Aerospace & Defence

WEBINAR
ADVANCED CODING AND MODULATION FOR NEW SPACE

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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

DVB-S2 versus DVB-S2X

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

Table 1: System configurations and application areas

System configurations		Broadcast services	Interactive services	DSNG	Professional services
QPSK	1/4,1/3, 2/5	O	N	N	N
	1/2, 3/5, 2/3, 3/4, 4/5, 5/6, 8/9, 9/10	N	N	N	N
8PSK	3/5, 2/3, 3/4, 5/6, 8/9, 9/10	N	N	N	N
16APSK	2/3, 3/4, 4/5, 5/6, 8/9, 9/10	O	N	N	N
32APSK	3/4, 4/5, 5/6, 8/9, 9/10	O	N	N	N
CCM		N	N (see note 1)	N	N
VCM		O	O	O	O
ACM		NA	N (see note 2)	O	O
FECFRAME (normal)	64 800 (bits)	N	N	N	N
FECFRAME (short)	16 200 (bits)	NA	N	O	N
Single Transport Stream		N	N (see note 1)	N	N
Multiple Transport Streams		O	O (see note 2)	O	O
Single Generic Stream		NA	O (see note 2)	NA	O
Multiple Generic Streams		NA	O (see note 2)	NA	O
Roll-off 0,35, 0,25 and 0,20		N	N	N	N
Input Stream Synchronizer		NA except (see note 3)	O (see note 3)	O (see note 3)	O (see note 3)
Null 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
Wide-band mode	(see annex M)	O	O	O	O

N = normative, O = optional, NA = not applicable.
NOTE 1: Interactive service receivers shall implement CCM and Single Transport Stream.
NOTE 2: Interactive Service Receivers shall implement ACM at least in one of the two options: Multiple Transport Streams or Generic Stream (single/multiple input).
NOTE 3: Normative for single/multiple TS input stream(s) combined with ACM/VCM or for multiple TS input streams combined with CCM.

Source: ETSI EN 302 307-2

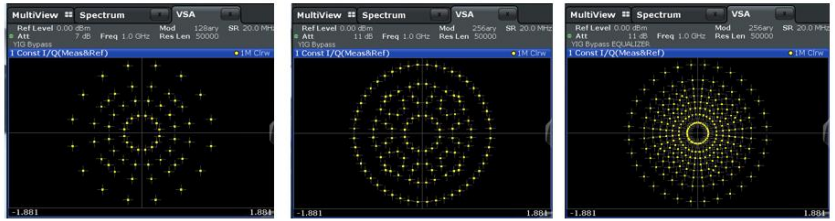
- Mobile connectivity, in-flight connectivity, maritime
- Professional services: Banking, news, e-governance
- Adaptive Coding and Modulation (ACM).

IMPROVEMENTS IN DVB-S2X

Main features

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

8APSK with pi/2 rotation | 16APSK | 32APSK

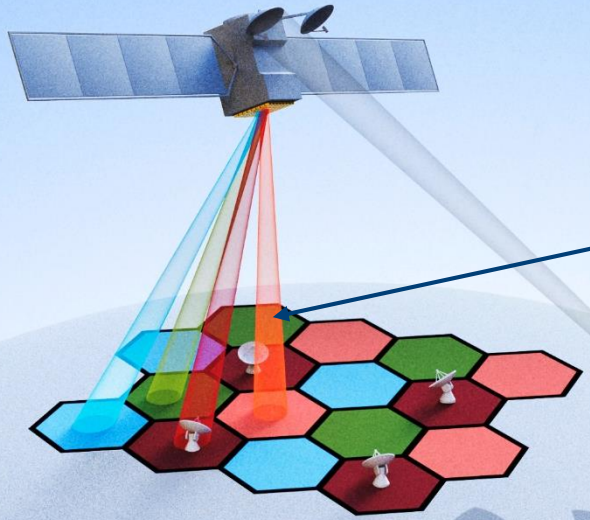


64APSK | 128APSK | 256APSK

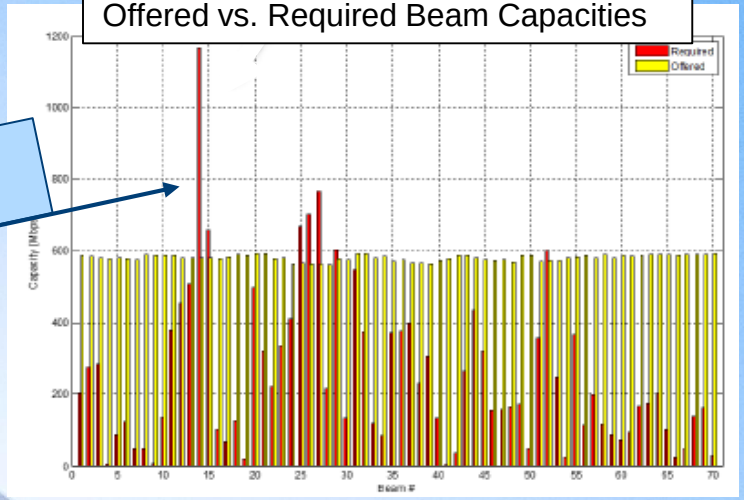
→ Capacity and flexibility in broadband interactive satellite networks.

REGULAR HTS

- High spot beams concentrate frequency spectrum and power on cells.
- Each beam: One fourth of the available bandwidth.



Some cells require more capacity.



Source: DVB Webinar –30 March 2020, Nadar Alagha, ESAESTEC,, Avi Freedman, Satixfy, Peter Nayler, EASii IC

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.

Reduce ↓
- **Unmet capacity**
- **Payload costs**
- **Payload power consumption**

