature

[1] Andreas ROESSLER, " Demystifying 5G – 5G NR coexistence with LTE based on dynamic spectrum sharing (DSS) ", https://www.youtube.com/watch?v= grVbzbs7Ar0

[2] Andreas ROESSLER, "Demystifying 5G – 5G NR coexistence with LTE – testing dynamic spectrum sharing (DSS), part 1", https://www.youtube.com/watch?v=SLGZPncy4Uc

[3] Andreas ROESSLER, "Demystifying 5G – 5G NR coexistence with LTE – testing dynamic spectrum sharing (DSS), part 2", https://www.youtube.com/watch?v=lRLT7J7klg8

[4] Miloslav MACKO, "How to use Rohde & Schwarz Instruments in MATLAB", Application Note, http://www.rohde-schwarz.com/appnote/1MA171

7 Ordering Information

This product recommendations are typical minimum requirements. Contact R&S with your specific needs.

Designation	Type	Order No.
R&S®FSW signal and spectrum analyzer	R&S®FSW8	1331.5003.08
EUTRA/LTE FDD BS measurements	FSW-K100	1313.1545.02
EUTRA/LTE TDD BS measurements	FSW-K104	1313.1574.02
FSW-B28 28MHZ ANALYSIS BANDWIDTH	FSW-B28	1313.1645.02
3GPP 5G-NR downlink measurements	FSW-K144	1338.3606.02
R&S®SMW200A Vector Signal Generator	R&S®SMW200A	1412.0000.02
Frequency range: 100 kHz to 6 GHz for RF path A	SMW-B1006	1428.4800.02
Signal routing and baseband main module, two I/Q paths to RF	SMW-B13T	1413.3003.02
2x Baseband generator with realtime coder and ARB	2 x SMW-B10	1413.1200.02
EUTRA/LTE	SMW-K55	1413.4180.02
EUTRA/LTE Release 9	SMW-K84	1413.5435.02
5G New Radio	SMW-K144	1414.4990.02

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Sustainable product design

- Environmental compatibility and eco-footprint
- Energy efficiency and low emissions
- Longevity and optimized total cost of ownership

Certified Quality Management ISO 9001

Certified Environmental Management ISO 14001

This application note and the supplied programs may only be used subject to the conditions of use set forth in the download area of the Rohde & Schwarz website.

Version GFM337_0e | R&S® Dynamic Spectrum Sharing (DSS) for 5G & LTE: Signal Generation and Analysis.

PAD-T-M: 3573.7380.02/03.00/EN

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