Aerospace & Defence

WEBINAR ADVANCED CODING AND MODULATION FOR NEW SPACE

Dr. Yvonne Weitsch, Market Segment Manager A&D Ralph Kirchhoff, Product Manager

ROHDE&SCHWARZ

Make ideas real





ADVANCED MODULATION AND CODING TECHNOLOGIES IN NEW SPACE

Content

- Motivation
 - DVB-S2X Annex E
 - DVB-RCS2
 - OFDM
- Applications
- Measurement setup
- Outlook



MOTIVATION FOR DVB-S2X

EBU DV3

ETSLEN 302 307-2

DVB-S2 versus DVB-S2X

- Improved performance by 30% and spectral efficiency.
- Additional features enabling new applications.

System con	figurations		Broadcast services	Interactive services	DSNG	Professional services
2PSK	1/4,1/3, 2/5		0	N	N	N
	1/2, 3/5, 2/3, 3/4 8/9, 9/10	, 4/5, 5/6,	Ν	N	N	N
PSK	3/5, 2/3, 3/4, 5 6	, 8/9, 9/10	N	N	N	N
6APSK	2/3, 3/4, 4/5, 5	, 8/9, 9/10	0	N	N	N
2APSK	3/4, 4/5, 5/6, 8/	, 9/10	0	N	N	N
CM			N	N (see note 1)	N	N
/CM			0	0	0	0
CM			NA	N (see note 2)	0	0
ECFRAME (normal)	64 800 (bits)		N	N	N	N
ECFRAME (short)	16 200 (bits)		NA	N	0	N
Single Transport Stream			N	N (see note 1)	N	N
Aultiple Transport Streams			0	O (see note 2)	0	0
Single Generic Stream			NA	O (see note 2)	NA	0
Aultiple Generic Streams			NA	O (see note 2)	NA	0
Roll-off 0,35, 0,25 and 0,20			N	N	N	N
nput Stream Synchronizer			NA except (see note 3)	O (see note 3)	O (see note 3)	O (see note 3)
Iull Packet Deletion			NA except (see note 3)	O (see note 3)	O (see note 3)	O (see note 3)
Dummy Frame insertion			NA except (see note 3)	N	N	N
ide-band mode	(see ann x M)		0	0	0	0

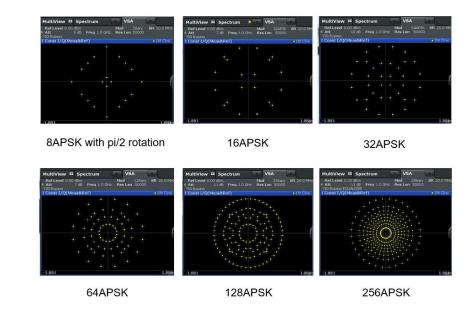
NOTE 3: Normal and single/multiple TS input stream(s) combined with ACMVCM or for multiple TS input streams combined with CCM.

- Mobile connectivity, in-flight connectivity, maritime
- Professional services: Banking, news, e-governance
- Adaptive Coding and Modulation (ACM).

IMPROVEMENTS IN DVB-S2X

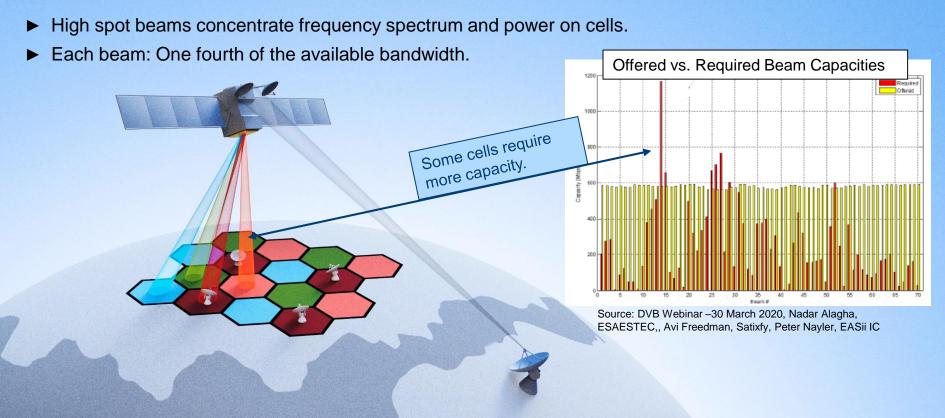
Main features

- More MODCODs
- Time slicing
- Lower roll off
- Scrambling
- Channel bonding



Capacity and flexibility in broadband interactive satellite networks.