Increase ↑
- **Payload flexibility**
- **Capacity**

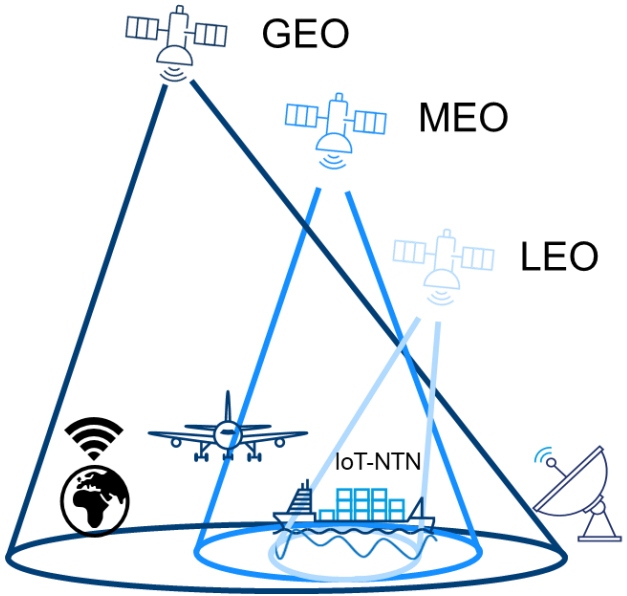
SOLUTION: BEAM HOPPING

Wider range of applications

- IOT, flight connectivity, consumer broadband, maritime, IP trunking,…

Serving technical requirements

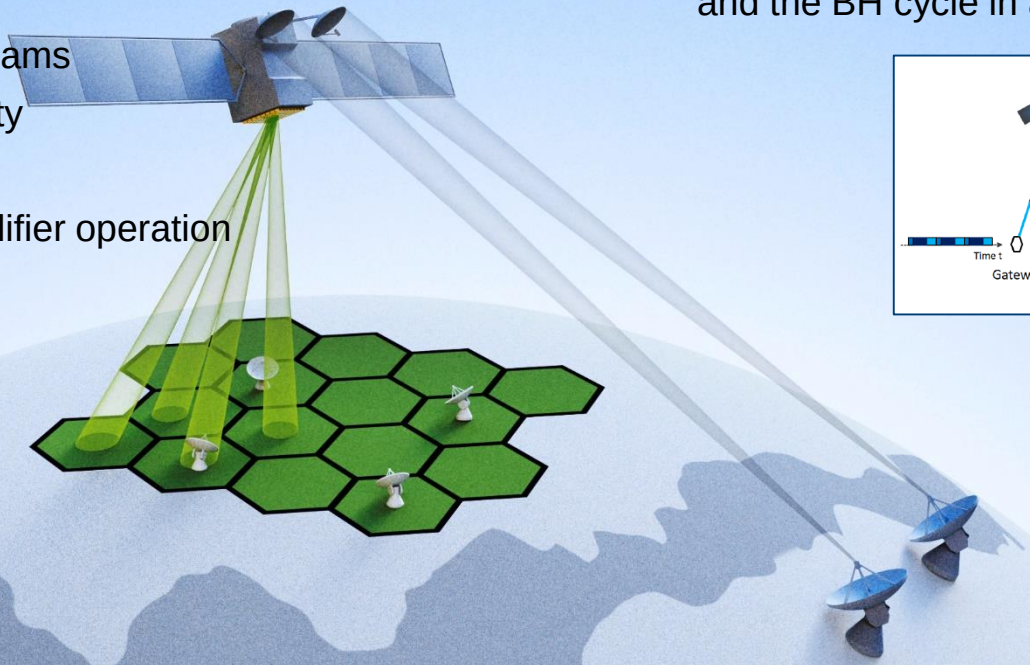
- High illumination ratios, single or multiple carriers per beam, low power, low latency, GEO, MEO, LEO



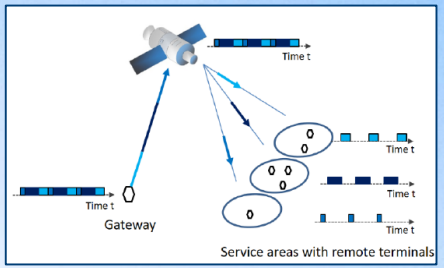
SOLUTION: BEAM HOPPING

- Reconfiguration according to changing traffic demands and user locations.

  + Entire BW at all beams
  + Increase of capacity
  + Lower interference
  + More efficient amplifier operation



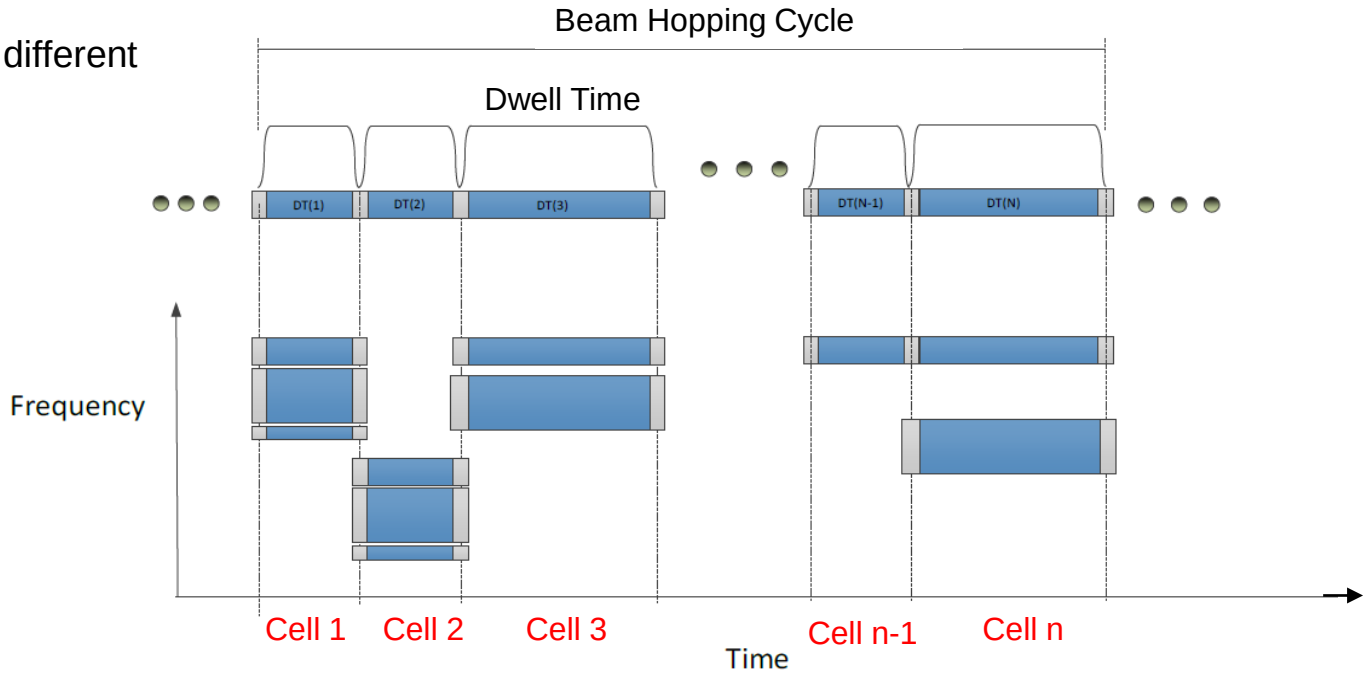
- The Beam Hopping time plan determines the dwell times on the cells and the BH cycle in a cluster.



