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World Broadcast

PLP's in ATSC3.0; Definition, Explanation and Application

Perry Priestley, Broadcast Electronics

WHAT DOES ATSC3.0 BRING TO THE TABLE? & ATSC HIGHLIGHTS

ATSC3.0 SYSTEM STRUCTURE and how to set up a SCHEDULER

RECOMMENDED PLP SETTINGS

DIFFERENCE BETWEEN ATSC AND ATSC3.0

-

FFT'S AND MODULATION

QUESTIONS?

AGENDA

ATSC highlights

- Configurable, Scalable, Interoperable, & Adaptable
- Robust Mobile Reception (OFDM)
- Ultra High-Definition Video (4K, HDR, WCG)
- Immersive Audio (AC-4)
- Internet Protocol Transport Enabled (IP)
- Advanced Application Support
- Emergency Alerting
- Terrestrial / Broadband Integration
- Interactive Applications

ATSC3.0 SYSTEM STRUCTURE (ref. A/351)

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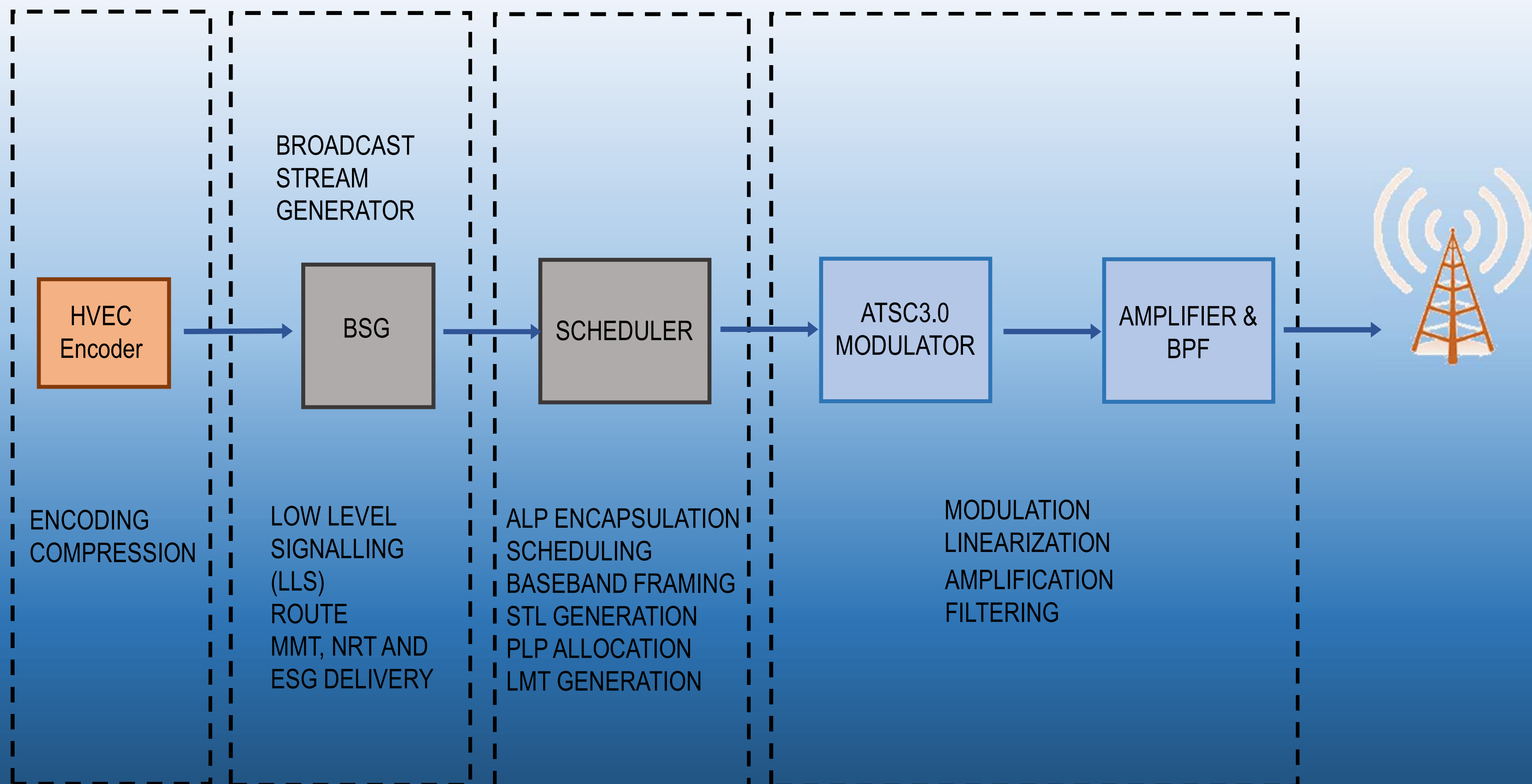
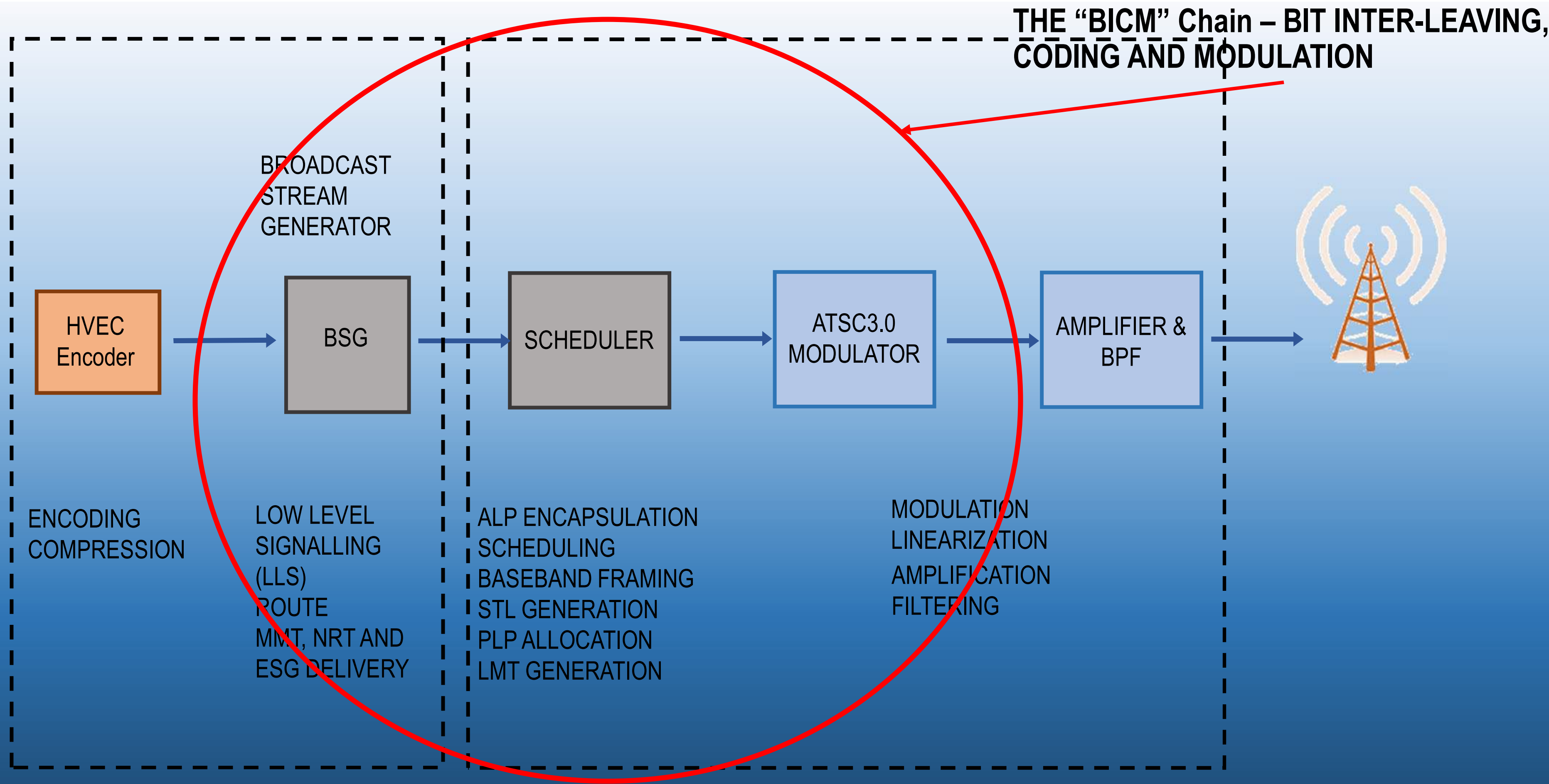


ATSC3.0 SYSTEM STRUCTURE (ref. A/351)



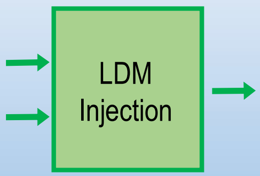
THE BICM Chain – BIT INTER-LEAVING, CODING AND MODULATION

