

Progress and R&D of Transmission Technologies for Satellite Broadcasting in Japan

NHK Science & Technology Research Laboratories

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NHK

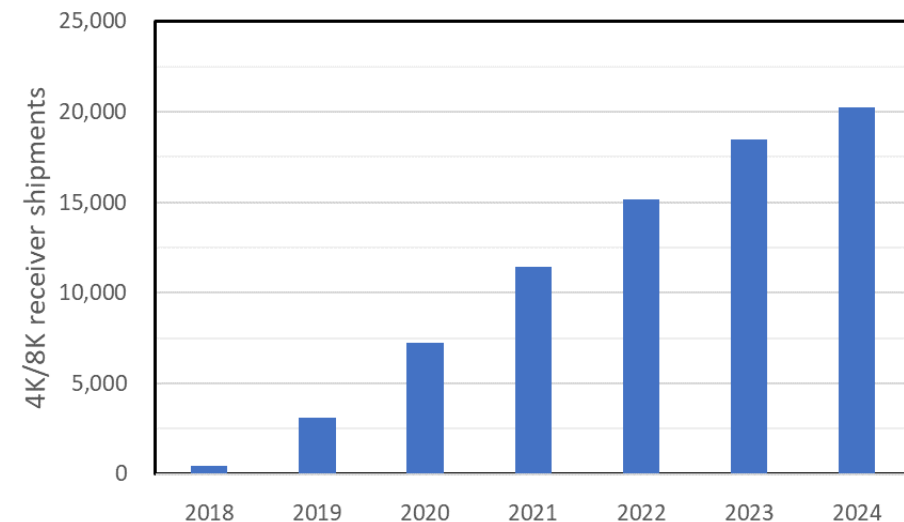
- ◆ Latest transmission technologies operated in 12-GHz-band satellite broadcasting in Japan
 - ISDB-S3 for 4K/8K UHD TV

- ◆ R&D for next-generation satellite broadcasting in 21-GHz-band satellite broadcasting
 - Feature of 21-GHz-band satellite broadcasting
 - Layered Division Multiplex (LDM) based transmission scheme
 - Advanced satellite broadcasting system with VVC multi-layer coding

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- ◆ Start regular 4K/8K UHDTV via 12-GHz-band satellite broadcasting nationwide in 2018
 - Development of ISDB-S3 for 8K UHDTV program in one transponder channel (34.5 MHz)
 - Total time of 4K and 8K programs of Tokyo Olympics/Paralympics in 2021 were more than 300 and 200 hours, respectively.
 - Total shipments of UHDTV available receivers are more than 20 millions.



Features of ISDB-S3 (Rec. ITU-R BO.2098)

- ◆ Increase of transmission rate in 12-GHz-band from ISDB-S for HDTV to ISDB-S3 for UHDTV in same bandwidth

- High efficient modulation

8PSK -> 16APSK

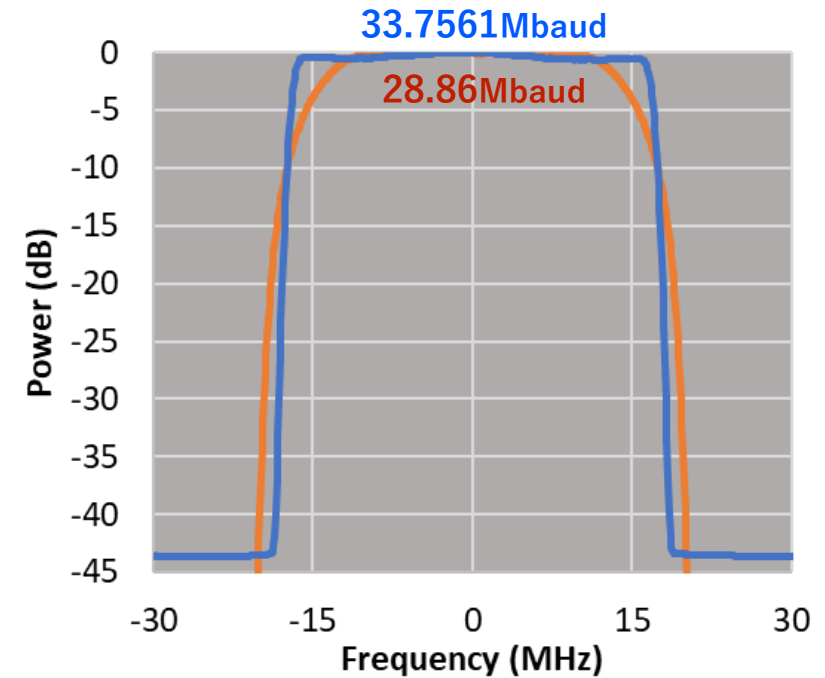
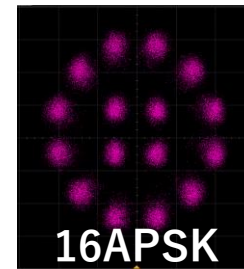
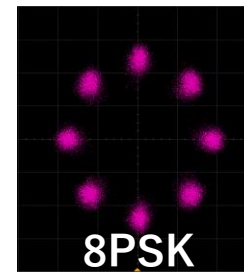
- Sharp roll-off filter