Source: BEAM-HOPPING SYSTEM CONFIGURATION AND TERMINAL SYNCHRONIZATION SCHEMES, Christian Rohde1, Doron Rainish2, Avraham Freedman2, Guy Lesthievent3, Nader Alagha4, Danielle Delaruelle5, Gerhard Mocker6, Xavier Giraud7, 25th Ka and Broadband. Communications Conference, (Ka 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

DVB-S2X ANNEX E – BEAM HOPPING AND SUPERFRAME

The super-framing structure has the following targets:

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

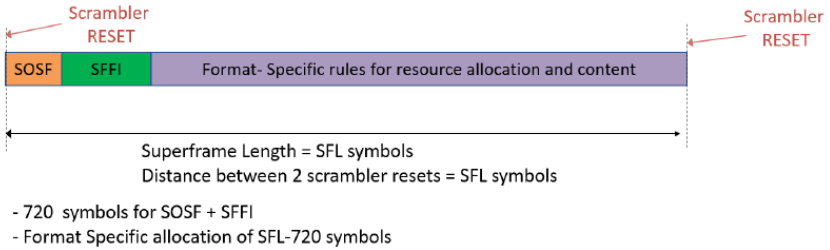
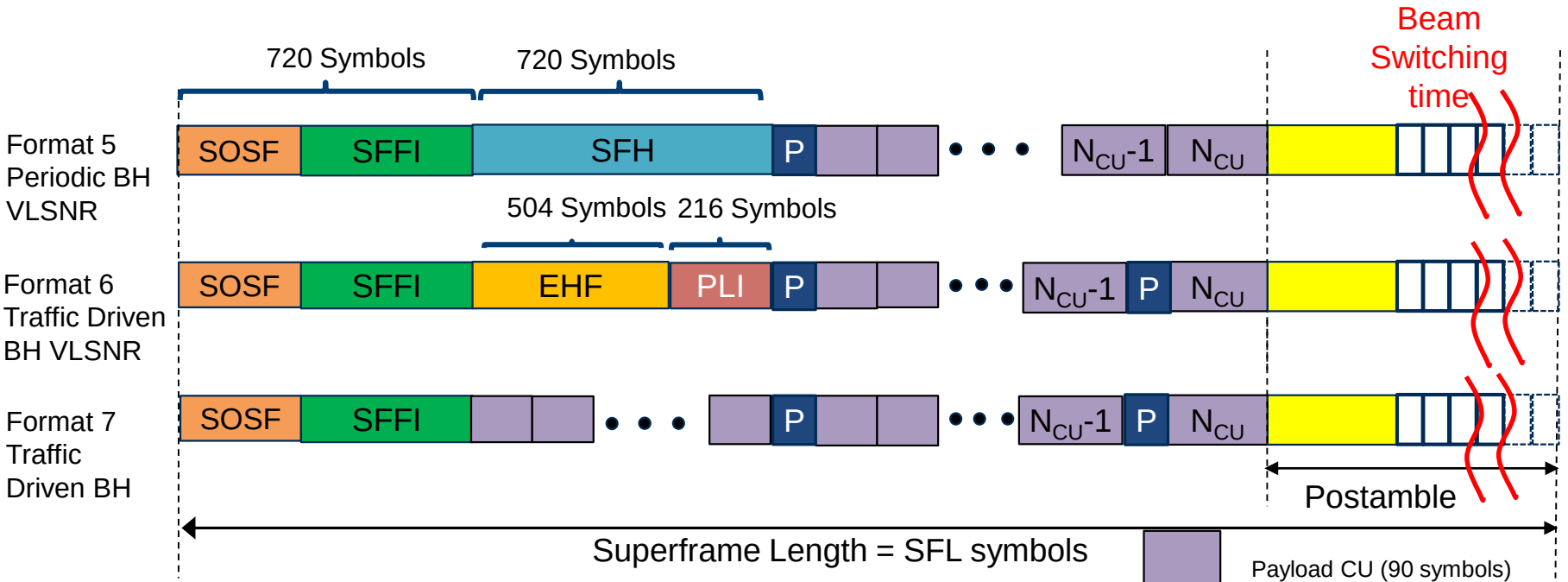


Figure E.1: Super-frames of length SFL symbols - the super-frame format specifies the resource allocation and content

ANNEX E: SUPER-FRAMING STRUCTURE



SOSF: Start Of SuperFrame
SFFI: SuperFrame Format Indication
SFH: SuperFrame Header

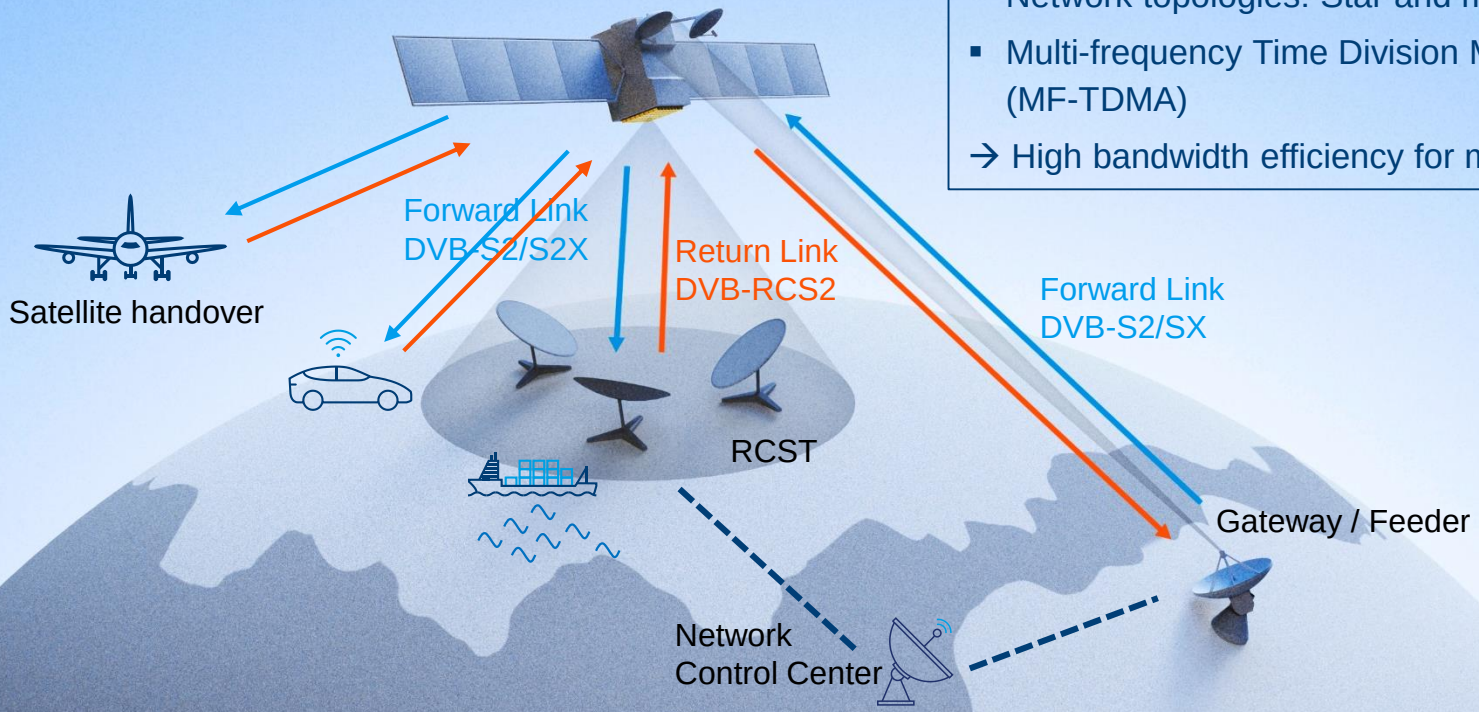
PLI : Protection level Indication
EHF: Extended Header Field