REGULAR HTS



DVB-S2X COULD DO BETTER....

User requirements



- Flexible allocation of satellite capacity to actual user demands
- ► Bandwidth allocation by timely requirements

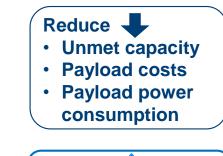
BUT



- Unmet and unused capacity
- The standard did not easily allow for dynamic reallocation of resources.

Satellite technology advances

 Flexible payloads, electronically steerable antennas, SSPAs, regenerative payloads.





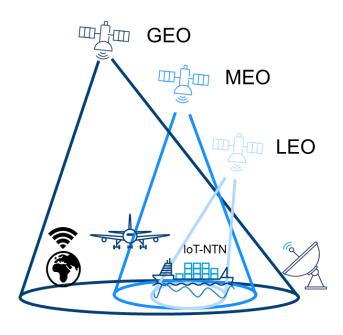
SOLUTION: BEAM HOPPING

Wider range of applications

 IOT, flight connectivity, consumer broadband, maritime, IP trunking,...

Serving technical requirements

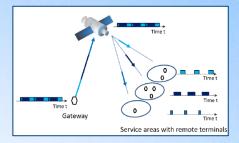
 High illumination ratios, single or multiple carriers per beam, low power, low latency, GEO, MEO, LEO



SOLUTION: BEAM HOPPING

- Reconfiguration according to changing traffic demands and user locations.
- + Entire BW at all beams
- + Increase of capacity
- + Lower interference
- + More efficient amplifier operation

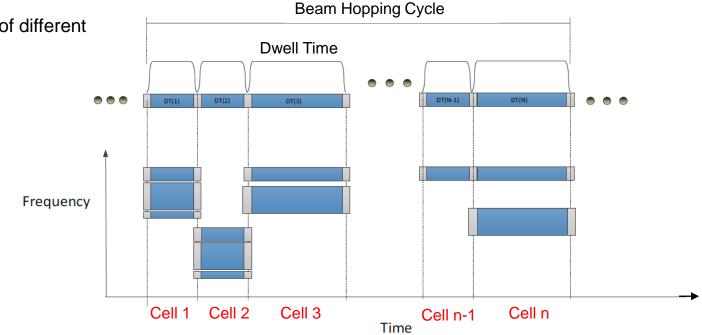
The Beam Hopping time plan determines the dwell times on the cells and the BH cycle in a cluster.



Source: BEAM-HOPPING SYSTEM CONFIGURATION AND TERMINAL SYNCHRONIZATION SCHEMES, Christian Rohdel, Doron Rainsh2, Avraham Freedman2 GryL esthievenX, Nader Alaghad, Danielle Delaruelle5, Gerhard Mocker6, Xavier Giraud7, 25th Ka and Broadband. Communications Conference, (K 2019), Sorrento, Italy

THE BEAM HOPPING SIGNAL

- Transmission time consists of cycles:
 - Dwell at cells
 - Several carriers of different bandwidth

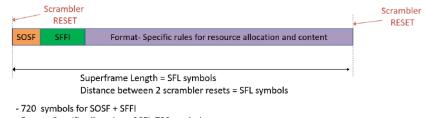


Source: Satixfy, Avi Freedman, Presentation at R&S satellite industry day, 2022 by Avi Freedman, A. Morello, N. Alagha: DVB-S2X Air Interface Supporting Beam Hopping Systems 25th Ka and Broadband Communications Conference, (Ka-2019), Sorrento, Italy, Oct. 2019 2 Rohde & Schwarz