0.35 -> 0.03

28.86Mbaud -> 33.7561Mbaud

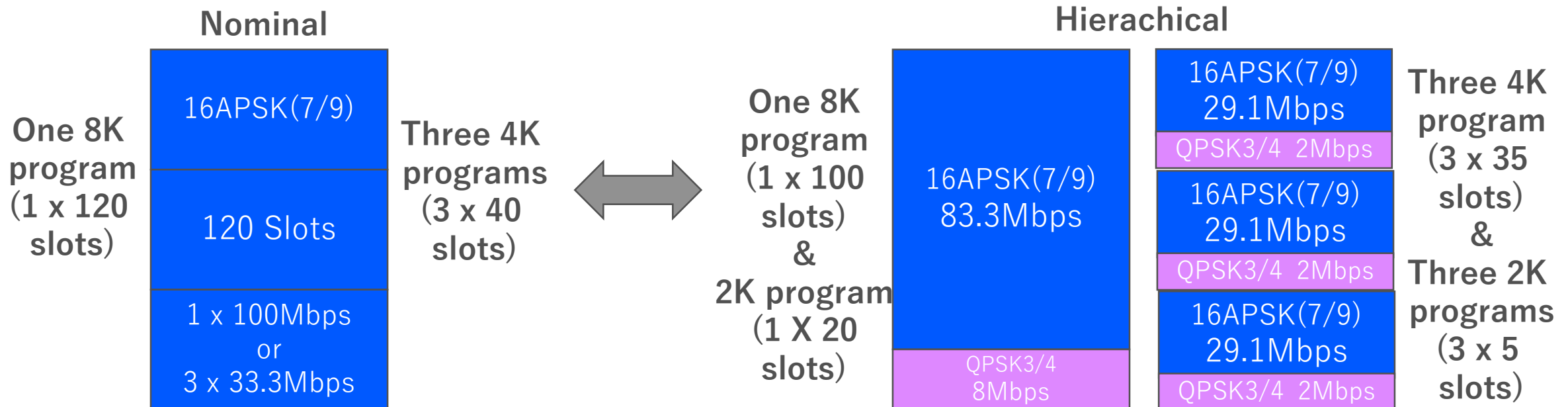
- LDPC code to decrease required reception C/N

52Mbps -> 100Mbps



One 8K program or three 4K programs are provided by using High Efficiency Video Coding (H.265/MPEG-H HEVC) in 34.5-MHz bandwidth

- ◆ Hierarchical transmission for rain fade survivability
 - Stable reception with low C/N by using robust transmission parameters
 - 16APSK(7/9) is applied for all 120 slots under no heavy rainfall nationwide (nominal operation)
 - QPSK(3/4) is applied for a part of slots when heavy rainfall is occurred (predicted) to provide same 2K programs for viewers under large rain att.



