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

#### Products:

I R&S<sup>®</sup>FSW I R&S<sup>®</sup>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.

pplication Note Gareth LLOYD

2020 - GFM337

MATLAB® is a registered trademark of The Mathworks, Inc.

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



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# 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.

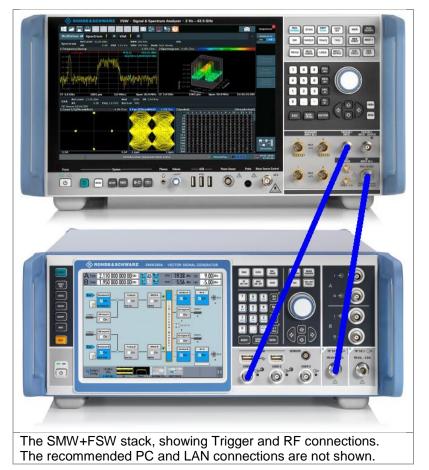
To that end, the third part of the document provides an exemplary MATLAB® script, functions and class, automating the set-up procedure completely, and may easily be modified or ported to automate the test scenarios. Note that only the core MATLAB® license is required to run the scripts.

# 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.



# 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

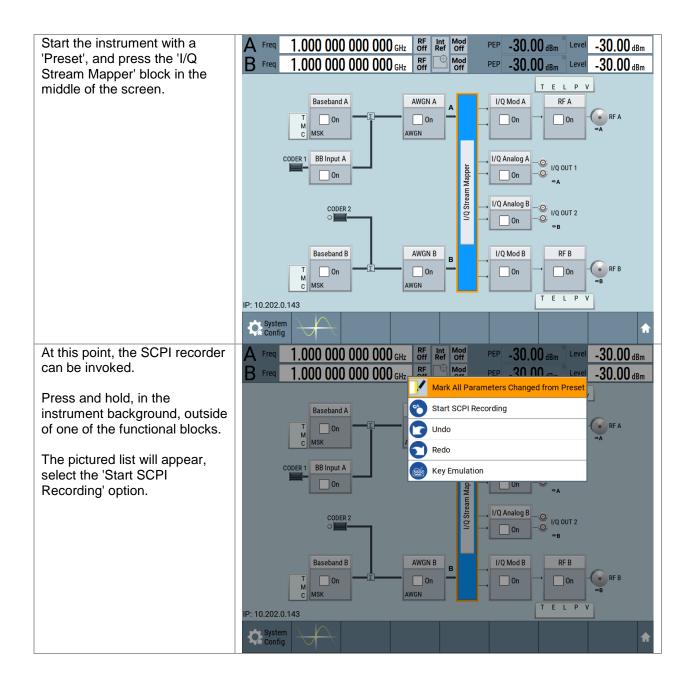
Before describing the manual set-up, it is worthwhile noting the existence of the SCPI recording feature, a productivity feature enabling faster, more repeatable testing.

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.



A 'Rec' button appears, to	A Freq 850.00		ef Mod PEP	-30.00 dBm <sup>°</sup>	Level -30.0	<b>O</b> dBm
indicate that SCPI recording is active.	B Freq 1.000 00	0 000 000 GHz RF	Mod Rec PEP	-30.00 dBm	Level -30.0	<b>O</b> dBm
active.	SCPI Recording List				—	×
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.	:SOURce1:FREQuency:CV	V 85000000				
	Remove All	Remove First	Remove L	ast	Export	
	Config Sceneral SCPI Rec. List					<b>f</b>
At the intersection of 'Combination' and 'RF A' press the button labeled 'Single', and	B Freq 1.000 00	00 000 000 GHz RF R 00 000 000 GHz RF	nt Mod ef Off PEP Mod Off PEP		Level -30.0 Level -30.0	<b>O</b> dBm
change its state to 'Add'.	System Configuration				—	×
This will eventually provide a	Multi Instrument Fading/Ba	seband Config I/Q Stream Mapp	er External RF and I	/Q Overview		
summation of the 5G and LTE	Frequency Pha Offs /Hz Offs	ISE RFA RFB I/Q I/Q OUT 1 OUT 2				
signals in the digital domain.	Stream A 0.00	0.00				
	Stream B 0.00	0.00				
The frequency of operation,	Combination	Add Single Single Single				
and generator output power level, may be changed at any						
point in the overall process.						
	System					
	Config					11

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).

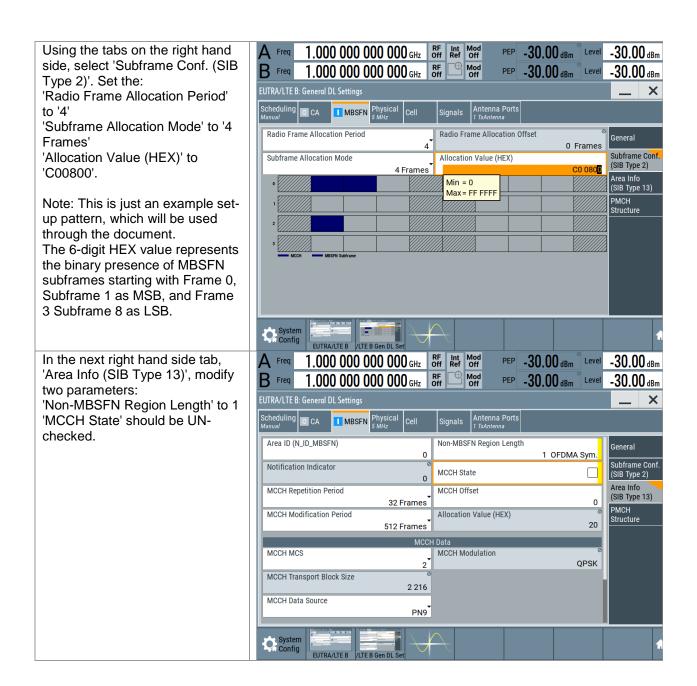
In the second phase, baseband B will be configured to generate the LTE kernel along with some empty subframes, into which 5G payloads will be inserted later.

Press 'Baseband B' (highlighted) and choose the EUTRA/LTE option	A         Freq         1.000 000 000 000 GHz         RF off         Int Ref         Mod off         PEP         -30.00 dBm         Level         -30.00 dBm           B         Freq         1.000 000 000 000 GHz         RF off         Off         Off         PEP         -30.00 dBm         Level         -30.00 dBm
	$\begin{array}{c} T \\ Baseband A \\ \hline \\ M \\ C \\ MSK \\ \end{array} \xrightarrow{AWGN A} A \\ \hline \\ AWGN \\ AWGN \\ AWGN \\ \hline \\ \\ AWGN \\ \hline \\ \\ AWGN \\ \hline \\ \\ \\ \\ AWGN \\ \hline \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ $
	CODER 1 BB Input A
	$\begin{array}{c c c c c c c c c c c c c c c c c c c $
	IP: 10.202.0.143
In the 'Trigger' tab, select 'Armed Auto' mode (highlighted).	A         Freq         1.000         000         000         GHz         RF Ref         Int Ref         Mod Off         PEP         -30.00 dBm         Level         -30.00 dBm           B         Freq         1.000         000         000         GHz         RF         C         Mod Off         PEP         -30.00 dBm         Level         -30.00 dBm
Then, select the 'Marker' tab.	EUTRA/LTE B  Clock Info Notch Filter
	Mode Armed Auto Stopped
	Source
	Internal
	System EITRA/ITE A

Select 'Restart (ARB)' from the 'Mode' scroll-box. Press 'Global Connectors'	A Freq 1.000 000 000 000 GHz RF Int Mod B Freq 1.000 000 000 000 GHz RF Mod Off PEP -30.00 dl EUTRA/LTE B	
	O General S™ Trigger In Marker Clock Info O Notch	
	Mode Rise Offset	Marker 1
	Restart(ARB) 0 1	Samples Restart Marker 2
	0 :	Samples Radio Frame Start
	Delay 0.000 Samples	Marker 3 Radio Frame Start
	Local Connectors	
	System FTP EUTRA/LTE B	1
Select 'Baseband B Marker 1' from the 'User 1' connector, ensuring its direction is set to output.	A         Freq         1.000 000 000 000 GHz         RF off         Int Ref         Mod off         PEP         -30.00 dH           B         Freq         1.000 000 000 000 GHz         RF off         Control off         PEP         -30.00 dH           Global Connectors         Global Connectors         Global Connectors         Global Connectors         Global Connectors	
This signal will be used to	Routing Characteristics	
synchronize the generator and	Connector Direction Signal	
analyzer on the 4 frame basis.	User 1 Output Baseband B Marker 1	
	User 2 Output- Baseband A Marker 2-	
	User 3 😰 Input• Global Trigger 1•	
	User 4 🛛 🖉 Input• Global Trigger 2•	
	User 5 😰 Output• Signal Valid A•	
	User 6 😰 Not Used- None	
	System FTP EliteAute Subal Connectors	4