LDM Injection	TI	OFDM Framer	FI	(Scattered) Pilot Inserter	IFFT	PAPR	Guard Interval Insertion	Bootstrap Insertion
Layer **D**ivision **M**ultiplex Combines multiple layers of data with streams with different BICM OPTIONAL	Time Interleave options None, Convolutional Time Interleaving (CTI) and Hybrid Time Interleaving (HTI)	Combines multiple inputs into a single stream and formats it in frames.	Frequency Interleaver	Inserts pilots and reserved tones for channel estimation and synch.	**I**nverse **F**ast **F**ourier **T**ransform Generates OFDM waveform	Reduces **P**eak to **A**verage **P**ower **R**atio	Inserts GI to combat multipath effects. 12 Guard interval lengths available	Inserts the bootstrap for service discovery, synchronization and core signaling

Structure

Waveform

ATSC3.0 SYSTEM STRUCTURE (ref. A/351)

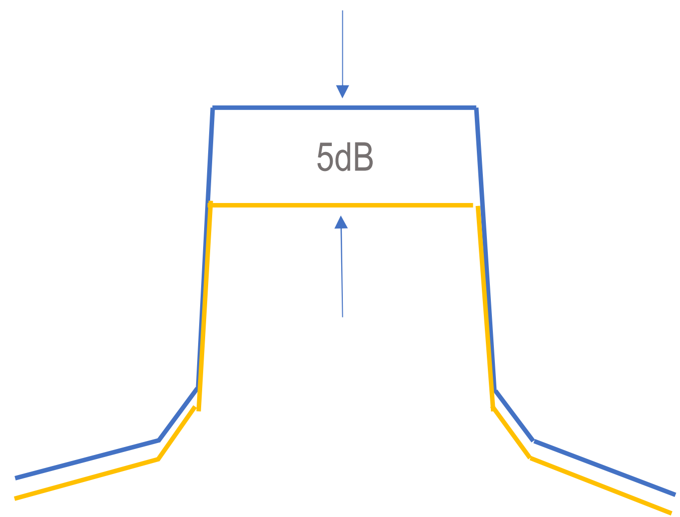


Combines multiple layers of data with streams with different BICM

Layered Division Multiplex

For each LDM layer, 100% of the RF bandwidth and time used to transmit the multi-layered signals for spectrum efficiency;

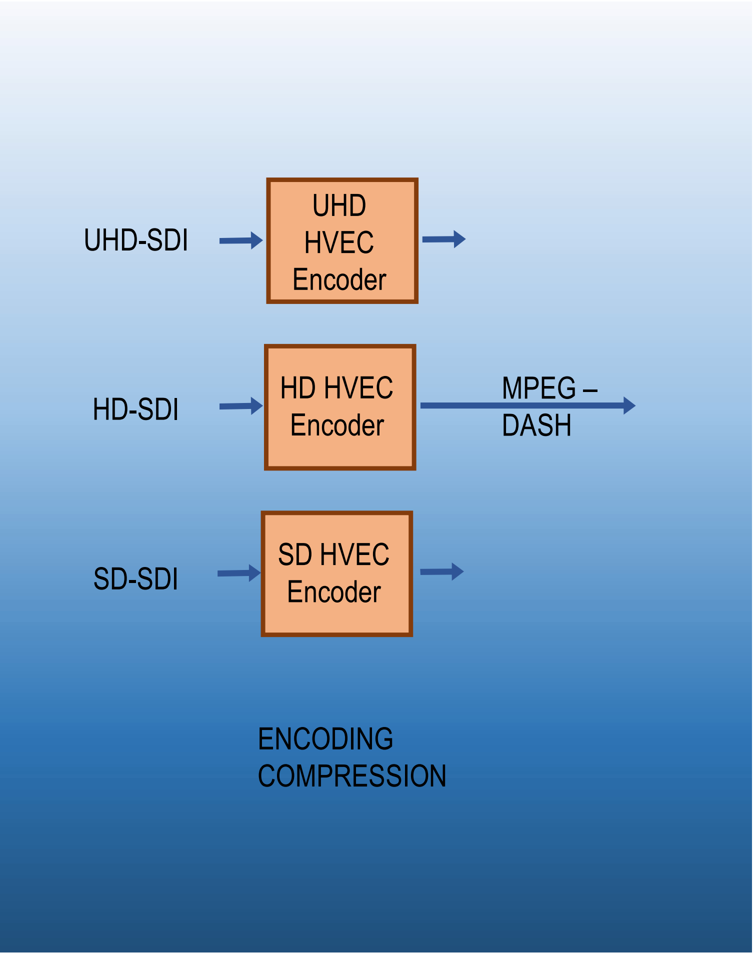
Signal cancellation can be used to retrieve the robust upper layer signal first, cancel it from the received signal, and then start the decoding of lower layer signal;