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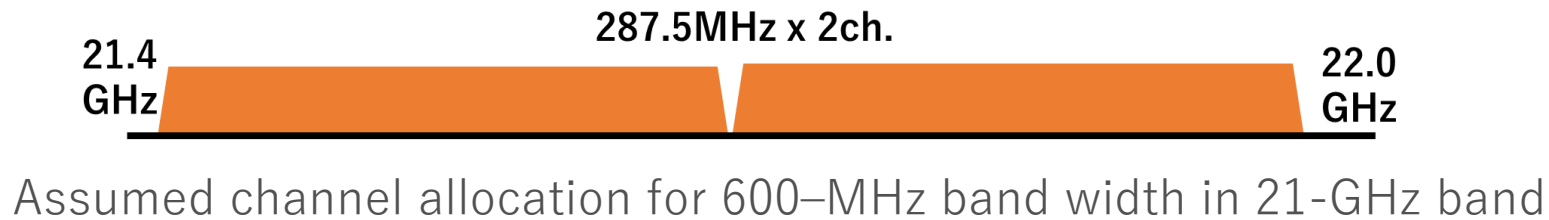
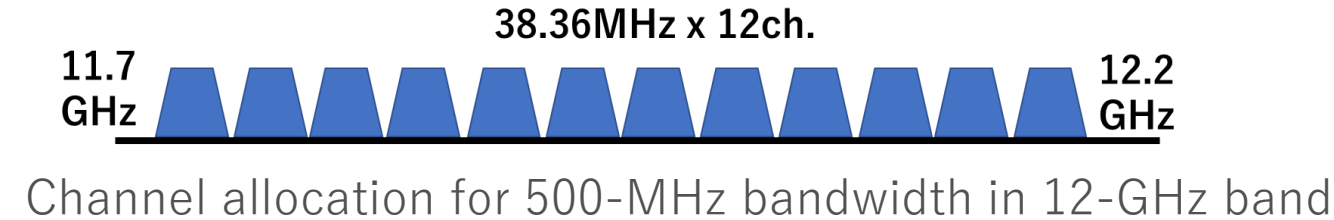
◆ Comparison of 12- and 21-GHz band satellite broadcasting

Item	12-GHz band	21-GHz band
Bandwidth	500MHz (11.7-12.2 GHz)	600MHz (21.4 – 22.0 GHz)
Channel BW	38.36MHz	-
Power flux density	-117.9dB(W/m ² · MHz) (-103.6dB(W/m ² · 27MHz))	-105.0dB(W/m ² · MHz)
Rain attenuation	Medium	Large
Satellite operators	Many	Few

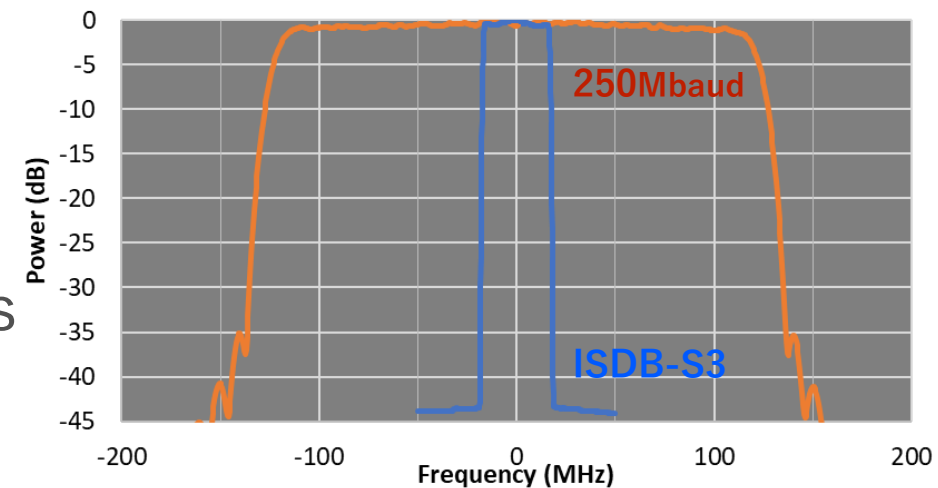
◆ R&D for 21-GHz-band satellite broadcasting system for both high-capacity transmission & efficient rain attenuation compensation