Press the	A Freq 1.000 000 000 000 GHz Off Ref Off Ref Off PEP -30.00 dBm Level	- <b>30.00</b> dBm
'Filter/Clipping/ARB/TDW/Power	B Freq 1.000 000 000 000 GHz OFF C Mod OFF -30.00 dBm Level	-30.00 dBm
' button	EUTRA/LTE B	_ ×
	o General Swer Trigger In Marker Clock Info Info Filter	
	Save Contraction Second	Generate Waveform
	Test Case Wizard	
	Mode Duplexing	
	Link Direction Test Models	FDD
	Downlink (OFDMA)	
	General Settings Frame Configuration	
	Filter/Clipping/ARB/TDW/Power LTE / Clip Off / 1 Frames	
	System FTP FTP	
	EUTRA/LTE B	
Select the 'ARB' tab, and enter '4	A Freq 1.000 000 000 000 GHz OFF Int Mod OFF -30.00 dBm Level	
Frames' as the sequence length.	B Freq 1.000 000 000 000 GHz RF Mod OFF -30.00 dBm Level	-30.00 dBm
Close the window with the 'X'.	EUTRA/LTE B: Filter/Clipping/ARB/TDW/Power Settings	_ ×
	Filter O Clipping ARB O Time Domain Power	
	Sequence Length	
	4 Frames	
	Min = 1 Frames Max = 13 333 Frames	
	System	
		1

Within the 'General' tab, press	A r 1 000 000 000 BE Int Mod are 00 00 ° . 00 00
the 'General Settings' button.	A Freq 1.000 000 000 GHz off Ref Off Off PEP -30.00 dBm Level -30.00 dBm
Select the 'Physical' tab, and in	EUTRA/LTE B: General DL Settings
the 'Channel Bandwidth' option,	Scheduling CA CA MBSFN Physical Cell Signals Antenna Ports
select '5 MHz'.	Channel Bandwidth Number of Resource Blocks per Slot
Some other values will be	FFT Size
automatically updated with new	512
default values.	Physical Resource Block Bandwidth Occupied Bandwidth 12 * 15 kHz 4.515 MHz
	Sampling Rate   Number of Occupied Subcarriers
	7.680 MHz 301 Number of Left Guard Subcarriers Number of Right Guard Subcarriers
	106
	System Config
Select the 'MBSFN' tab, and for	A Freq 1.000 000 000 000 GHz RF Int Mod PEP -30.00 dBm Level -30.00 dBm
'MBSFN Mode' select 'Mixed'	B Freq 1.000 000 000 000 GHz off G 200 000 off 200 000
This is the most without phase of	EUTRA/LTE B: General DL Settings
This is the most critical phase of the set-up process, creating	Scheduling of CA TIMESEN Physical Cell Signals Antenna Ports
space for the 5G payload to be	
inserted.	MBSFN Mode General
	MBSFN Rho A UE Category Subframe Conf. 0.000 dB 5 (SIB Type 2)
	Area Info (SIB Type 13)
	PMCH Structure
	System EUTRA/LTE B Gen DL Set



In the 'PMCH Structure' tab,	A Freq 1.000 000 000 000 GHz RF Int Mod PEP -30.00 dBm Level -30.00 dBm
switch the state to 'Off'	B Freq 1.000 000 000 000 GHz BF C Mod PEP -30.00 dBm Level -30.00 dBm
	EUTRA/LTE B: General DL Settings
	Scheduling CA MBSFN Physical Cell Signals Antenna Ports
	Common SF Alloc Period Number of PMCHs General
	4 1
	Start End Table 2 MCS Modulation Period Source Pattern State (SIB Type 2)
	0 0 7 🗌 0 QPSK - PN9 - Off Area Info (SIB Type 13)
	PMCH Structure
Finally, in the 'Cell' tab, enter a	System Config EUTRA/LTE B /LTE B Gen DL Set A Freq 1.000 000 000 000 GHz OFF Ref Off PEP -30.00 dBm Level -30.00 dBm
value of '457' for the 'Cell ID'	B Freq 1.000 000 000 GHz off Off PEP -30.00 dBm Level -30.00 dBm
variable. (for example)	EUTRA/LTE B: General DL Settings
Close the window, using the 'X' in	Cohoduling Dhusiast Astance Data
the top right.	Manual 5 MHz Gen Gigitats 1 TxAntenna
	Cell ID Physical Cell ID Group Physical Layer ID 457 152 1
	Cyclic Prefix Normal
	PDSCH P_B PDSCH Ratio rho_B/rho_A
	0 0.000 dB PDCCH Ratio rho_B/rho_A PBCH Ratio rho_B/rho_A
	0.000 dB
	PHICH N_g PHICH Duration
	RA_RNTI
	1
	System EUTRA/LTE B /LTE B Gen DL Set

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.	A Freq 1.000 000 000 000 GHz RF Int Mod OFF -30.00 dBm Level -30.00 dBm
of Configurable Subframes' parameter to '40'.	B Freq 1.000 000 000 000 GHz RF Mod PEP -30.00 dBm Level -30.00 dBm
parameter to 40.	EUTRA/LTE B: DL Frame Configuration
There are now 40 subframes	General User Time LAA Subframe PCFICH PHICH (E)PDCCH
which can be configured.	Plan Sr 0 Sr 0 Sr 0 Sr 0
Ū.	40 Keset All Subframes
	E Min = 1 Max = 40
	Dummy Data Dummy Data Configuration
	Modulation
	QPSK Data Source
	PN9
	Power 0.000 dB Omit PRS Subframes
	System EUTRA/LTE B Frame Con
Select the 'Subframe' tab.	A Freq 1.000 000 000 GHz off Ref Off PEP -30.00 dBm Level -30.00 dBm
	B Freq 1.000 000 000 000 GHz RF Mod OFF -30.00 dBm Level -30.00 dBm
From here, the subframes can	EUTRA/LTE B: DL Frame Configuration
be programmed.	
For 'Subframe 0', ' 10', '	Plan sfo sfo sfo
20' and ' 30'	Cell Subframe PCell 0 OPrev ONext Ocopy Paste
Select '3' for 'No. Of Used	Cyclic Prefix <sup>©</sup> No. of Used Allocations
Allocations'. A third row will	Normal 3- CW Modu- Enhanced VRB No. No. Offset Offset Auto Phys. Data DList / ρ.Α. Content State Gor- Hation Settings Can DB Sym DB Sym DB Sym // B Tung Hater //B Tung
appear.	anon oettings dap no oyni. No oyni. Dits oonee ratteni 7db rype not
Within that third row, modify	0 1/1 QPSK Config 6 4 9 7(1/0) 480 MIB - 0.000 PBCH On
Within that third row, modify the 'QPSK' parameter to be	1 1/1 QPSK - 25 2 0 0(0/0) 944 PDCCH - 0.000 PDCCH On
'16QAM' and 'No. RB' should	2 1/1 16QAM Config 25 12 0 2(0/2) 🔽 12120 PN9 - 0.000 PDSCH On
be set to '25'.	
	System A
	EUTRA/LTE B //LTE B Frame Con