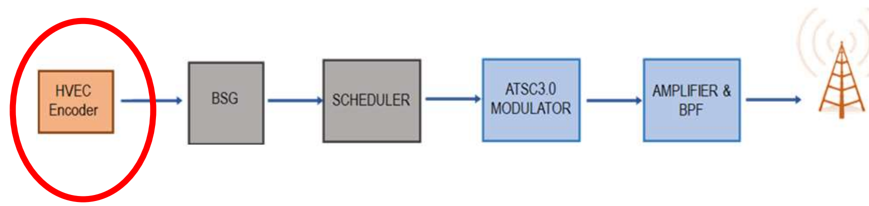


The upper layer (UL) is ultra-robust and well suited for HD portable, indoor, mobile reception. The high data rate lower layer (LL) transmission system is well suited for multiple-HD and 4k-UHD high data rate fixed reception.

Potential Future Extension Layer (FEL) can be added later with backward compatibility.

SYSTEM STRUCTURE - **ENCODER(S)**



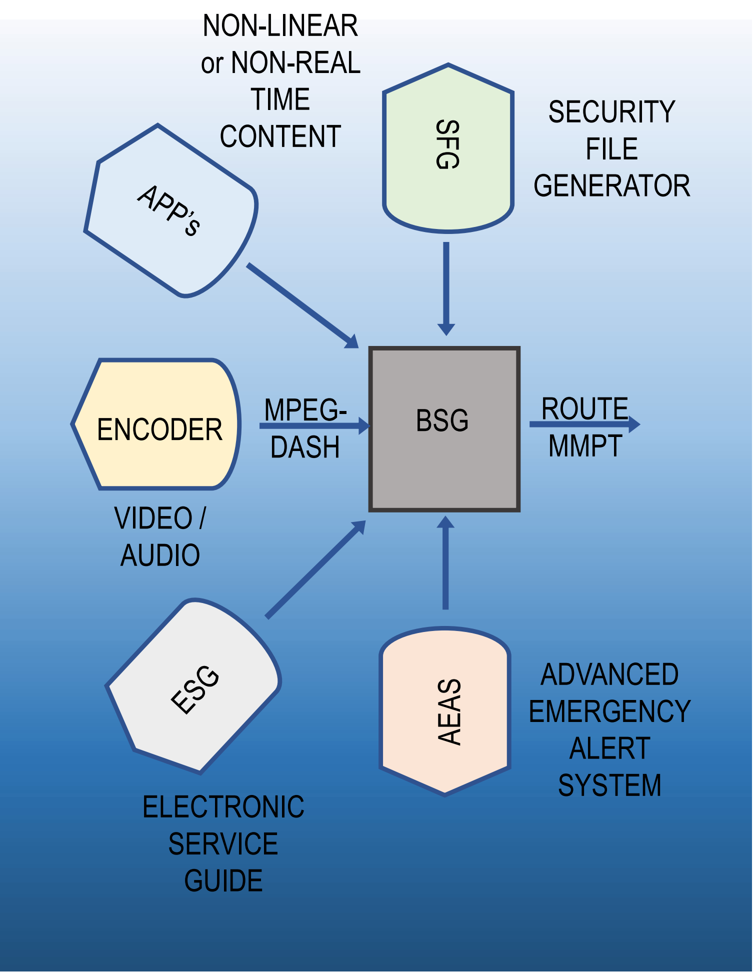


- Server or Cloud
- HEVC or H.265 is not a new technology and used in many other industries
- HEVC more efficient than H.264 and MPEG-2
  (MPEG 2 developed prior to1995 / HEVC in 2012)
- Supports UHD, 4K and 8K
- Compression ~ 4 X MPEG 2 (ATSC)
- Inputs HD or UHD via HD-SDI
- Outputs MPEG DASH segments

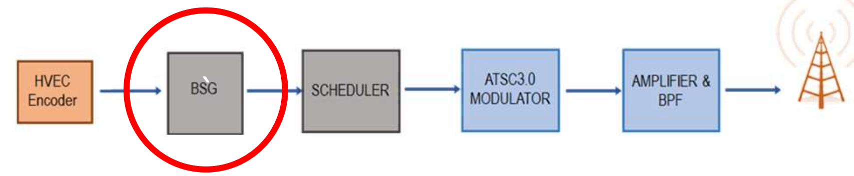
- The Output is sent to the Broadcast Stream Generator.