Wideband Transmission in 21GHz-band Satellite Broadcasting

- ◆ Wideband transponder for high-capacity transmission in 21-GHz band



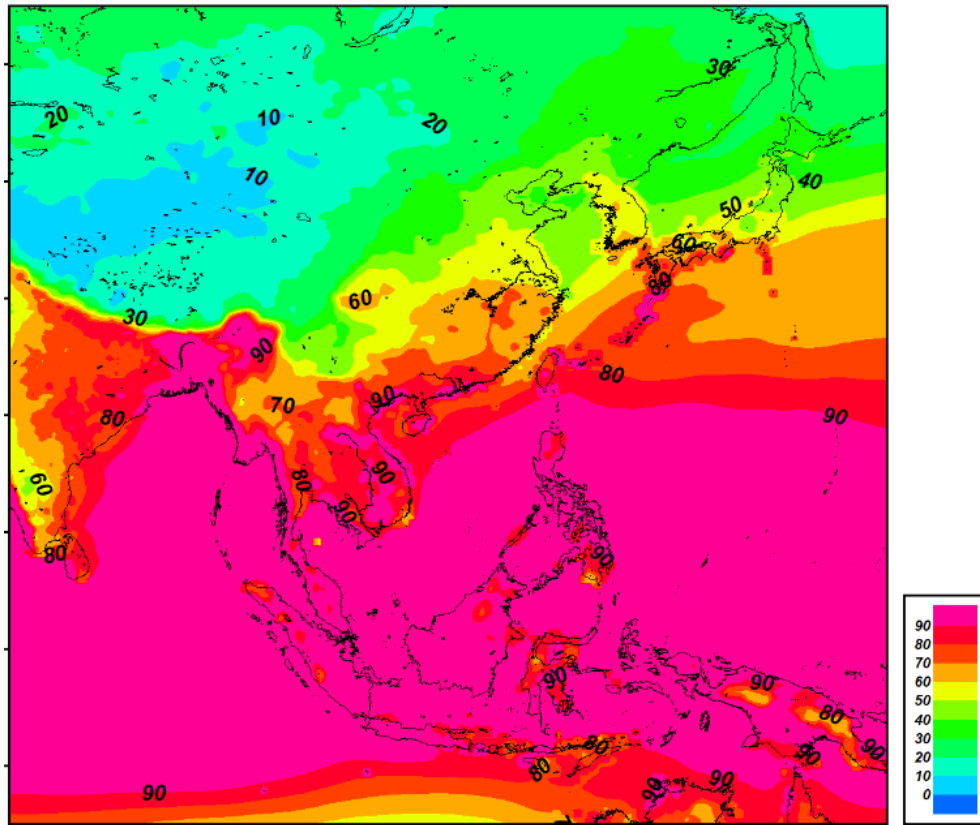
- ◆ BSAT-4a satellite launched in Sep. 2017 equips 300MHz-class transponders to evaluate wideband transmission performance
- ◆ NHK STRL has developed wideband modulators and demodulators, and confirmed its good performance via transmission experiments



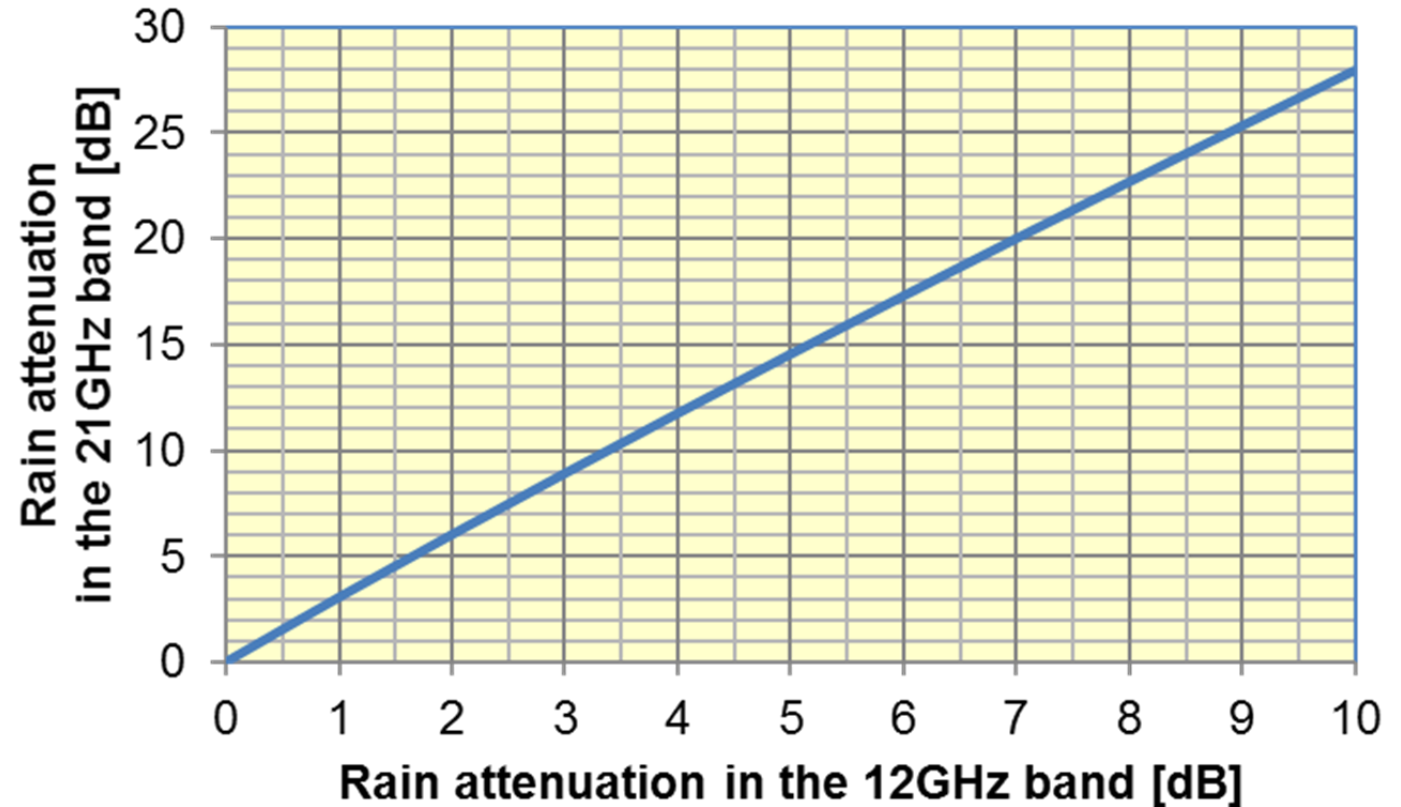
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Rainfall rate of 0.01% of year
in Rec. ITU-R P.837