Source: Satixfy, Avi Freedman, Presentation at R&S satellite industry day, 2022

DVB-RCS2

- Two-way Interactive Satellite System models:
- Return Channel Satellite interacting with DVB-S2/S2X as forward link
- Network topologies: Star and mesh NW
- Multi-frequency Time Division Multiple Access (MF-TDMA)

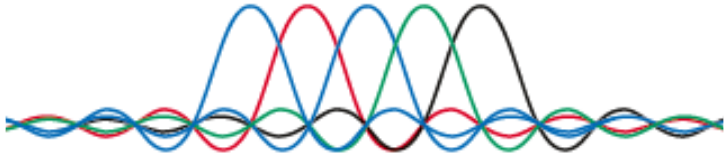
→ High bandwidth efficiency for multiple users



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

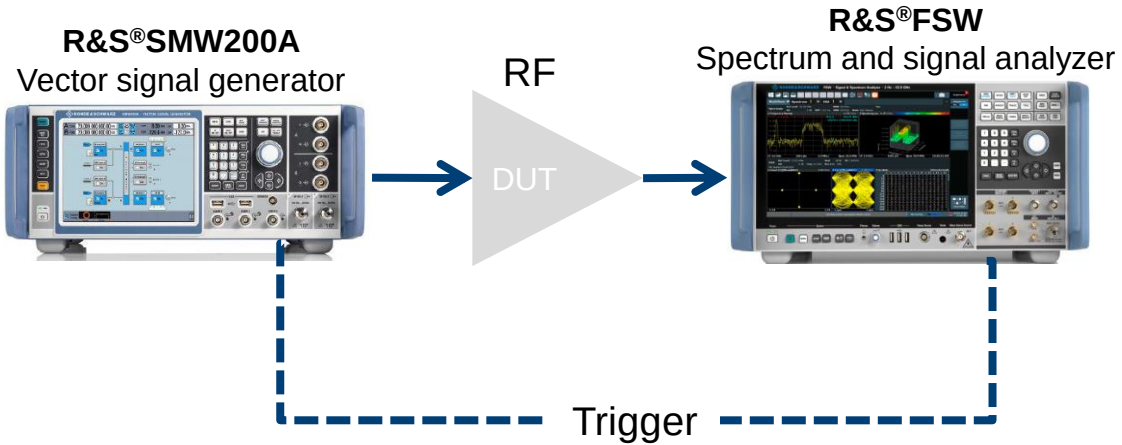
- DVB-S2X Beam Hopping applications
  - Traffic oriented internet connection
  - Time-flexibility in illuminating service areas

- 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

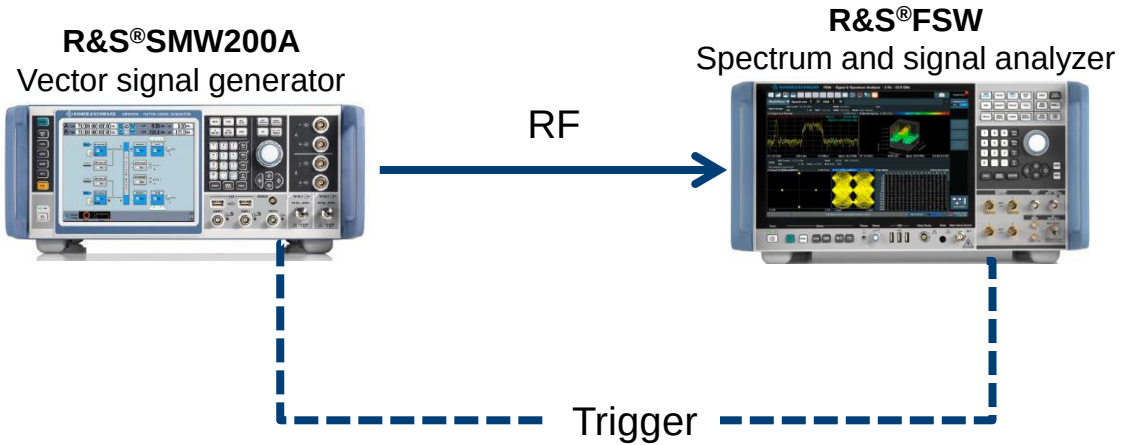
MEASUREMENT SETUP

► Principle measurement setup



MEASUREMENT SETUP

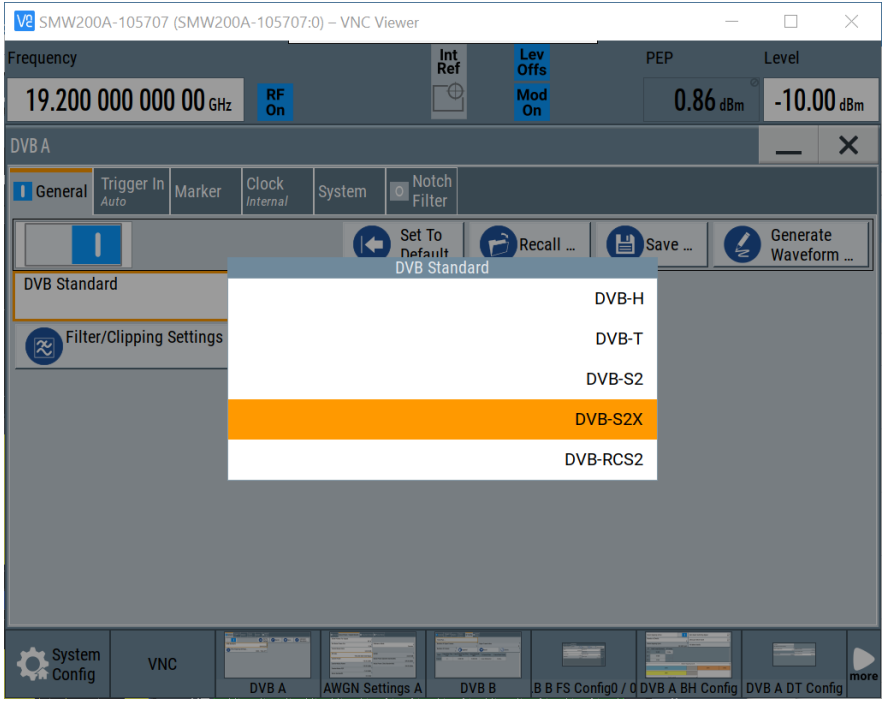
- Simplified measurement setup



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 BEAM HOPPING AND SUPERFRAME