With Subframes 0, 10, 20, 30 configured, returning to subframe 1	A         Freq         1.000         000         000         GHz         BF         Int         Mode         PEP         -30.00 dBm         Level         -30.00 dBm           B         Freq         1.000         000         000         GHz         BF         Mode         PEP         -30.00 dBm         Level         -30.00 dBm           EUTRA/LTE B: DL Frame Configuration
Leave subframes 1, 2 and 21 alone.	General     User     Time Plan     LAA     Subframe Sf 1     PCFICH Sf 1     PHICH Sf 1     E(E)PDCCH       Cell     Subframe PCell     Subframe 1     Prev     Next     Scopy     Paste <sup>o</sup>
They will be filled with 5G payloads, later.	Vocini Prefix         No. of Used Allocations         No.       No.       Of Used Allocations       1         CW       Modu       Enhanced       VRB       No.       Offset       Offset       Auto       Phys.       Data       DList /       p.A.       Content       State       Con-         0       1/1       QPSK       -       25       1       0       0(0/0)       344       PDCCH       -       0.000       PDCCH       On
	System EUTRA/LTE B /LTE B Frame Con
As a general instruction: For the potential MBSFN subframes {1,2,3,6,7,8,11,12 38,39}; there are two options	A Freq       1.000 000 000 000 GHz       RF       Rtf       Mod Off       PEP       -30.00 dBm       Level       -30.00 dBm         B       Freq       1.000 000 000 000 GHz       RF       Mod Off       PEP       -30.00 dBm       Level       -30.00 dBm         EUTRA/LTE B: DL Frame Configuration
(1) to allocate to 5G, in which case leave with the default settings; do not make any changes.	Cyclic Prefix         No. of Used Allocations           Cw         Modu- lation         Enhanced VRB Settings         No.         No.         Offset Sym.         Phys.         Data Bits         DList / Source         p A Pattern         Content //B         State Type         State Flict           0         1/1         QPSK         -         25         1         0         0(0/0)         344         PDccH         -         0.000         PDccH         On
<ul><li>(2) to allocate to LTE, in which case use the next step</li><li>Use 'Next' and 'Prev' to move between the subframes.</li></ul>	
	System EUTRA/LTE B /LTE B Frame Con

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.

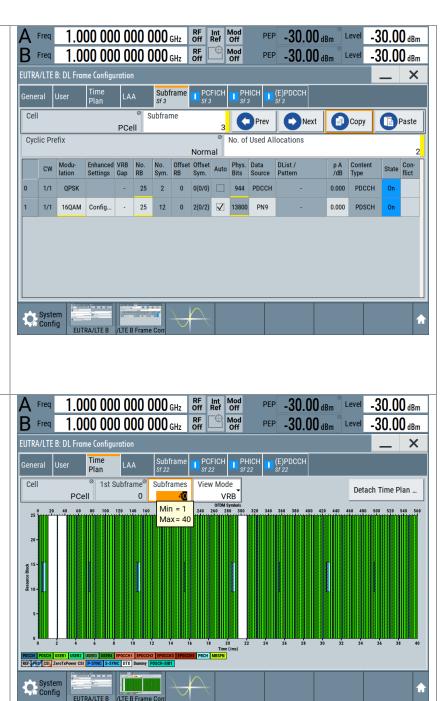
In the second row modify: 'Modulation' to 16QAM 'No. RB' to 25

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.



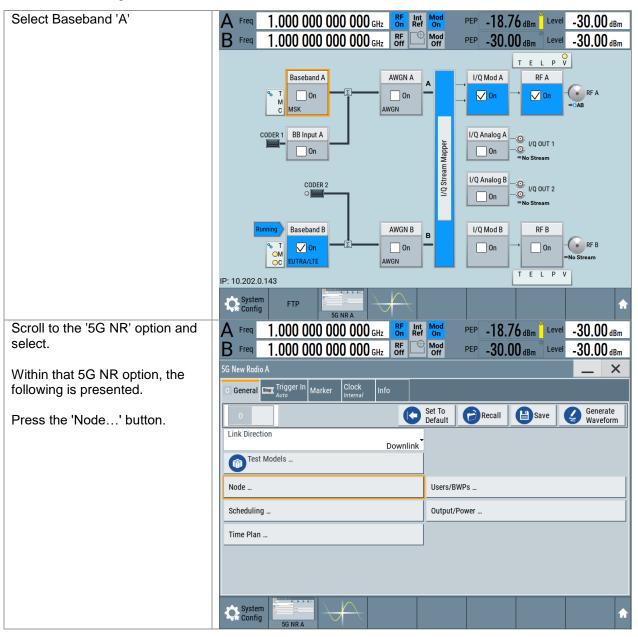
Switch On the LTE modulation, at which point the Trigger will be automatically activated.	A Freq 1.000 000 000 000 GHz R F Ref Mod PEP -18.23 dBm Lev B Freq 1.000 000 000 000 GHz R F Mod PEP -18.23 dBm Lev	
be automatically activated.	EUTRA/LTE B	_ ×
RF may also be switched on at this point.	General Res Trigger In Marker Clock Info Notch Filter	
	Set To Default CRecall Save	Generate Waveform
	Test Case Wizard	
	Mode LTE Duplexing	FDD
	Link Direction Downlink (OFDMA) Test Models	
	General Settings Frame Configuration	
	Filter/Clipping/ARB/TDW/Power LTE / Clip Off / 4 Frames	
	System EUTRA/LTE B	•

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

+207
*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.

GFM337\_0e



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

In the 'Carriers' tab make the following modifications: 'RF Phase Compensation' to OFF		30.00 dBm 30.00 dBm X
'Cell ID' variable to '123' (for example) 'Channel BW' to '5MHz'	Scheduling Manual       Carriers       TXBW Cell 0       LTE-CRS Coexistence Cell 0       SS/PBCH Cell 0       Dummy REs Cell 0       Carrier Mapping         Number of Carriers       Image: Carrier Cell ID       N1 ID       N2 ID       Deployment       Frequency /GHz       Channel BW       DMRS TypeA Position       SUL         0       Cell 0       0       123       41       0       f <= 3GHz	0
Next, select the 'TxBW' tab.		<b>1</b> 30.00 dBm
Make the following changes: In the 'Use' column, deselect '30 kHz' Select '15 kHz'. Press 'Resolve Conflicts'	5G New Radio A: Node Settings Scheduling Carriers TXBW Cell 0 LTE-CRS Coexistence SS/PBCH Dummy REs Carrier Mapping Carrier: Cell 0 0	30.00 dBm
This resolution will modify the 'Point A to Carrier Center' value.	Point A to Carrier Center -2.250 MHz  Resolve Conflicts  Use N_RB TXBW k0µ 15 kHz Z 25 0 0.0 30 kHz 1 11 0 -	5 MHz
	Config	A

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'.	A Freq       1.000 000 000 000 GHz       RF       Mod Orf       PEP       -18.76 dBm       Level       -30.00 dBm         B Freq       1.000 000 000 000 GHz       RF       Mod Orf       Mod PEP       -30.00 dBm       Level       -30.00 dBm         5G New Radio A: Node Settings
Select the 'Config' option under 'PBCH'	Interview       SC Spacing / CP     Offset Offset 0     Offset Offset 0     Offset Offset 0     Offset Offset 0     Offset Offset 0     Offset 0     Offset 0     Offset 0     Offset 0     Offset 0     Offset 0     Offset 0     Offset 0     Output 0     Output 0     Description 0     Description 0     Description 0     Output 0     Output 0
	System 5G NR A R A Node Settings
and ensure that 'Auto Subcarrier Offset' is switched to 'On'	A Freq 1.000 000 000 000 GHz BF Ref Mod B Freq 1.000 000 000 000 GHz BF Mod B Freq 1.000 000 000 000 GHz BF Mod Off PEP -18.76 dBm Leve -30.00 dBm PEP -30.00 dBm Leve -30.00 dBm Deve -30.00 dBm Freq -30.00
	0 CORESET Zero 0 Search Space Zero 0 Cell Barred
	System Config 56 NR A R A Node Settings R A PBCH Settings