Long-term frequency scaling of rain attenuation
in Rec. ITU-R P.618

- ◆ Countermeasure for severe rain attenuation in 21-GHz band compared to 12-GHz band is required.

◆ Comparison of 12- and 21-GHz band satellite broadcasting

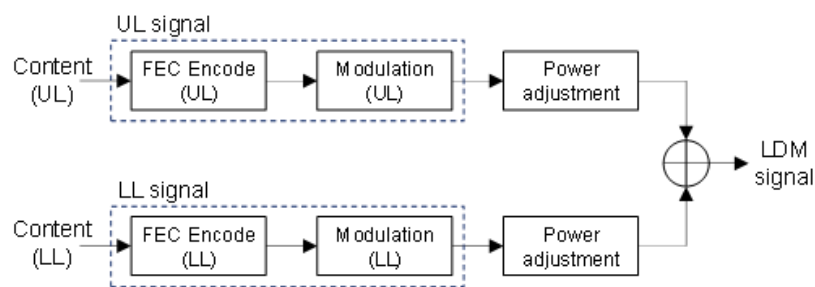
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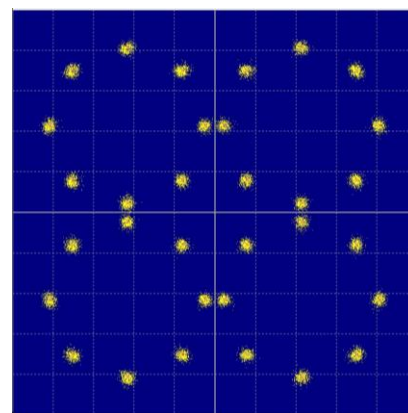
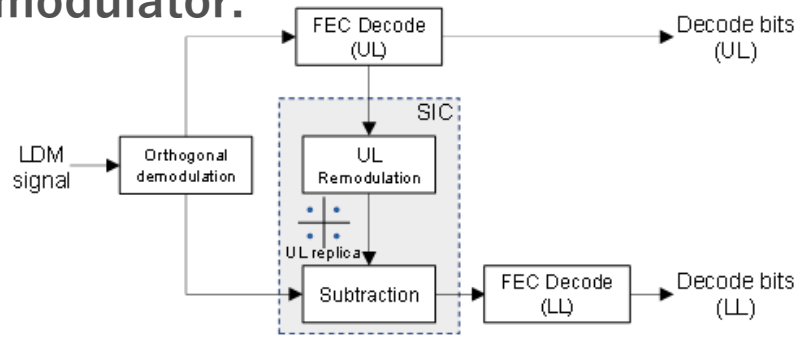
Layered Division Multiplex (LDM) based Transmission Scheme

- ◆ LDM that overlays multiple signals in a common RF channel, enables to apply flexible transmission parameters.
 - ATSC 3.0 standard has adopted and Advanced ISDB-T also considers.
- ◆ NHK STRL developed LDM based wideband modulator and demodulator for satellite broadcasting in 21-GHz band.