DVB-S2X Annex E configuration

- Basic DVB-S2X configuration

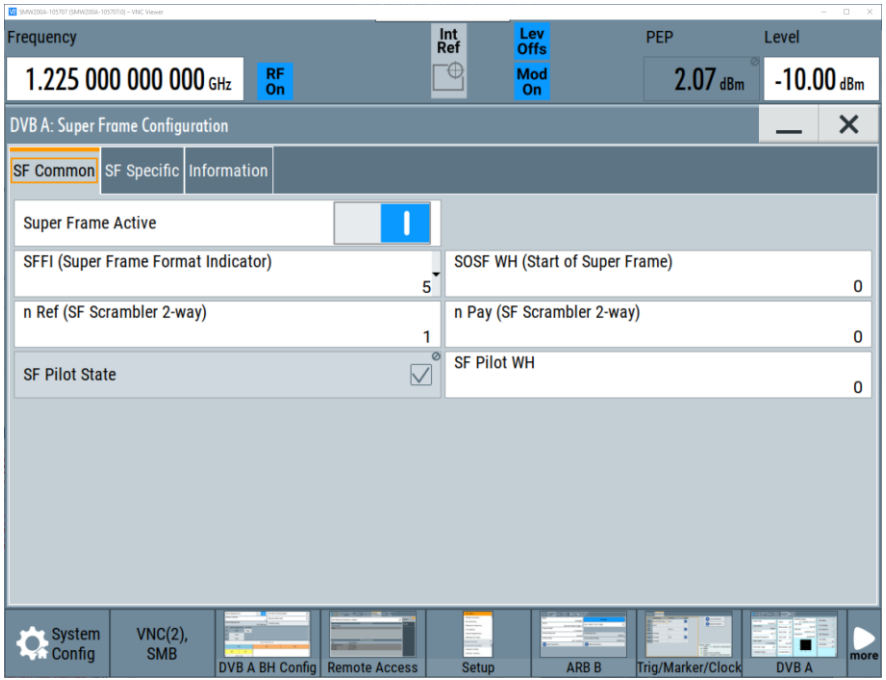
- Enhanced configuration DVB-S2/S2X menu
  - SF configuration (Superframe)
  - BH configuration (Beam hopping)

DVB-S2X BEAM HOPPING AND SUPERFRAME

Superframe configuration

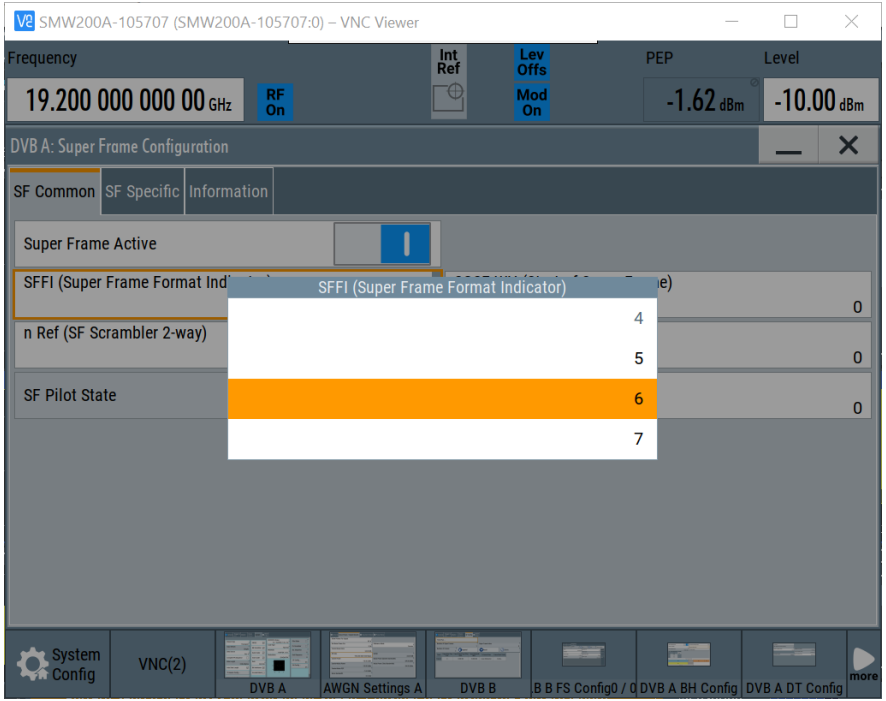
- **SF Common**
  - Superframe Format Indicator selection
  - Start of Superframe Walsh-Hadamard (WH)
  - Two-Way Scrambler
    - Reference and Payload
  - Pilot configuration
    - Pilot State
    - Pilot Walsh-Hadamard (WH) sequence
- **SF Specific**
  - Expected SF Length
  - PLH Protection Level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