Close the 'Node' window and press the 'Users/BWPs' button.	A Freq       1.000 000 000 000 GHz       Bref       Infree         B Freq       1.000 000 000 000 GHz       Bref       Bref         5G New Radio A       Seneral       Second A         • General       Second A       Clock       Info	Mod PEP -30.00 dBm Level -30.00 dBm
	Link Direction Downlink	Set To Default CRecall Save Generate Waveform
	Node	Users/BWPs
	Scheduling	Output/Power
	Time Plan	
	Config 56 NR A	<b>☆</b>
In the 'General' tab, verify that 'Number of Users' is set to '1'.		Mod Mod Off         PEP         -18.76 dBm         Level         -30.00 dBm           Mod Off         PEP         -30.00 dBm         Level         -30.00 dBm
	General Properties DL BWPs DL BWP Config UL BWPs User 0 / Cell 0 User 0 / Cell 0 / BWP 0 / Cell 0 / Cell 0 / BWP 0 / Cell 0 / Cell 0 / BWP 0 / Cell 0 / Cell 0 / BWP 0 / Cell	s UL BWP Config
	System 56 NR A sers/BWP Setting	<b>☆</b>

In the 'Properties' tab, switch on 'DSCH Channel Coding'	A       Freq       1.000 000 000 000 GHz       Br       Ref       Mod       PEP       -18.76 dBm       Level       -30.00 dBm         B       Freq       1.000 000 000 000 GHz       Ref       Mod       PEP       -30.00 dBm       Level       -30.00 dBm         5G       New Radio A: Users/BWP Settings
	0 DSCH Channel Coding DSCH Data Source PN9
In 'DL BWPs', enter '25' for 'No. RBs'	System         Solution         <
	Number of DL BWPs       1         BWP       SC Spacing/ CP       No. RBs       RB Offset       Af to Carrier in TXBW to PointA (Centers) /MHz         0       0       15 kHz NCP       25       0       0.000 000

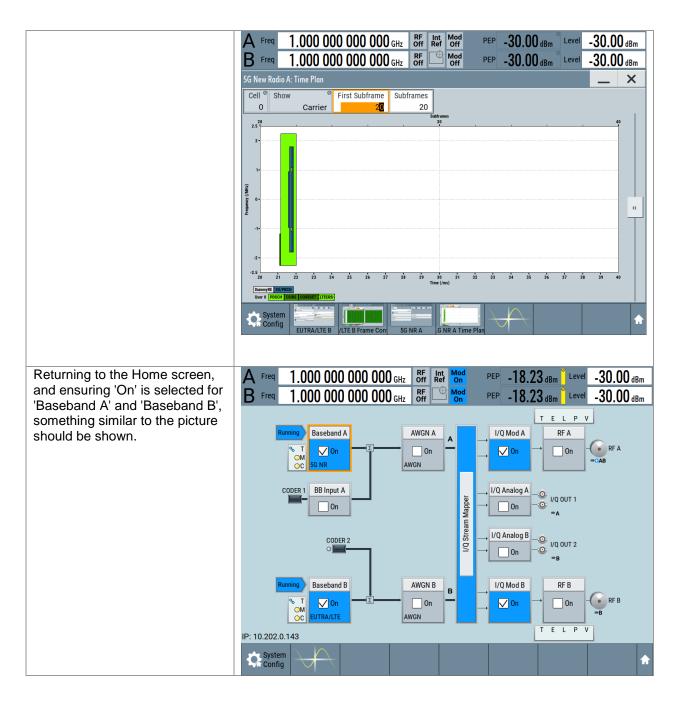
In 'DL BWP Config', ensure 'MCS Table' is set to '64QAM' and 'Resource Block Group Size' is set to 'Config 1'	A       Freq       1.000 000 000 000 GHz       RF       Net       Mod       PEP       -18.76 dBm       Level       -30.00 dBm         B       Freq       1.000 000 000 000 GHz       RF       Mod       PEP       -30.00 dBm       Level       -30.00 dBm         5G New Radio A: Users/BWP Settings
	User: Carrier: Cell BWP O
	General Settings PDSCH
	Use PDSCH Scrambling ID Data Scrambling ID 22 ZP CSI-RS
	Max. Number of Codewords Per DCI VRB-to-PRB Interleaver Non-Interleaved NZP CSI-RS
	MCS Table Resource Allocation
	64QAM Type 1 Resource Block Group Size
	Config 1 DMRS for Mapping Type A
	Config Type Additional Position Index
	Max Length 2
	System Sers/BWP Setting
In 'UL/BWPs' select '25' for 'No. RBs'	A Freq 1.000 000 000 000 GHz B Int Mod B Freq 1.000 000 000 000 GHz B F Int Mod F Int Mod PEP -18.76 dBm Level -30.00 dBm PEP -30.00 dBm Level -30.00 dBm
	5G New Radio A: Users/BWP Settings   General Properties DL BWPs DL BWP Config UL BWPs UL BWP Config User 0 / Cell 0 User 0 / C
	General         User 0 / Cell 0         User 0
	0 0
	1
	BWP SC Spacing / No. RBs Gffset RB Offset in TXBW RB Offset to PointA (Centers) /MHz
	0 0 15 kHz NCP 25 0 0 0.000 000
	System SG NR A sers/BWP Setting

Close the 'Users/BWPs' window and select 'Output Power'	A       Freq       1.000 000 000 000 GHz       B. Interpretended         B       Freq       1.000 000 000 000 GHz       B. Freq         5G New Radio A       General       Sec. Trigger In Marker       Clock Internal         0       Concept       Concept       Concept	
	Link Direction Downlink	Users/BWPs
	Scheduling	Output/Power
	Time Plan	
	System 56 NR A	<b>↑</b>
Set the 'Sequence Length' parameter to '4 Frames'	A         Freq         1.000 000 000 000 GHz         BF         Integer           B         Freq         1.000 000 000 000 GHz         BF         C           56 New Radio A: Output Settings         Settings         Settings         Settings         Settings	
	Output O Time Domain Windowing Power	
	Sequence Length 4 Frames	Suppress Subcarrier on Output Center
	Filter Mode Channel BW	Sample Rate Mode
	Clipping Level	Clipping Mode Vector  i+jq
	Output         Sample Rate /HZ         Conflict Variation         Sample Rate /HZ         Playback Rate /HZ         Phy XML Export           BB A         7 680 000          7 680 000	
	Config	

Close the 'Output Power'	A Freq 1.000 000 000 000 GHz Ref	
window and select	B Freq 1.000 000 000 000 GHz RF	Mod PEP -30.00 dBm Level -30.00 dBm
'Scheduling'		_ ×
	General Stort Trigger In Auto     Marker Clock Info	
		Set To Default Precall Save Generate Waveform
	Link Direction	
	Downlink	
	Node	Users/BWPs
	Scheduling	Output/Power
	Time Plan	
		_
	System Config	
	5G NR A	
In Subframe 0, ensure a value of		f On PEP -18.76 dBm Level -30.00 dBm
'0' is entered for 'No. Alloc.'.	B Freq 1.000 000 000 000 GHz BF	Mod PEP -30.00 dBm Level -30.00 dBm
Ensure that is the case also for	5G New Radio A: Scheduling Settings	_ ×
Subframes {0,3,4,5,6,7,9,	Cell <sup>©</sup> Subframe	Prev Prev
10,11,12,13,14,15,16,17,18,19,	0 Context No. SC Spacing / o	0 0 0
20,22,23,24,25,26,27,28,29,30,	Content Alloc CP S	lot Type Sym. Offset RBs Offset Settings 708 State Repetition
31,32,33,34,35,36,37,38,39}	▼ Common	
	▼ User 0, BWP 0 0 15 kHz NCP	25 Config
Go to Subframe 1.		
	System	
	Config	