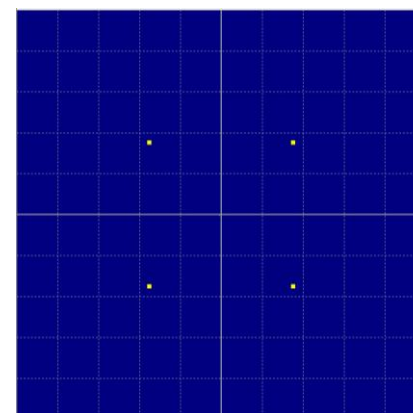
Modulator:



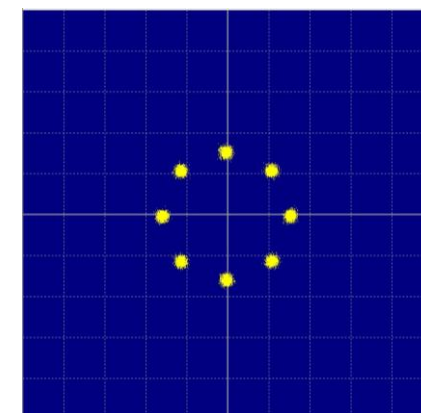
Demodulator:



LDM signal



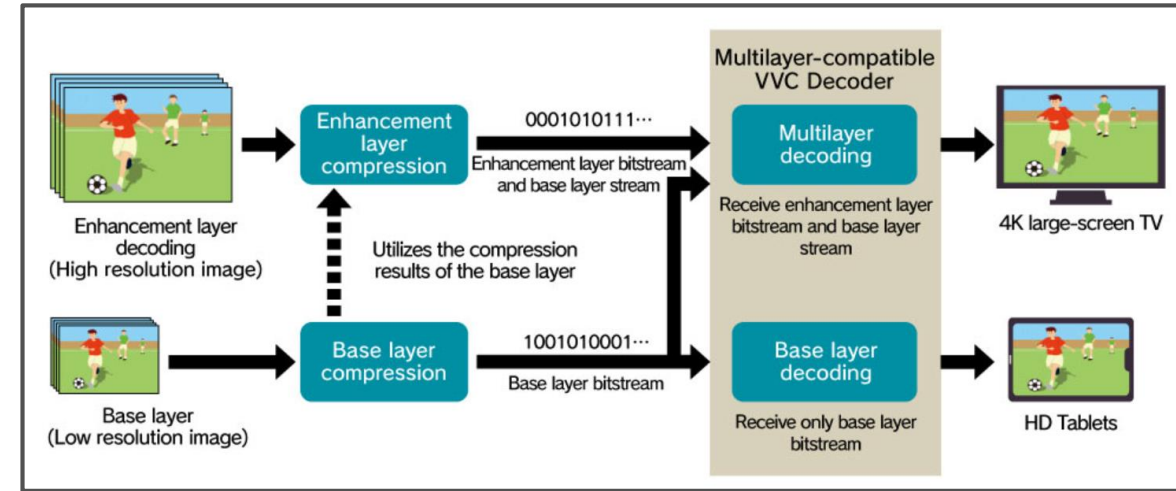
UL signal (QPSK)



LL signal (8PSK)

- ◆ Versatile Video Coding (H.266/VVC) enables multi-layer coding for efficiently encoding multiple videos.

- VVC enables spatial scalability that encodes low-resolution video as a base layer (BL) and high-resolution video as an enhancement layer (EL) together.



- ◆ An advanced satellite broadcasting system in which the BL with 4K resolution and EL with 8K resolution in multi-layer coding of VVC are assigned to the UL and LL of the LDM transmission

- One of effective countermeasure for degradation of receiving condition due to severe rain attenuation in the 21-GHz band satellite broadcasting.