Abreviation PLH: Physical Layer Header



DVB-S2X BEAM HOPPING AND SUPERFRAME

- **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

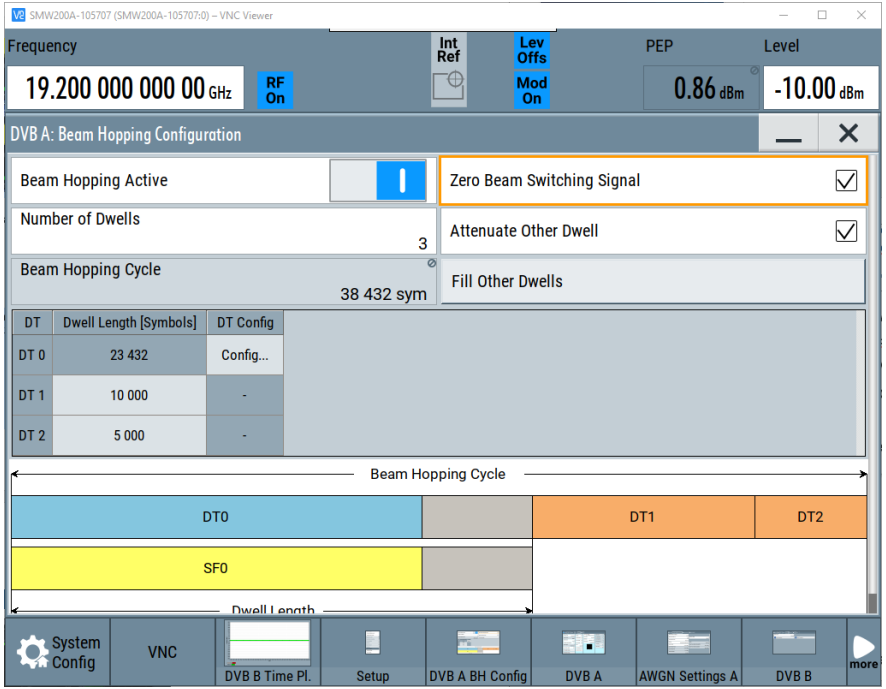


DVB-S2X BEAM HOPPING AND SUPERFRAME

- **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

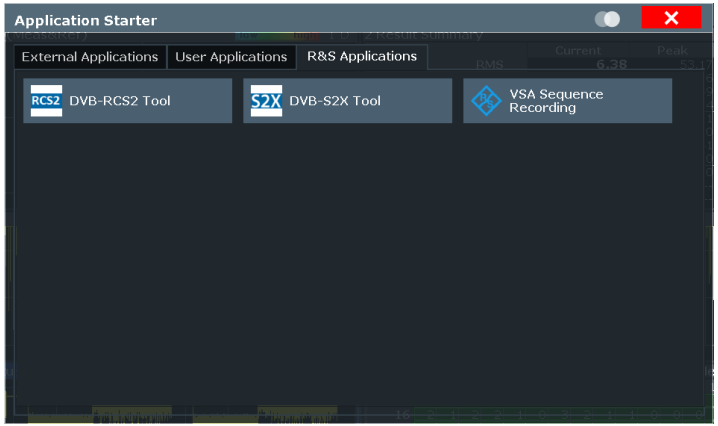
- **Dwell content definition**
  - Dwell 0: definable content
  - Other Dwells with dummy pattern

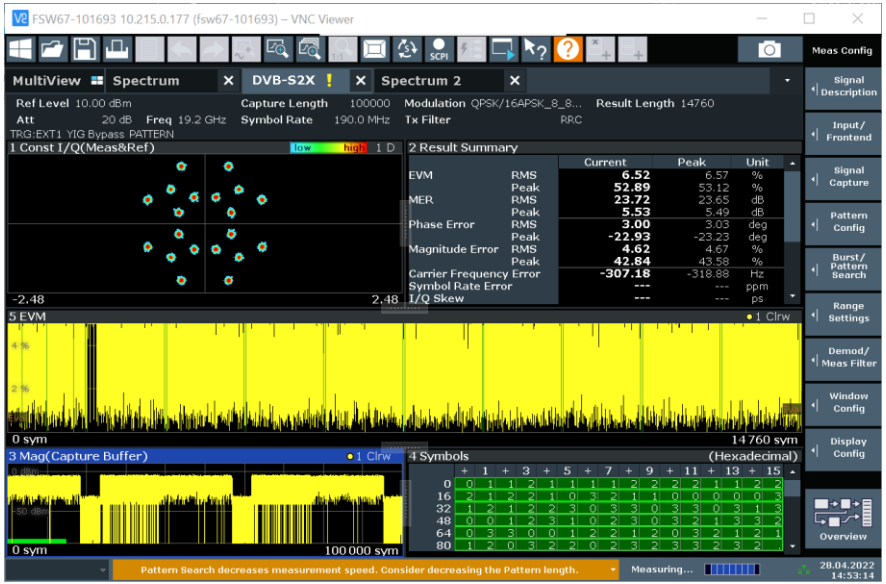


DVB-S2X BEAM HOPPING SIGNAL ANALYSIS

DVB-S2X signal analysis

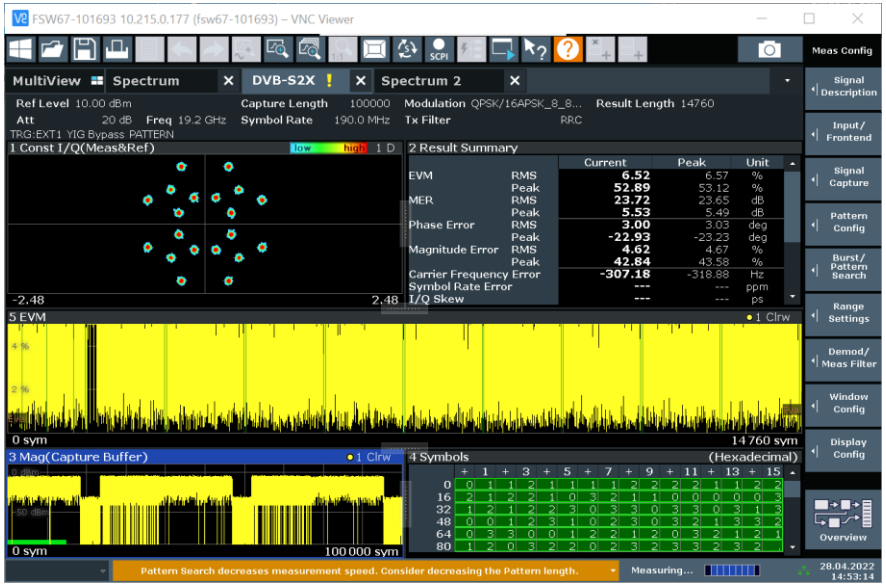
- ► FSW internal applications
- ► DVB-S2X Tool