DVB-S2X ANNEX E – BEAM HOPPING AND SUPERFRAME

The super-framing structure has the following targets:

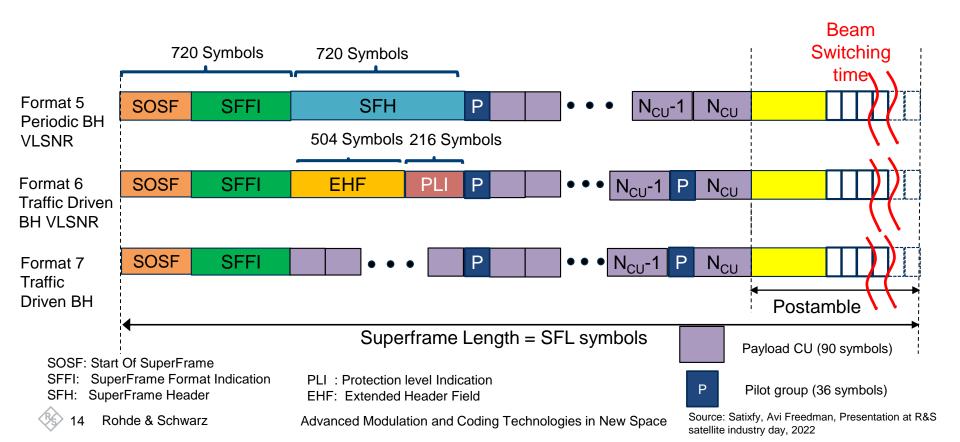
- Increased resilience to co-channel interference due to superframe-wide scrambling.
- Support of synchronization algorithms
- ► Future proof frame design supporting
 - Interference mitigation techniques.
 - Beam hopping operations.
 - Multi-format transmission.



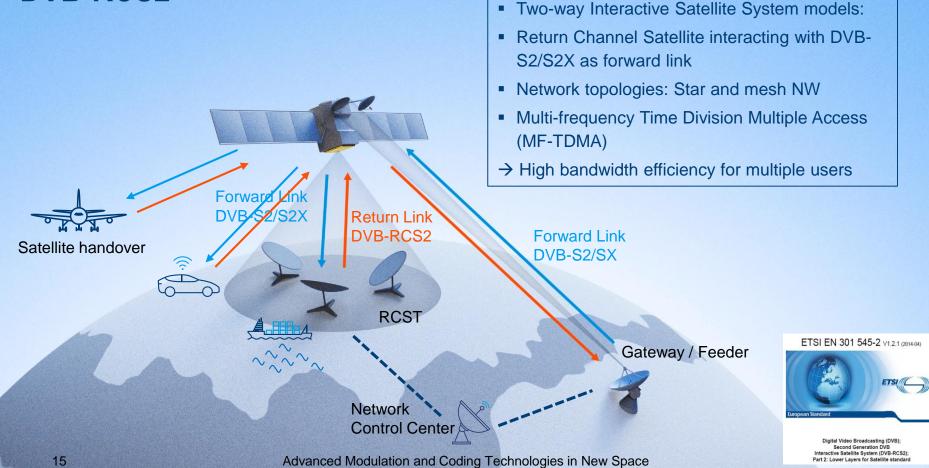
- Format Specific allocation of SFL-720 symbols

Figure E.1: Super-frames of length SFL symbols - the super-frame format specifies the resource allocation and content

ANNEX E: SUPER-FRAMING STRUCTURE



DVB-RCS2



ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

Advantages of OFDM

- High spectral efficiency
- Mitigation of inter-symbol interference
- High data rate transmission
- Versatility in mobile applications.



OFDM promising for New Space applications and for NTN as part of international mobile telecommunications.