MPEG-DASH = Dynamic Adaptive Streaming over HTTP…

SYSTEM STRUCTURE - BROADCAST STREAM GENERATOR



- Server – Cloud Device



- Input MPEG-DASH from the Encoder
- Output ROUTE Content packaged in MPEG DASH Segments.
- Generation of ATSC 3.0 Low Level Signaling (LLS):
- Service List Table (SLT): Discovery and description
  - Ratings Region Table (RRT), System Time (STT), Advanced Emergency Alert Table (AEAT) and Onscreen Message Notification
- Non-real Time (NRT) services are applications like
  - Electronic Service Guide (ESG),
  - Emergency Alert Service (AEAS)
  - APP's (NRT)- via ROUTE interactive applications or content to be downloaded onto the receiver
- Generates the ATSC 3.0 low level signaling (LLS) on the multicast address (224.0.23.60:4937)

ROUTE = Real-time Object delivery over Unidirectional Transport
MMTP = MPEG Multiplexing Transport Protocol

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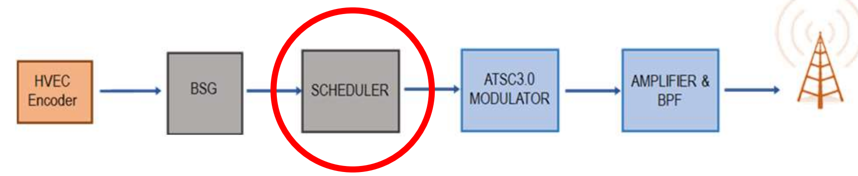
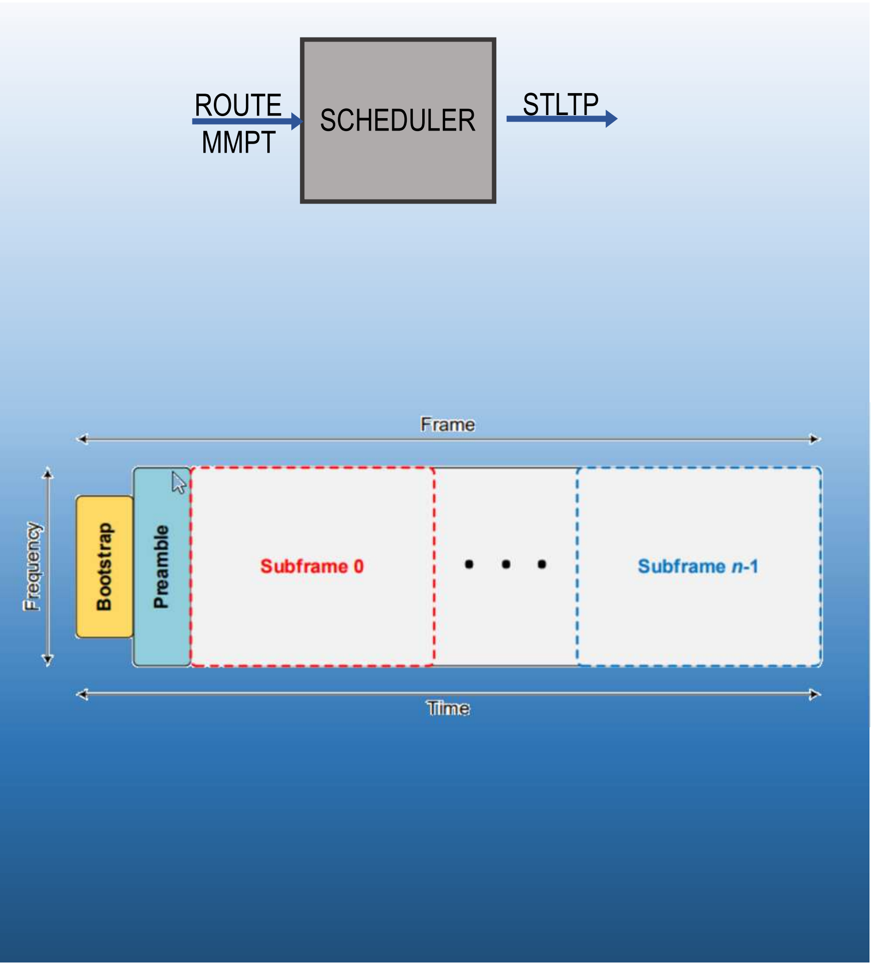
SYSTEM STRUCTURE - **SCHEDULER**