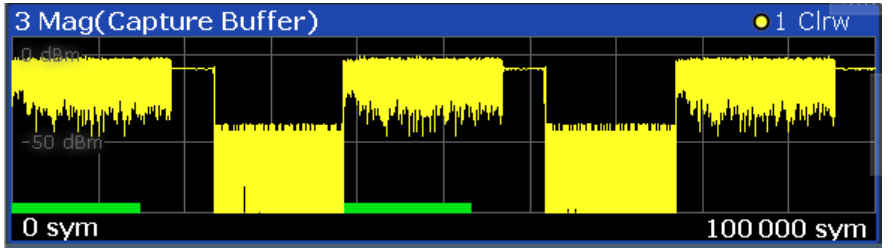


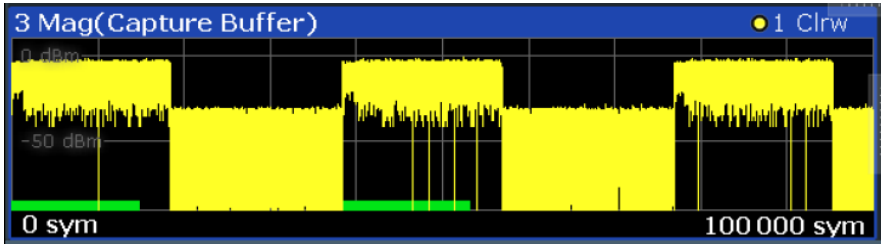
DVB-S2X BEAM HOPPING SIGNAL ANALYSIS

Constellation, EVM, signal / pattern capture



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

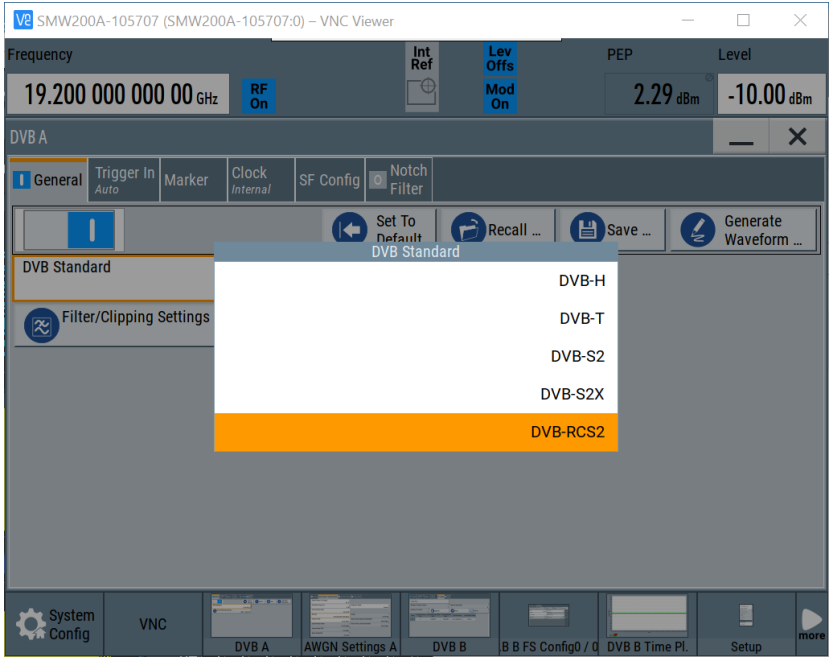




DVB-RCS2 SIGNAL GENERATION

Key facts

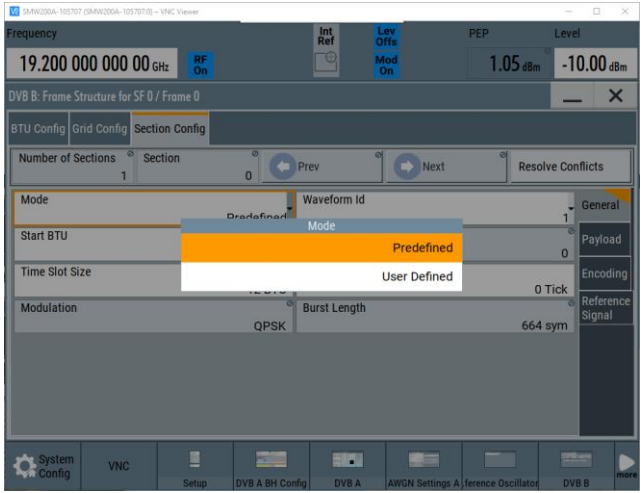
- DVB-RCS2 acc. to ETSI EN 301 545-2
- Turbo FEC encoder linear modulation (TC-LM) and Pi/2-BPSK, QPSK, 8PSK, 16QAM modulation schemes
- Support of linear modulation and spread spectrum linear modulation bursts
- Predefined waveforms as defined in ETSI EN 301 545-2 Annex A
  - TC-LM and Spread Spectrum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