APPLICATIONS DVB-S2X ANNEX E, DVB-RCS2, OFDM

- DVB-S2X Beam Hopping applications
 - Traffic oriented internet connection
 - Time-flexibility in illuminating service areas
- ► DVB-RCS2 applications
 - Satellite communication
 - Interactive internet connection
 - Return Channel of DVB-S2/S2X Interactive / Professional Services
 - Two-way satellite broadband VSAT systems
- OFDM applications
 - Portable and mobile satellite communication

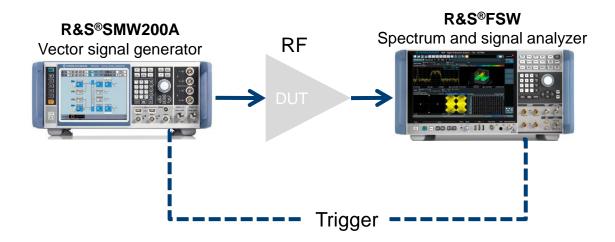
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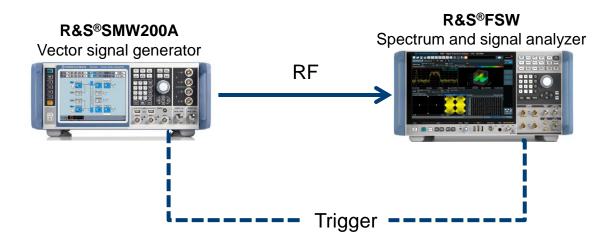
MEASUREMENT SETUP

► Principle measurement setup



MEASUREMENT SETUP

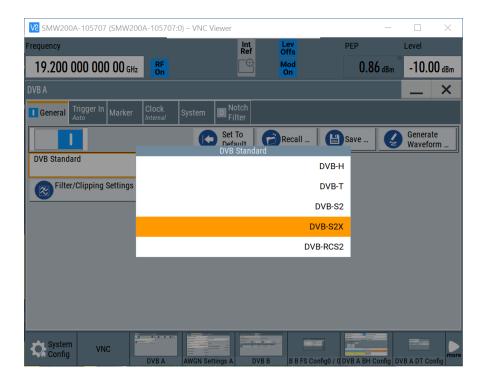
► Simplified measurement setup



DVB-S2X BEAM HOPPING AND SUPERFRAME SIGNAL GENERATION

Key facts

- DVB-S2X beam hopping and superframe signals acc. to EN 302 307-2 V1.3.1 Annex E
- ► Super-frame formats 4, 5, 6, 7
- Physical layer header (PLH)
- Superframe pilots
- Two-way scrambling
- Beam hopping with configurable Dwell time



DVB-S2X Annex E configuration

- ► Basic DVB-S2X configuration
- Enhanced configuration DVB-S2/S2X menu
 - SF configuration (Superframe)
 - BH configuration (Beam hopping)

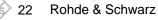
V2 SMW200A-105707 (SMW200A-10)5707:0) – VNC Viewer			
Frequency		Int Lev Ref Offs	PEP I	Level
	RF Dn	Mod On	0.86 dBm	-10.00 dBm
DVB A				_ ×
General Trigger In Auto Clou		otch Iter		
Stream Type Transport	CRC32	61: 16APSK 1/2-L	Pilot State	
Input Stream Single	BB Scrambler 🔽	Code Type Norm MODCOD	PL Scramb Scr. Sequer	
Data Source PN 9	Outer Coder 🗹	16APSK 1/2 Modulation	→	0
Complete PN Sequence	Inner Coder 🗹	(8+8)APS	sk i	0
Data Length 0 3 864 Bytes	Rate 90/180	1	SF Config	On
Auto Data Length 🗹	Bit Interleaver 🗹	-1	BH Config	 On
TS Header Config	Uncoded Mode	-1 0 1		
BB Header Config				
System VNC DVE	AWGN Settings A	DVB B B FS Config0 / 0	DVB A BH Config DVE	A DT Config

Superframe configuration

► SF Common

- Superframe Format Indicator selection
- Start of Superframe Walsh-Hadamard (WH)
- Two-Way Scrambler
 - Reference and Payload
- Pilot configuration
 - Pilot State
 - Pilot Walsh-Hadamard (WH) sequence
- ► SF Specific
 - Expected SF Length
 - PLH Protection Level Index