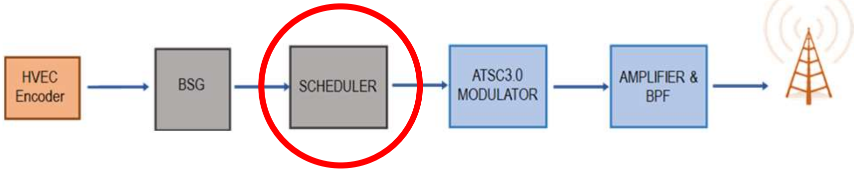


- Server – Cloud Device – Or included inside the EXCITER
- Input ROUTE MMT from the Broadcast Stream Generator
- Output STLTP
- IP encapsulation into ALP packets
- Subframe creation and PLP allocation (up to a total of 8 PLPs).
- STL generation and delivery (if external to exciter)
- Validation of ATSC 3.0 modulation parameters
- ATSC 3.0 SFN (Single Frequency Network) Adaption (if applicable)

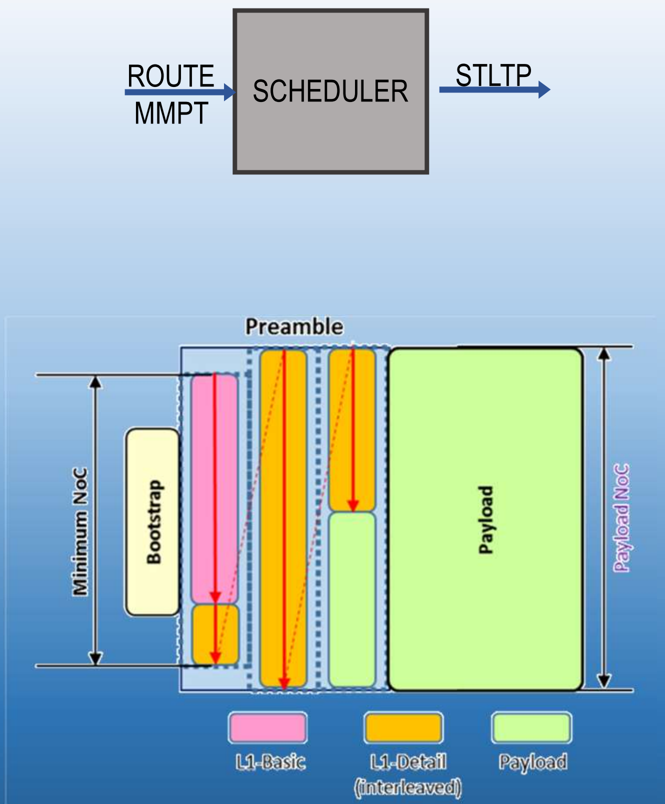
ALP = ATSC Link Layer Protocol
LMT = Link Mapping Table
LLS = Low Level Signaling
STLTP = Studio to Transmitter Link Transfer Protocol

SYSTEM STRUCTURE - BOOTSTRAP





- The Bootstrap is a signaling table providing channel frequency offset estimation, system bandwidth, emergency alert wake-up information, and important data on physical frame versioning.
- The bandwidth of the Bootstrap is only 4.5 MHz, adding further robustness.
- There are four important pieces of information inside the bootstrap:
  - Version information
  - EAS wake up bit
  - EAS and sampling rate
  - Demod and decoding information



Layer 1 Basic - part of the Preamble following the “bootstrap,” and carries the most fundamental signaling information as well as data necessary to decode L1 Detail.

Layer 1 Detail - part of the Preamble following the L1 Basic. It has the information necessary to decode subframes including their ModCods (modulation Coding), number of PLPs, pilot pattern, FEC, etc.

Settings

MFN or SFN

Internal Scheduler or External Scheduler

Settings for L1-Basic

FFT: 8K = Fixed

Guard Interval 5/1024 = Fixed

Pilot (Scattered) Dx = 3, 6 or 12 = The least dense patterns provide the greatest payload as fewer carriers are used for pilots, and subsequently more are available to carry data.

SYSTEM STRUCTURE - PLP's (ref. : A/322 and A/327)