In Subframe 1, make the	Δ Freq	1.000 000	000 000	RF	Int I Ref	Mod Off	P	EP _	<b>3</b> 0	<b>00</b> dl		evel	20	<b>00</b> dBm
following parameter changes:	B Freq				-0 I	Mod				00 at 00 di				00 dBm
'No. Alloc' to '2'	-	dio A: Scheduling Setti				Off			50.		sm		-00.	X
Select 'CORESET' in the first block.	Cell	alo A. Scheddinig Setti	Ø	Subframe										
Set 'No. Sym.' to 1			0	1						1	C	Prev		Next
Set 'Sym. Offset' to 1		Content	No. Alloc	SC Spacing / CP	Slot	Мар Туре	No. Sym.	Sym. Offset	No. RBs	RB Offset	Settings	Power /dB	State	Repetition
Set 'No. RBs' to '6'	▼ Com	mon												
Set 'Repetition' to 'Off' option		SS/PBCH		15 kHz NCP	0		4	8	20	•	Config	0.00	On	
In the second row, select	▼ User	0, BWP 0	2	15 kHz NCP					25		Config			
'PDSCH', and modify the		CORESET		15 kHz NCP	0		1	1	6	0	Config	0.00	On	Off
parameters to the values shown.		PDSCH		15 kHz NCP	0	Α	12	2	25	0	Config	0.00	On	Off
	Svet	sm										_		
	Conf	ig EUTRA/LTE B	5G NR A cl	neduling Setting		≁	$\mathbf{t}$							<b>•</b>
Under 'Settings', press 'Config' for the PDSCH option and select '64QAM'.	A Freq B Freq 5G New Ray	1.000 000 1.000 000	000 000		-0 r	Mod On Mod Off				76 at 00 at				00 dBm 00 dBm
Close the 'PDSCH Settings' tab.	General	TxScheme DMRS	PTRS Auto Cha	nnel Coding	Anter	nna Po	orts							
, , , , , , , , , , , , , , , , , , ,	PDSCH T	уре	Auto			Numbe	er of C	odewo	rds					
Repeat these settings into 'Subframe 21'.			D	CI Format 1	_1									1
Subirame 21.		d by CORESET 0												
	Modulati	on		64QA	-	Numbe	er of P	hysica	l Bits					20 700
	Cont	em FTP	56 NR A	reduling Setting	ISA PD	SCH Se	ttings							<b>↑</b>

Enter a value of '2' for the 'Subframe' parameter.	A Freq 1.000 000 000			Ref	/lod On					Bm <sup>Ø</sup> Le			<b>00</b> dBm
Subframe parameter.	B Freq 1.000 000 000	000	GHz Off		/lod Off	P	PEP _	30.	0 <b>0</b> dl	Bm Le	evel	-30.	<b>00</b> dBm
Copy the settings as shown in	5G New Radio A: Scheduling Settings	0	Oubfeame									_	×
the picture.		0	Subframe						2	C	Prev		Next
Again, press the 'Config' button	Content	No. Alloc	SC Spacing / CP	Slot	Мар Туре	No. Sym.	Sym. Offset		RB Offset	Settings	Power /dB	State	Repetition
at the intersection of 'PDSCH'	▼ Common												
and 'Settings', and select	▼ User 0, BWP 0	2	15 kHz NCP					25		Config			
64QAM.	CORESET		15 kHz NCP	0		1	1	6	0	Config	0.00	On	Frame
Close the 'Config' tab, to	PDSCH		15 kHz NCP	0	A	12	2	25	0	Config	0.00	On	Frame
return to the screen shown.													
	System Config		$\setminus \land$										
	5G NR A  cheduling		$\bigvee$										<u> </u>
Close the 'Output/Power' tab, and select 'Time Plan'.	A Freq 1.000 000 000			lef 0	od ff	PE		30.0					<b>O</b> dBm
	B Freq 1.000 000 000	<b>000</b> (	GHz Off		od ff	PE	P -	30.0	<b>O</b> dBr	n Lev	el _	30.0	<b>O</b> dBm
Enter '0' for 'First Subframe' and	5G New Radio A: Time Plan											_	×
a value of '20' for 'Subframes'.	Cell Show First Subf	rame 0	Subframes 20										
	2.5	- 11	Su	bframes 10									20
Assuming the process was successful, the opposite is	2												
presented in the Time Plan													
display of the 5G NR generator.													
	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1)												
Similarly, a 'First Subframe'	Freques												"
value of '20' should yield the second graphic.	-1•												
second graphic.	-2-												
Finally, return to the main '5G	-2.5	<u> </u>				12			5 16			19	
NR' window by closing the tab.	0 1 2 3 4 5 0	1	8 9 Ti	10 me (/ms)	11	12	13 1	• 15	, 16	17	18	19	20
	User 0 PDSCH CSIRS CORESET LITECRS				-			$\wedge$					
	Config	ne Con	5G NR A	.G NR	A Time	Plan	$\forall$	$ \neq $					A



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
```



 
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```
: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 '11000000000010000000000', 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 OAM16
: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: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  $0\sim39$  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:REPetitions OFF
```

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.

A Freq	850.00	0 000 000 MHz	RF Int On Ref	Mod On	PEP	7.52 dBm	Level	-10.00 df	Bm
<b>B</b> Freq	1.000 00	<b>0 000 000</b> GHz	RF Off	Mod On	PEP <b>-1</b>	7.79 dBm <sup>°</sup>	Level	-30.00 dl	Bm
Save/Recall								_ >	×
Operation	Mode		Recall	Rece Files					0
/var/user									
🗅 /var/us	er								
/var/vo	latile								
Exclude F	requency			Exclude Le	evel			(	
Reca	II 🕺 🧲	Recall Immediate1	Recall Imme	diate2	Ref Im	call mediate3		ile Manager	
Syste Confi		Save/Recall	$\wedge$						A
		Rcl' hard-ke					Oper	ation	

# 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

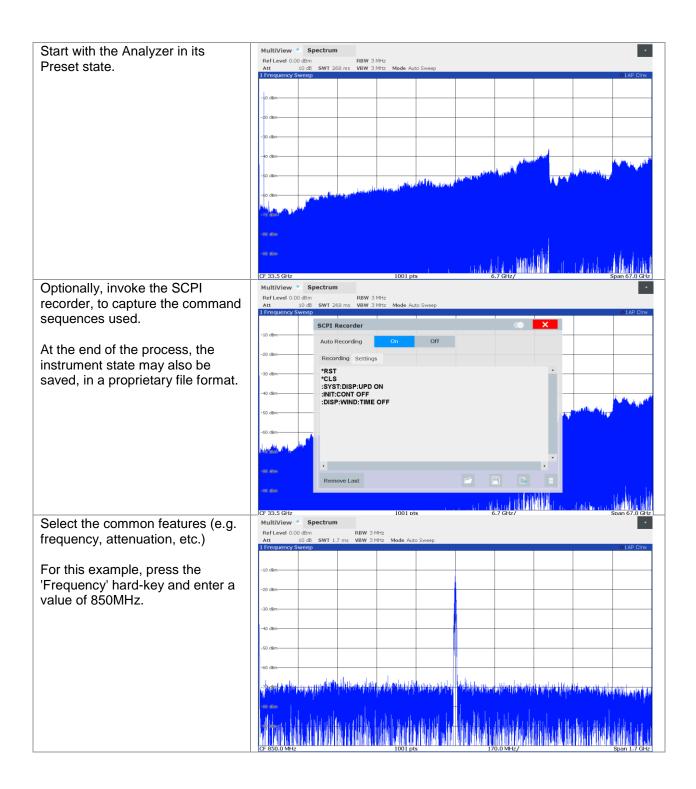
Before describing the manual set-up, it is worthwhile noting the existence of the SCPI recording feature, a productivity feature enabling faster, more repeatable testing.

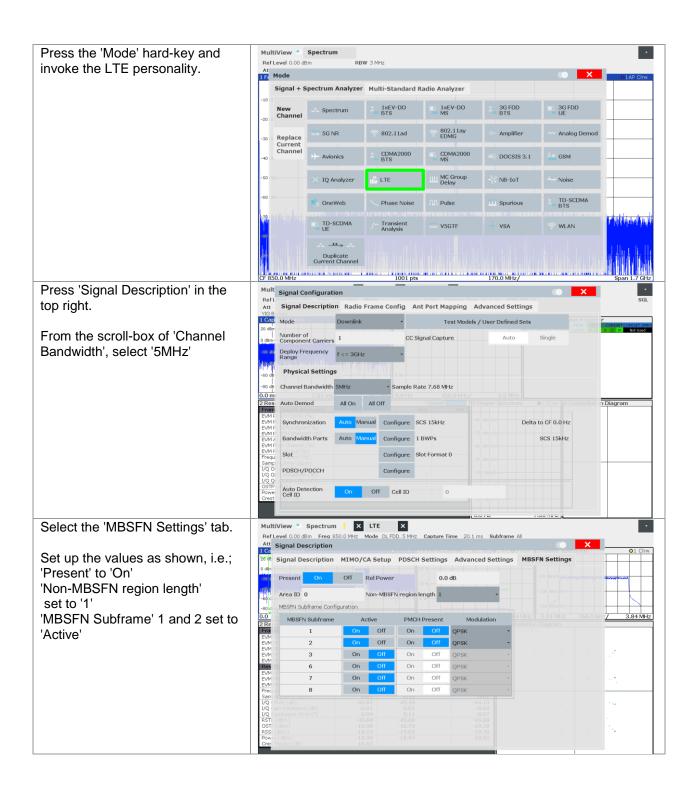
This is especially so for relatively lengthy parameter setting processes, where one or more parameters might need to be changed.