Abreviation PLH: Physical Layer Header



International Control (SMW200A-105707.0) − VNC Viewer					-	0 ×
Frequency	Int	Lev Offs		PEP	Level	
1.225 000 000 000 GHz	_€			2.07 dBm	-10.0	<mark>)</mark> dBm
DVB A: Super Frame Configuration					_	X
SF Common SF Specific Information						
Super Frame Active	l					
SFFI (Super Frame Format Indicator)	5	SOSF WH <mark>(</mark> Start	of Super Fra	ame)		0
n Ref (SF Scrambler 2-way)	1 r	Pay (SF Scram	bler 2-way)			0
SF Pilot State	s 🖉	F Pilot WH				0
			-			_
System VNC(2), SMB DVB A BH Config R	emote Access	Setup	ARB B T	rig/Marker/Clock	DVB A	more

- Superframe configuration
- Support of new Superframe formats
 4, 5, 6, 7
- Available application modes
 - Format 4: Flexible with VL-SNR
 PHL tracking
 - Format 5: Pre-scheduled with VL-SNR and fragmentation
 - Format 6, 7: Traffic-driven w/o VL-SNR

V8 SMW200A-105707 (SMW20	0A-105707:0) – VI	NC Viewer			_		\times
Frequency	_	Int Ref	Lev Offs	PEP		Level	
19.200 000 000 00 GHz	RF On		Mod On	-1.	62 dBm	-10.0	0 dBm
DVB A: Super Frame Configuration						_	×
SF Common SF Specific Inform	ation						
Super Frame Active		1					
SFFI (Super Frame Format Ind	SFFI	(Super Frame Forr	nat Indicator)	- ie)			0
n Ref (SF Scrambler 2-way)				4			0
				5			0
SF Pilot State				6			0
				7			
System VNC(2)				- 2			
	DVB A AWG	N Settings A DV	'B B B FS Cor	nfig0 / 0 DVB A B	H Config DVI	B A DT Co	nfig more

- Beam Hopping configuration
- Definition of Beam Hopping time plan
 - Number of Dwells for service areas
 - Dwell time for traffic demands
 - Beam Hopping Cylcle definition by
 - Number of Dwells
 - Dwell Lengths
 - Beam Switching

Dwell content definition

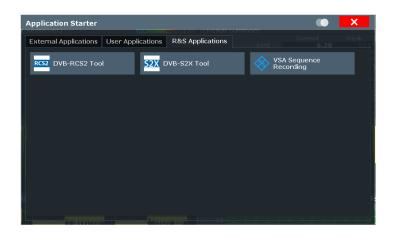
- Dwell 0: definable content
- Other Dwells with dummy pattern

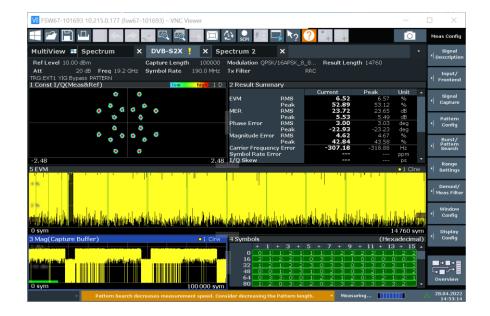
reque	ncy				ev ffs	PEP	Level	
19.	200 000 000 00	GHz RF			od)n	0.86 dBm	-10.00	dBn
OVB A:	VB A: Beam Hopping Configuration							
Bean	n Hopping Active		1	Zero Beam	Switching Signa	I	5	\checkmark
Num	ber of Dwells		3	Attenuate C	ther Dwell		5	\checkmark
Bean	n Hopping Cycle		⊘ 38 432 sym	Fill Other D	wells			
DT	Dwell Length [Symbols]	DT Config						
DT 0	23 432	Config						
DT 1	10 000	-						
DT 2	5 000	-						
			Beam Hop	ping Cycle -				_
	I	ото			C)T1	DT2	
		SF0						
r		— Dwell Le	nath	,]			
-	System VNC	1		-				I