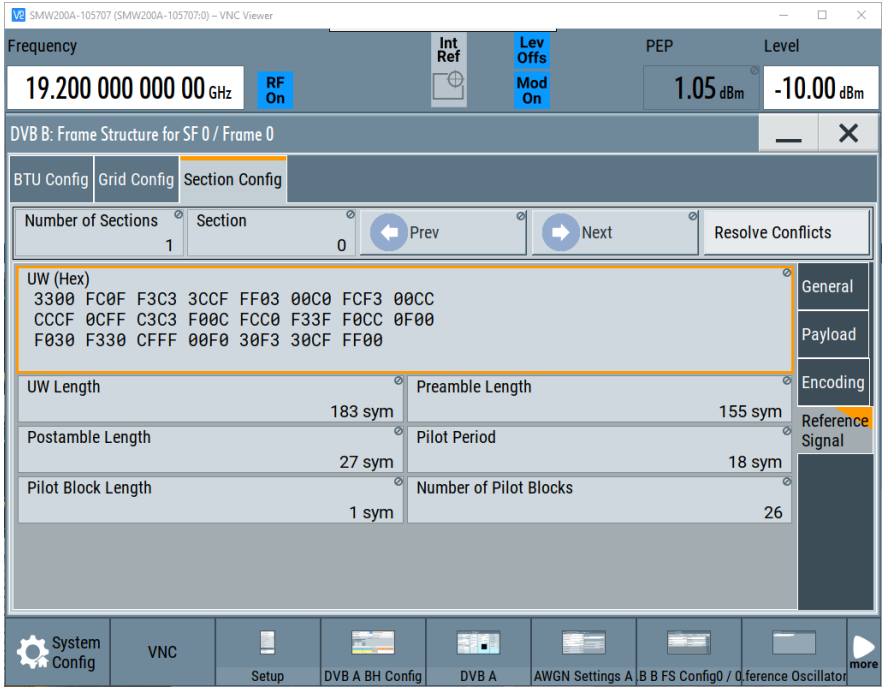


DVB-RCS2 SIGNAL GENERATION

Configuration

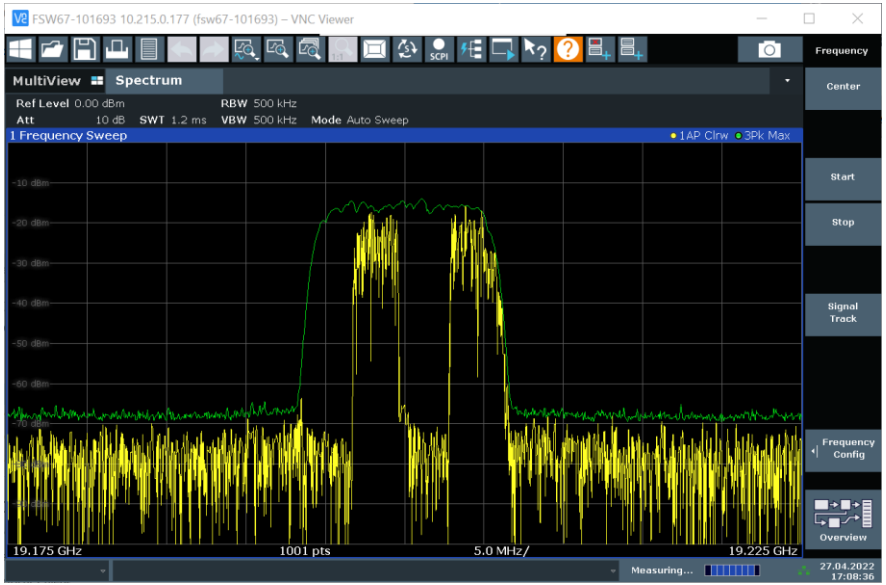
- Predefined waveforms as defined in ETSI EN 301 545-2 Annex A
- User-defined waveforms



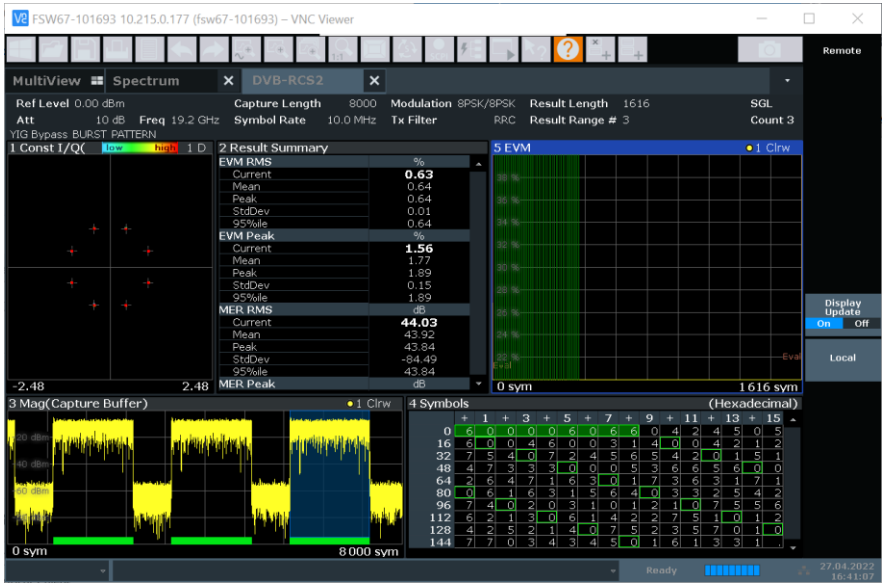


DVB-RCS2 SIGNAL ANALYSIS

DVB-RCS2 signal in spectrum analysis



DVB-RCS2 Tool for signal analysis



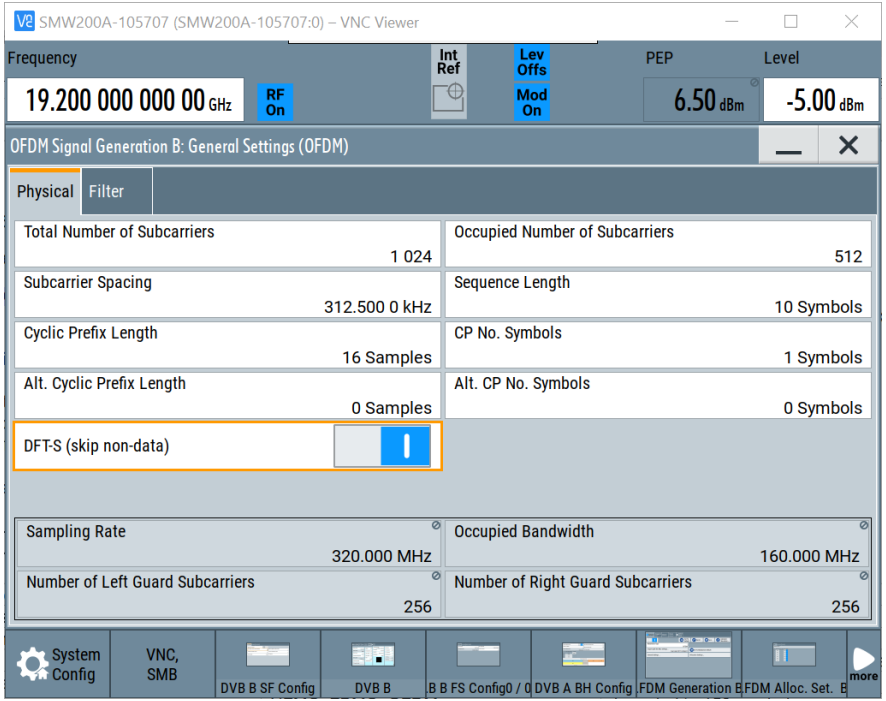
OFDM SIGNAL GENERATION

Key facts

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

Latest enhancement

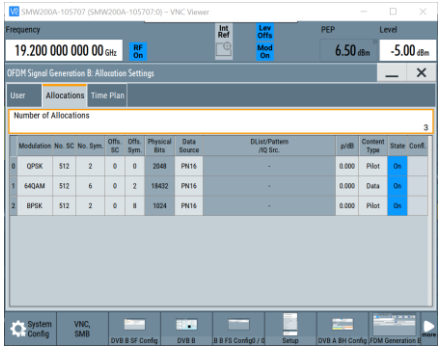
- DFT-S OFDM
  - Customized pattern configuration
- Advantage: crest factor reduction

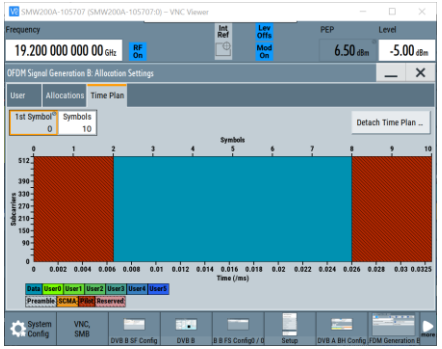


DFT-S OFDM SIGNAL GENERATION AND ANALYSIS

DFT-S Signal Configuration

- Allocation Settings
  - Pilot
  - Data
- Time Plan





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