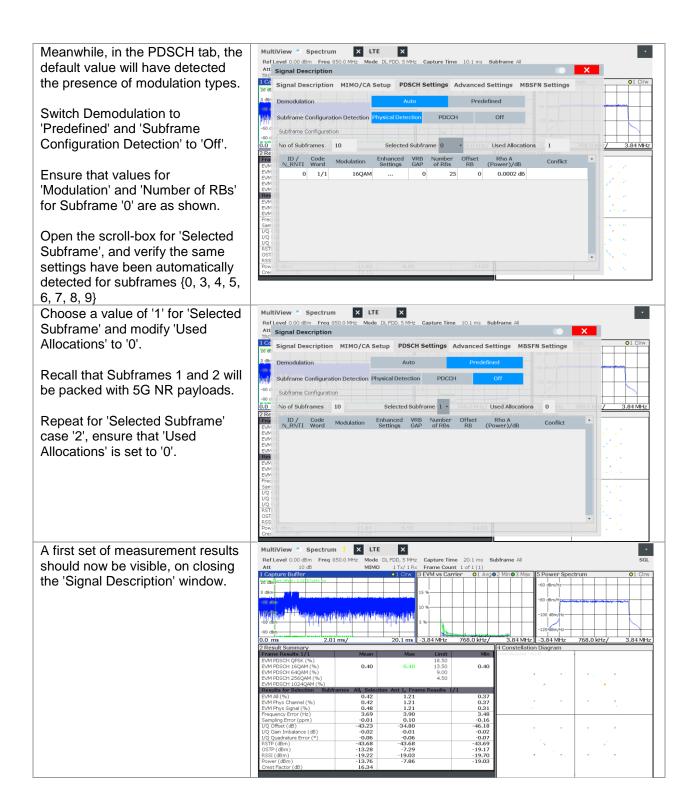
Alternatively, if the intention is to migrate to a production testing, this feature will also come in useful.

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

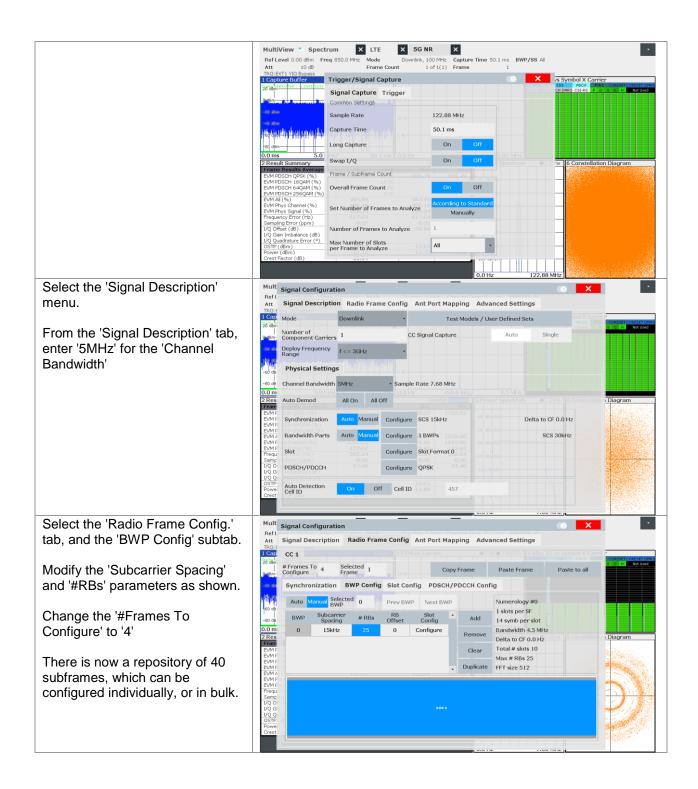
Set up of the FSW using the touchscreen or web interface is as follows.