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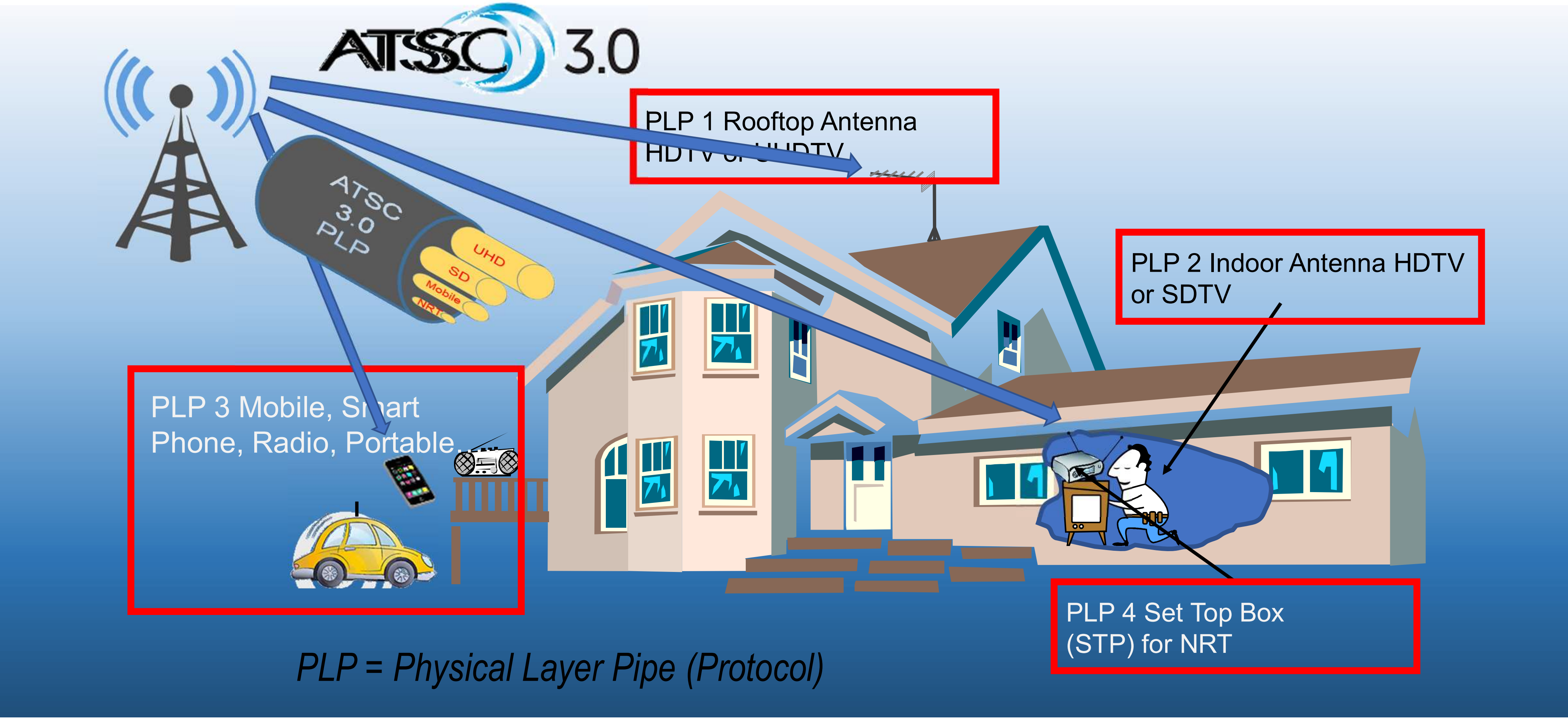
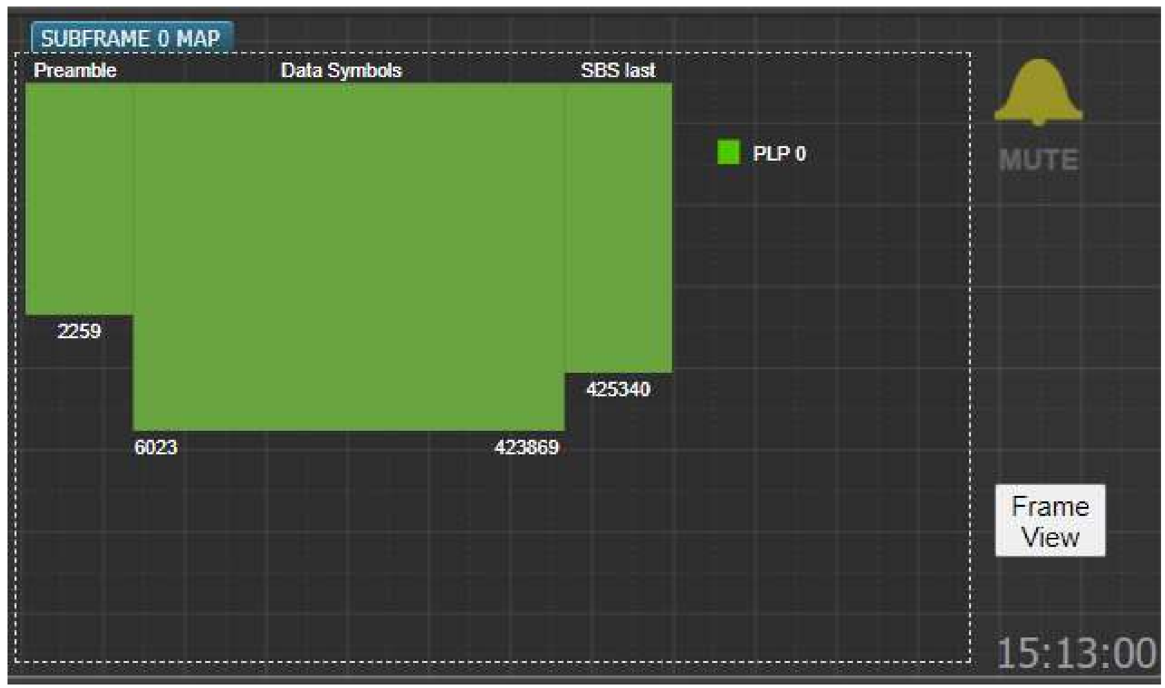