Advanced Satellite Broadcasting System with VVC Multi-layer Coding

Multilayer VVC

Efficient compression with layer divisions

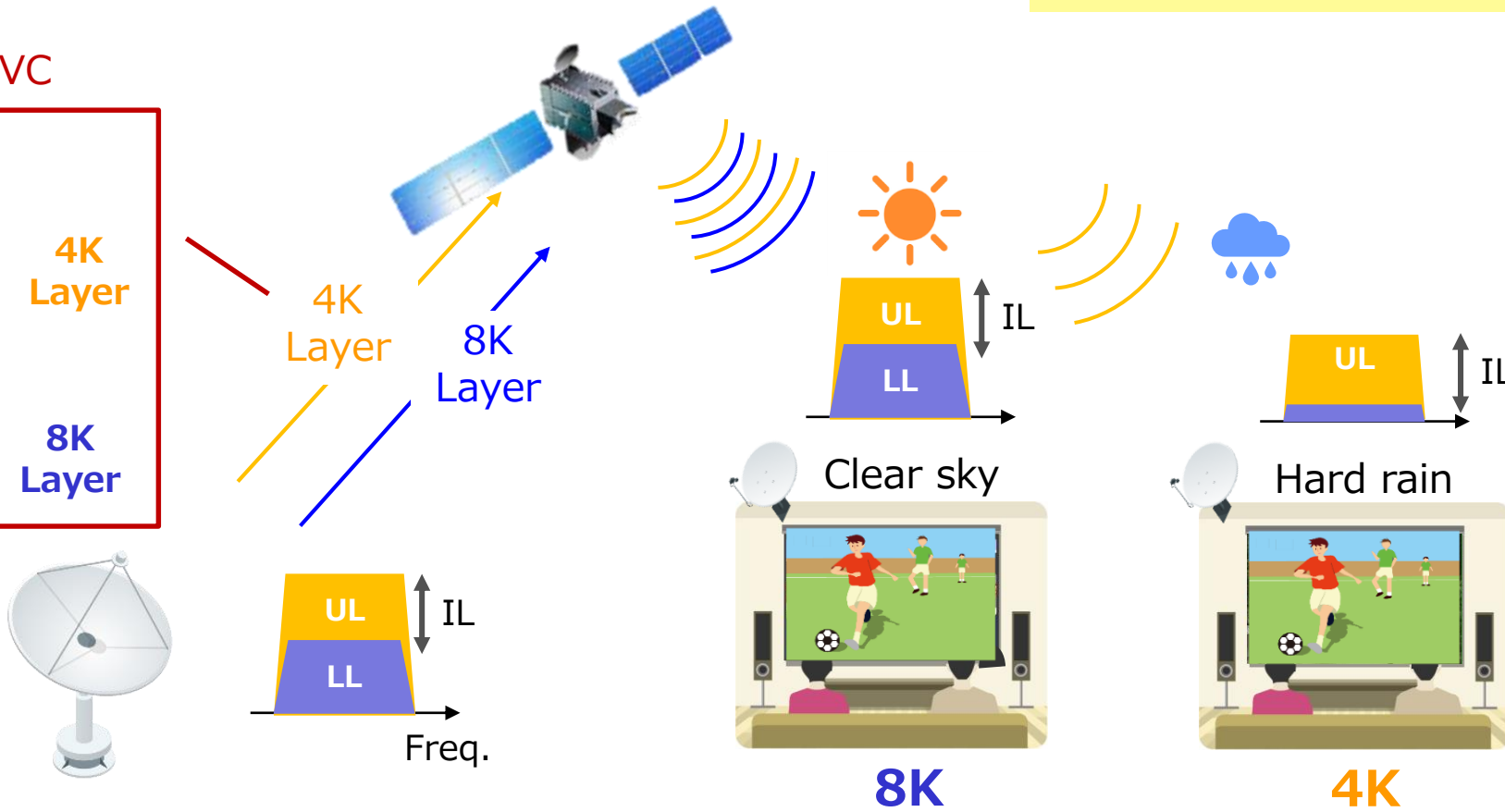
- Base Layer → 4K video
- Enhancement Layer → additional information for 8K video

LDM Transmission

Multiplex multiple modulation signals with difference power level (IL: Injection level)

- UL (Upper layer) → High robustness
- LL (Lower layer) → High bit rate

Multilayer VVC



Dynamic switch between 4K and 8K in accordance with receiving condition automatically



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Thank you for kind attention

NHK