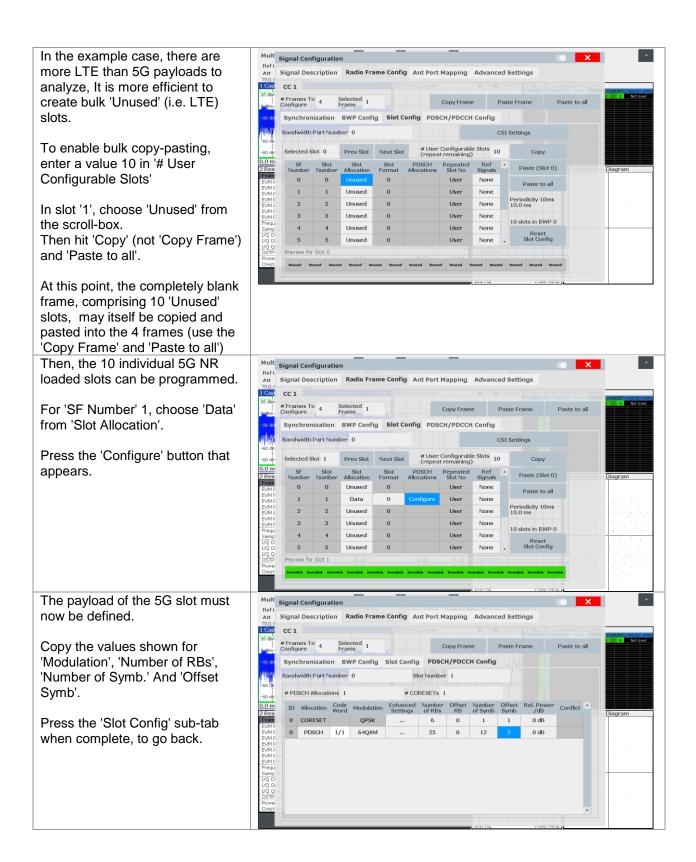




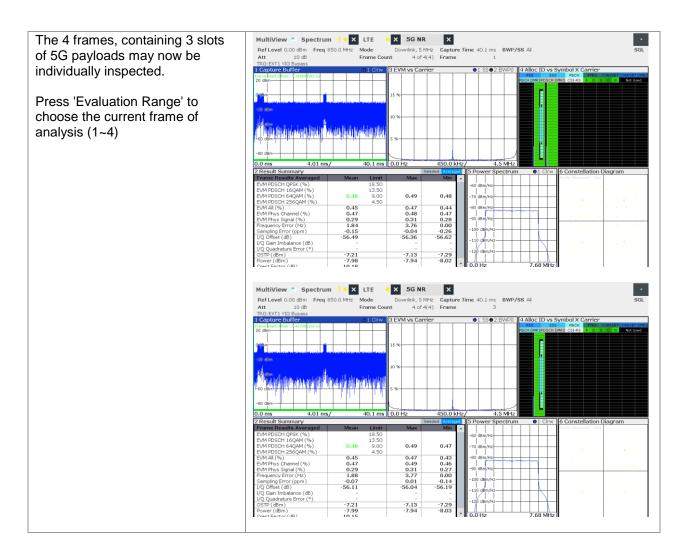


Those results may be augmented, for example, by pressing 'Meas. Config' hard-key, and dragging 'Alloc ID vs Symbol X Carrier'. The 2 empty MBSFN subframes, configured earlier, are clearly visible. Metrics for, and constellation diagram of, the 16QAM LTE payloads are reported.		Bit         Freq 850.0 MHz           0 dB         57283 bit           157283 bit         57283 bit           15728 bit         5728 bit <th>MIMO 1 TV / 1 RV c/ (1 c) v 1 V/ c/ (1</th> <th>Capture Time 20.1 m Frame Count 1 of 1 (1 EVM vs Carrier 01 3.84 MHz 766.0 k 3.84 MHz 766.0 k 100004451 10000451 100000451 10000000000</th> <th>) Avy@2 Min @ 3 Max   Hz/ 5.84 MHz Hz/ 5.84 MHz S.84 MHZ</th> <th>3 Power Spectrum</th> <th>SGL OIC/IW C/ 3.84 MHz C/ 3.84 MHz C/ 3.84 MHz C/ 60 Drd</th>	MIMO 1 TV / 1 RV c/ (1 c) v 1 V/ c/ (1	Capture Time 20.1 m Frame Count 1 of 1 (1 EVM vs Carrier 01 3.84 MHz 766.0 k 3.84 MHz 766.0 k 100004451 10000451 100000451 10000000000	) Avy@2 Min @ 3 Max   Hz/ 5.84 MHz Hz/ 5.84 MHz S.84 MHZ	3 Power Spectrum	SGL OIC/IW C/ 3.84 MHz C/ 3.84 MHz C/ 3.84 MHz C/ 60 Drd
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.	MultiView Ref Level 0.00 ( At Mode Signal +	Spectrum Analyzei	1xEV-DO	Radio Analyzer	3G FDD	3G FDD	01AP Cirw
Press the 'Mode' hard-key and	-20 Channel	-A_ Spectrum	<sup>obo</sup> BTS	■ MS	BTS	™ UE	
select the 5G NR personality.	-30 Replace Current Channel	5G NR	CDMA2000	EDMG CDMA2000	->- Amplifier	··· Analog Demod	
	-40	>> Avionics	A BTS	G MS	CDOCSIS 3.1	GSM	
	-50 (0)	IQ Analyzer	LE LTE	MC Group Delay	NB-IoT	www Noise	
	-70 months last	NeWeb	Phase Noise		Spurious	TD-SCDMA BTS	instaalide on allee alle
		Duplicate Current Channel	Contransient Analysis	VSGTF	VSA 170.0 MHz/	VLAN VLAN	Span 1.7 GHz
Firstly, the triggering and capture length are set-up.	MultiView Ref Level 0.00 ( Att 10 TRG:EXT1 YIG By 1 Capture Buffe	dBm <b>Freq</b> 850.0 MHz DidB pass	LTE X 5G Mode Downlink Frame Count mal Capture	NR X , 100 MHz Capture Tin 1 of 1(1) Frame	ne 20.1 ms BWP/SS . 1	All Jol X Carrie	•
In the 'Trigger' tab, select 'Ext Trigger 1', ensure that offset is set to zero.	20 dBm 0 dBm -c0 dBm -c0 dBm			Dut Segmented Ca - Drop-Or	pture ut Time 0.0 s		S C H Not Used
In the 'Signal Capture' tab, select a value great than 40ms, which corresponds to 4 frames. In this case, 50.1ms is used.	-80 dBm 0.0 ms 2 Result Summa Frame Results A EVM PDSCH 0504 1604 EVM PDSCH 4604 EVM PDSCH 46404 EVM PDSCH 46404 EVM Phys Channe EVM Phys Signal ( Frequency Error (	Hysteresis           (%)           MM (%)           MM (%)           AMM (%)           (%)           479.5           400.5           430.5           40	20.1 0.0 s 3.0 dB 3.5 0 4.5		98. Rising O.O s alloyte dante	Falling	Diagram
'Set Number of Frames to Analyze' should be set to 'Manually' and '4' entered for 'Number of Frames to Analyze'.	Sampling Error (p I/Q Offset (dB) I/Q Quadrature Er OSTP (dBm) Power (dBm) Crest Factor (dB)	-40.0	33 0 44 -40 - 12 -12 2 -12 2 -11 -	-10 -10 -10 -10 -10 -10 -10 -10 -10 -10	0 dbm/h0	.88 MHz	





Press 'Copy', to copy this	Mult Signal Configuration	
prototype 5G slot.	Ref L Att Signal Description Radio Frame Config Ant Port Mapping Advanced Settings	
	TRG:         OL Co.         3 EVM vs Carrier         01 SS02 EWP0         4 Alloc ID vs Symbol X Carrie	
	26'36 m	Not Used
Select 'SF Number' 2, and press	Copy Frame Paste Frame Paste to all	
'Paste'.	Synchronization BWP Config Slot Config PDSCH/PDCCH Config	
	Bandwidth Part Number 0 CSI Settings	
It just remains to configure the	-60 da -60 de Selected Slot 2 Prev Slot Next Slot (renest remaining) Copy	
remaining slot, in subframe 21.	0.0 m SF Slot Slot Slot PDSCH Repeated Ref	
	2 Res Number Number Allocation Format Allocations Slot No Signals Paste (Slot 1) Constellation Diagr	am
	EMP Paste to all	1.1
	EVMF         1         1         Data         0         Configure         User         None           EVMF         2         2         Data         0         Configure         User         None         Periodicity 10ms           EVMF         2         2         Data         0         Configure         User         None         10.0 ms	distant.
	EVM F EVM F 3 3 Unused 0 User None	
	Frequi Samp 4 4 Unused 0 User None 10 slots in BWP 0	
	I/Q 0 I/Q G 5 5 Unused 0 User None Slot Config	
	UQ 0 OSTP Preview for Slot 2 9.53 9.54 9.54 9.54 9.54	방송 사
	Power Crest Downlink	NA SA
Enter a value '3' for 'Selected	Mult Signal Configuration	
Frame'.	Ref L Att Signal Description Radio Frame Config Ant Port Mapping Advanced Settings	
Traine.	TRG: TRG: TRG: TRG: TRG: TRG: TRG: TRG:	
	20 deir H Franzes To Sciented	Not Used
In Slot 1, repeat the configuration	Copy Frame Paste (Frame 2) Paste to all	
steps detailed previously.	Synchronization BWP Config Slot Config PDSCH/PDCCH Config	
	Bandwidth Part Number 0 CSI Settings	
	-60 dBr -90 dBr Selected Slot 1 Prev Slot Next Slot # User Configurable Slots 10 Copy	
	0.0 m cc Clot Slot Slot BDSCH Reported Ref.	
	2 Res Number Number Allocation Format Allocations Slot No Signals Paste Const. Late Diagr	am
	EVMF 1 1 Data 0 Configure Liter None	1. J.
	EVM F 2 2 Unused 0 User None Periodicity 10ms	Sec.
	EVM P EVM P B M r 3 3 Unused 0 User None	
	Frequence 4 4 Unused 0 User None 10 slots in BWP 0	
	U/Q 0 5 5 Unused 0 User None Slot Config	
	UQQ OSTP Preview for Slot 1	관습니다
	Powei Crest Downlink	
	0.0 Hz 7.08 MHz	
Finally, in the 'Advanced Settings'	Mult Signal Configuration	•
tab, set 'Phase Compensation' to	Ref L Att Signal Description Radio Frame Config Ant Port Mapping Advanced Settings	
'Off'.	TRG: FILLING SUPPORT	
OII.		Not Used
	Global Settings Handling of Carrier Leakage None	
	RF Upconversion	
	Reference Phase Compensation On Off	
	Reference Point A         Phase Compensation         On         Off           40 dm         f_0 =         CF         Manual	
	Reference Point A         Phase Compensation         On         Off           60 dw         f_0 =         CF         Manual           0.0 m         5.0 lms         5.0 lms         0.0 m         0.1 m	
	Reference Point A     Phase Compensation     On     Off       60 dw     f_0 =     CF     Manual       20 dw     5.0 lms     5.0 lms     5.0 lms       2 Res     Stanmary     5.0 lms     6.0 mg	am
	Reference Point A     Phase Compensation     On     Off       60 dw     f_0 =     CF     Manual       0.0 m     5.01 ms     5.01 ms     0.01 ms       7 Res     Statement     50 dw     50 dw       8 Statement     50 dw     50 dw     60 cm       7 Res     Statement     50 dw     60 cm       8 Statement     50 dw     50 dw     60 cm	am
	Reference Point A     Phase Compensation     On     Off       60 dw     f_0 =     CF     Manual       0.0 m     5.01 ms     50.1 ms     60.0 MHz       2 Res     Statement     50.50 State     50.50 State       France     Manual     50.50 State     50.50 State       EVM F     COSCAL State     50.50 State     50.50 State       EVM F     State     50.50 State     50.50 State       EVM F     COSCAL State     50.50 State     50.50 State	
	Reference Point A     Phase Compensation     On     Off       60 de 60 d	
	Reference Point A         Phase Compensation         On         Off           40 dm         f_0 =         CF         Manual           40 dm         f_0 =         CF         Manual           40 dm         S0.0 ms         S0.0 ms         S0.0 ms         CF           20 dm         S0.0 ms         S0.0 ms         S0.0 ms         CF         Manual           20 dm         S0.0 ms         S0.0 ms         S0.0 ms         CF         Manual           20 dm         S0.0 ms         S0.0 ms         S0.0 ms         CF         Manual           20 dm         S0.0 ms         S0.0 ms         S0.0 ms         CF         Manual           20 dm         S0.0 ms         S0.0 ms         S0.0 ms         CF         Manual           EVM F         S0.0 ms         S0.0 ms         S0.0 ms         S0.0 ms         S0.0 ms         CF           EVM F         S0.0 ms         S0.0 ms         S0.0 ms         S0.0 ms         S0.0 ms         CF         Manual           EVM F         S0.0 ms         Manual         S0.0 ms         S0.0 ms         S0.0 ms         S0.0 ms         S0.0 ms	  
	Reference Point A         Phase Compensation         On         Off           60 db         F_0 =         CF         Manual           60 db         50 mm         00 mm         00 mm         00 mm           2 Res         50 mm         00 mm         00 mm         00 mm         00 mm           2 Res         50 mm         00 mm         <	· · · ·
	Reference Point A         Phase Compensation         On         Off           60 de 60	
	Reference Point A         Phase Compensation         On         Off           66 dpint A         F_O =         CF         Manual           66 dpint A         F_O =         CF         Manual           66 dpint A         F_O =         CF         Manual           70 dpint A         So in mo         So in mo         So in mo         So in mo           20 dpint A         So in mo         So in mo         So in mo         So in mo           20 dpint A         So in mo           20 dpint A         So in mo           20 dpint A         So in mo           20 dpint A         So in mo           EVMF Find So in So in mo           EVMF Find So in So in mo           EVMF Find So in mo           So in mo <td< td=""><td></td></td<>	