DVB-S2X BEAM HOPPING SIGNAL ANALYSIS

DVB-S2X signal analysis

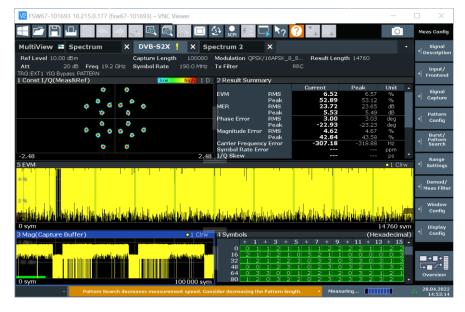
- ► FSW internal applications
- DVB-S2X Tool



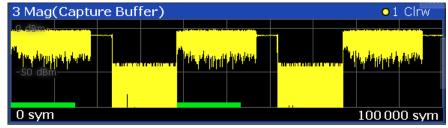


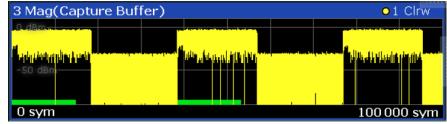
DVB-S2X BEAM HOPPING SIGNAL ANALYSIS

Constellation, EVM, signal / pattern capture



Beam hops with beam switching time (w/o Zero Beam Switching cycle)

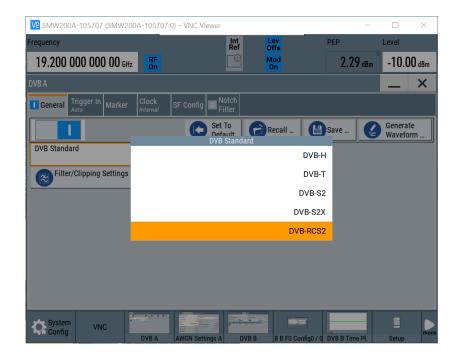




DVB-RCS2 SIGNAL GENERATION

Key facts

- ► DVB-RCS2 acc. to ETSI EN 301 545-2
- Turbo FEC encoder linear modulation (TC-LM) and Pi/2-BPSK, QPSK, 8PSK, 16QAM modulation schemes
- Support of linear modulation and spread spectrum linear modulation bursts
- Predefined waveforms as defined in ETSI EN 301 545-2 Annex A
 - TC-LM and Spread Spectrum TC-LM
- User-defined waveforms (settable parameters)
- Multi-carrier and multi-section configuration



DVB-RCS2 SIGNAL GENERATION

Configuration

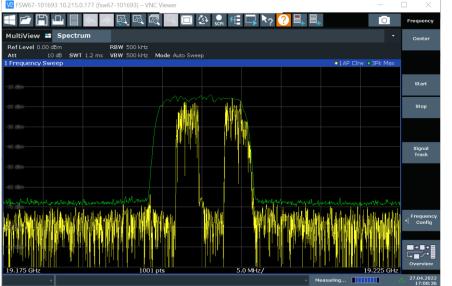
- Predefined waveforms as defined in ETSI EN 301 545-2 Annex A
- User-defined waveforms

105 SMW200A-105707 (SMW200A-105707:0) - VINC View	6)				- 🗆 🗙
Frequency		Int Ref	Lev Offs	PEP	Level
19.200 000 000 00 GHz	RF On		Mod On	1.05 dBm	-10.00 dBm
					_ ×
BTU Config Grid Config Section Con	fig				
Number of Sections * Section	° C	Prev	Next	Resolu	ve Conflicts
Mode	Dredefined	Waveform I	d		- General
Start BTU		Mode	Predefined		Payload
Time Slot Size		_	User Defined	10	Encoding
Modulation	QPSK	Burst Lengt	h	664 :	© Reference Signal
System VNC	. 20	515			-
Config Se	tup DVB A BH Cor	nfig DVB A	AWGN Settings A	ference Oscillator	DVB B