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:STAT ON :CONF:LTE:DL:CC:MBSF:AI:NMRL 1 :CONF:LTE:DL:CC:MBSF:SUBF1:STAT ON :CONF:LTE:DL:CC:MBSF:SUBF1:STAT ON :CONF:LTE:DL:CC:MBSF:SUBF2:STAT ON :CONF:LTE:DL:CC:MBSF:SUBF2: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'	
: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:SIBF1:STAT ON :CONF:LTE:DL:CC:MBSF:SUBF1:STAT ON :CONF:LTE:DL:CC:MBSF:SUBF2:STAT ON :CONF:LTE:DL:CC:MBSF:SUBF3:STAT ON :SENS:LTE:DL:CC:MBSF:SUBF8:STAT ON :SENS:LTE:DL:CC:MBSF:SUBF8:STAT ON :SENS:LTE:DL:CC:SUBF1:ALC 0 :CONF:LTE:DL:CC:SUBF1:ALC 0 :CONF:LTE:DL:CC:SUBF8:ALC 0	*RST
<pre>: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:SUBF2:STAT ON :SENS:LTE:DL:DEM:AUTO OFF :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</pre>	*CLS
<pre>: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:STAT ON :CONF:LTE:DL:CC:MBSF:SUBF1:STAT ON :CONF:LTE:DL:CC:MBSF:SUBF1:STAT ON :CONF:LTE:DL:CC:MBSF:SUBF2:STAT ON :CONF:LTE:DL:CC:MBSF:SUBF3:STAT ON :SENS:LTE:DL:DEM:AUTO OFF :SENS:LTE:DL:DEM:AUTO OFF :CONF:LTE:DL:CC:SUBF1:ALC 0 :CONF:LTE:DL:CC:SUBF1:ALC 0 :CONF:LTE:DL:CC:SUBF3:ALC 0</pre>	:SYST:DISP:UPD ON
<pre>: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:SUBF3: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</pre>	: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:SUBF3: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	:INST:CRE:NEW LTE, 'LTE'
: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	:INIT:CONT OFF
: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	:SENS:SWE:TIME 0.0101
: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	:TRIG:SEQ:SOUR EXT
: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	:CONF:LTE:DL:CC:BW BW5_00
: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	:CONF:LTE:DL:CC:MBSF: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	:CONF:LTE:DL:CC:MBSF:AI:NMRL 1
: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	:CONF:LTE:DL:CC:MBSF:SUBF1: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	:CONF:LTE:DL:CC:MBSF:SUBF2:STAT ON
: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	:CONF:LTE:DL:CC:MBSF:SUBF8:STAT ON
:CONF:LTE:DL:CC:SUBF1:ALC 0 :CONF:LTE:DL:CC:SUBF2:ALC 0 :CONF:LTE:DL:CC:SUBF8:ALC 0	:SENS:LTE:DL:DEM:AUTO OFF
:CONF:LTE:DL:CC:SUBF2:ALC 0 :CONF:LTE:DL:CC:SUBF8:ALC 0	:SENS:LTE:DL:FORM:PSCD OFF
:CONF:LTE:DL:CC:SUBF8:ALC 0	:CONF:LTE:DL:CC:SUBF1:ALC 0
	:CONF:LTE:DL:CC:SUBF2:ALC 0
:INST:CRE:NEW NR5G, '5G NR'	: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:SL0T:PAST:ALL :CONF:NR5G:DL:CC1:FRAM1:BWP0:SL0T0:ATYP UNUS :CONF:NR5G:DL:CC1:FRAM1:BWP0:SL0T0:COPY :CONF:NR5G:DL:CC1:FRAM1:BWP0:SL0T: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.	:INST:SEL "DSS_LTE" :CONF:LTE:DL:CC:MBSF:SUBF2:STAT ON :CONF:LTE:DL:CC:SUBF2:ALC 0
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_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	:INST:SEL "DSS_LTE"
Subframe 2 is also a MBSFN subframe, but is	:CONF:LTE:DL:CC:MBSF:SUBF3:STAT OFF
NOT occupied with a 5G payload.	:CONF:LTE:DL:CC:SUBF3:ALC 1
It is an LTE payload.	:CONF:LTE:DL:CC:SUBF3:ALL0:CW1:MOD QAM16
Thus, while SUBF and SLOT indices are	:CONF:LTE:DL:CC:SUBF3:ALL0:RBC 25
incremented, the command sequences sent are	:CONF:LTE:DL:CC:SUBF3:ALL0:RBO 0
different.	: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	:INST:SEL "DSS_5G_NR"
	:CONF:NR5G:DL:CC1:FRAM2:BWP0:SSP SS15
The EDAM index is incremented (to 0)	:CONF:NR5G:DL:CC1:FRAM2:BWP0:RBC 25
The FRAM index is incremented (to 2)	:CONF:NR5G:DL:CC1:FRAM2:BWP0:CSL 10
The potential contents of each MBSFN subframe	:CONF:NR5G:DL:CC1:FRAM2:BWP0:SLOT:PAST:ALL
as set to a default value (15Khz spacing, etc.)	: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

- 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=IRLT7J7klg8
- [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	Туре	Order No.
R&S®FSW signal and spectrum analyzer	R&SFSW8	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&SSMW200A	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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### **Regional contact**

Europe, Africa, Middle East +49 89 4129 12345 customersupport@rohde-schwarz.com

North America 1 888 TEST RSA (1 888 837 87 72) customer.support@rsa.rohde-schwarz.com

Latin America +1 410 910 79 88 customersupport.la@rohde-schwarz.com

Asia Pacific +65 65 13 04 88 customersupport.asia@rohde-schwarz.com

China +86 800 810 82 28 |+86 400 650 58 96 customersupport.china@rohde-schwarz.com

### Sustainable product design

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

Certified Quality Management

Certified Environmental Management ISO 14001

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Rohde & Schwarz GmbH & Co. KG Mühldorfstraße 15 | 81671 Munich, Germany Phone + 49 89 4129 - 0 | Fax + 49 89 4129 - 13777

www.rohde-schwarz.com