Ke SMW200A-105707 (SMW200A-105707:0) – VNC Viewer				– 🗆 X
Frequency	Int Ref	Lev Offs	PEP	Level
19.200 000 000 00 GHz		Mod On	1.05 dBm	-10.00 dBm
DVB B: Frame Structure for SF 0 / Frame 0				_ ×
BTU Config Grid Config Section Config				
Number of Sections Section 0	Prev	Ø ● Next	Resolv	e Conflicts
UW (Hex) 3300 FC0F F3C3 3CCF FF03 00C0 FCF3 CCCF 0CFF C3C3 F00C FCC0 F33F F0CC F030 F330 CFFF 00F0 30F3 30CF FF00	0F00			© General Payload
UW Length 183 sy	Preamble Leng m	gth	155 s	ym Reference
Postamble Length 27 sy	Pilot Period		18 s	Signal
Pilot Block Length 1 sy	Number of Pilo	ot Blocks	100	26
System VNC Setup DVB A BH		AWGN Settings A	B B FS Config0 / 0 fer	ence Oscillator

DVB-RCS2 SIGNAL ANALYSIS

DVB-RCS2 signal in spectrum analysis



DVB-RCS2 Tool for signal analysis



OFDM SIGNAL GENERATION

Key facts

- ► OFDM Signal Generation
- ► OFDM, f-OFDM, UFMC, FBMC, GFD

Latest enhancement

- DFT-S OFDM
 - Customized pattern configuration
- Advantage: crest factor reduction

V2 SMW200A-105707 (SMW200A-105707:0) – VNC Viewer	_	
Frequency	Int Lev PEP Ref Offs	Level
19.200 000 000 00 GHz	Ф Мод 6.50 dBm	-5.00 dBm
OFDM Signal Generation B: General Settings (OFDM)		_ ×
Physical Filter		
Total Number of Subcarriers	Occupied Number of Subcarriers	
1 024	Occurrent to a with	512
Subcarrier Spacing 312.500 0 kHz	Sequence Length	10 Symbols
Cyclic Prefix Length	CP No. Symbols	
16 Samples		1 Symbols
Alt. Cyclic Prefix Length	Alt. CP No. Symbols	
0 Samples		0 Symbols
DFT-S (skip non-data)		
Sampling Rate	Occupied Bandwidth	0
320.000 MHz		160.000 MHz
Number of Left Guard Subcarriers	Number of Right Guard Subcarriers	0.54
256		256
Config VNC, SMB DVB B SF Config DVB B B	B FS Config0 / Q DVB A BH Config FDM Generation B	FDM Alloc. Set. B

DFT-S OFDM SIGNAL GENERATION AND ANALYSIS

DFT-S Signal Configuration

Level

_ ×

19.200 000 000 00 GHz

1st Symbol[®] Symbols

0 10

330 270 210

Time Plan

6.50 dBm -5.00 dBm

p/dB Content State Con

0.000 Pilot

0.000 Data

0.000 Pilo

Allocation Settings

Int

DN 16

PN16

PN16

- Pilot
- Data

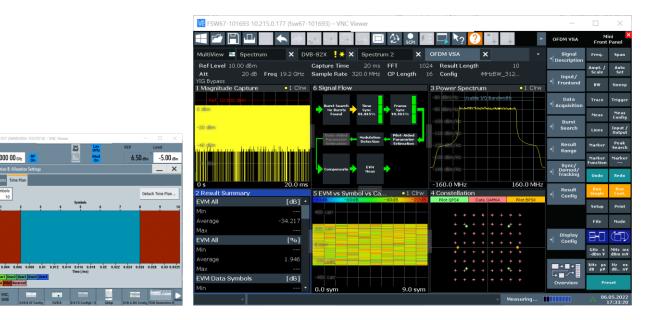
Time Plan

19.200 000 000 00 GHz

lumber of Alloca

BPSK 512

DFT-S Signal Analysis





OUTLOOK

- Development and usage of transmission standards
 - Proprietary transmission technologies still present

- Standardized transmission technologies will increase

Discrete Fourier transform spread OFDM will increase

- 5G NTN and 6G NTN will be relevant in the near future