And Now.. How actually to set up a Scheduler



SCHEDULER – Step 1 – Map physical inputs

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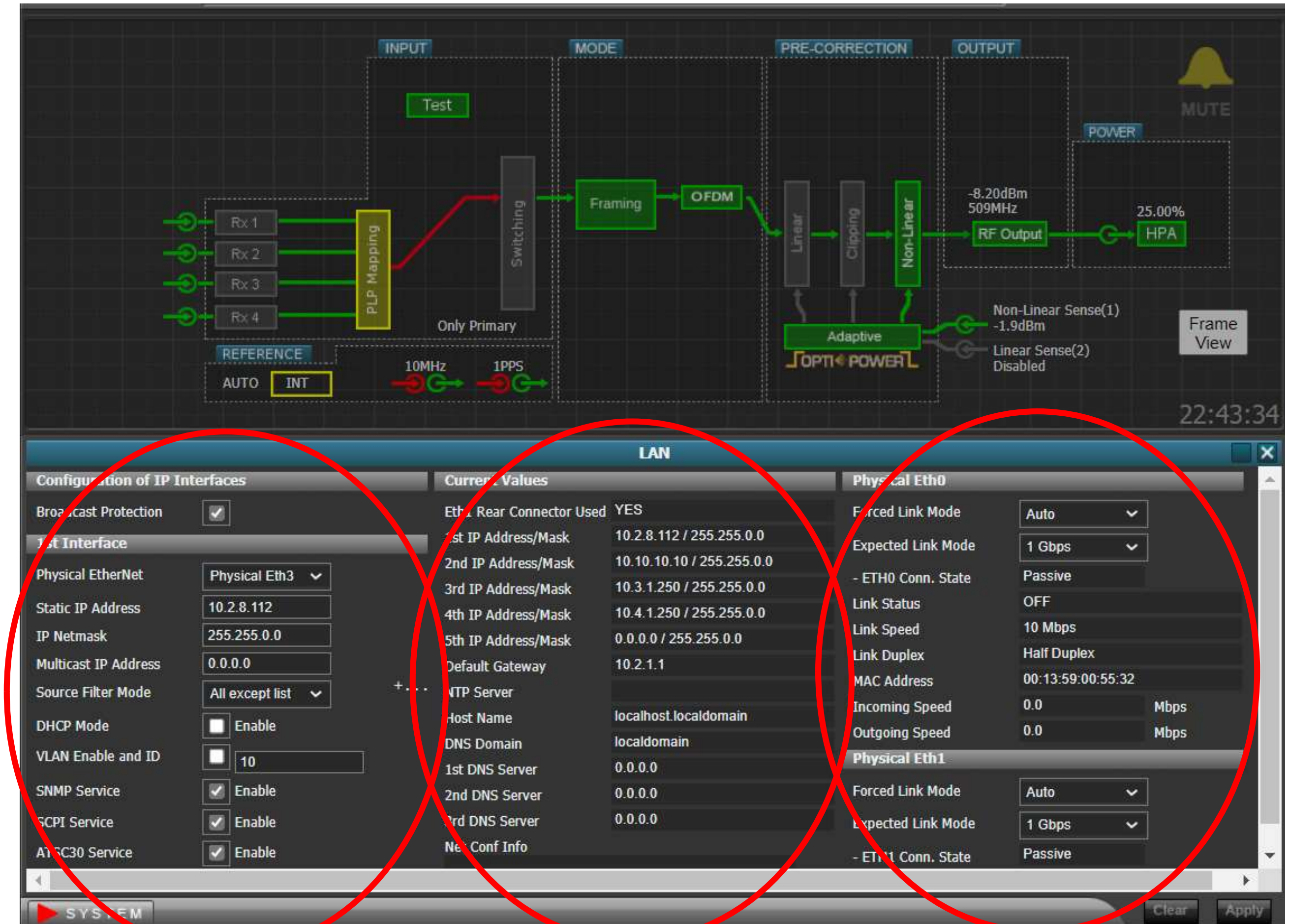


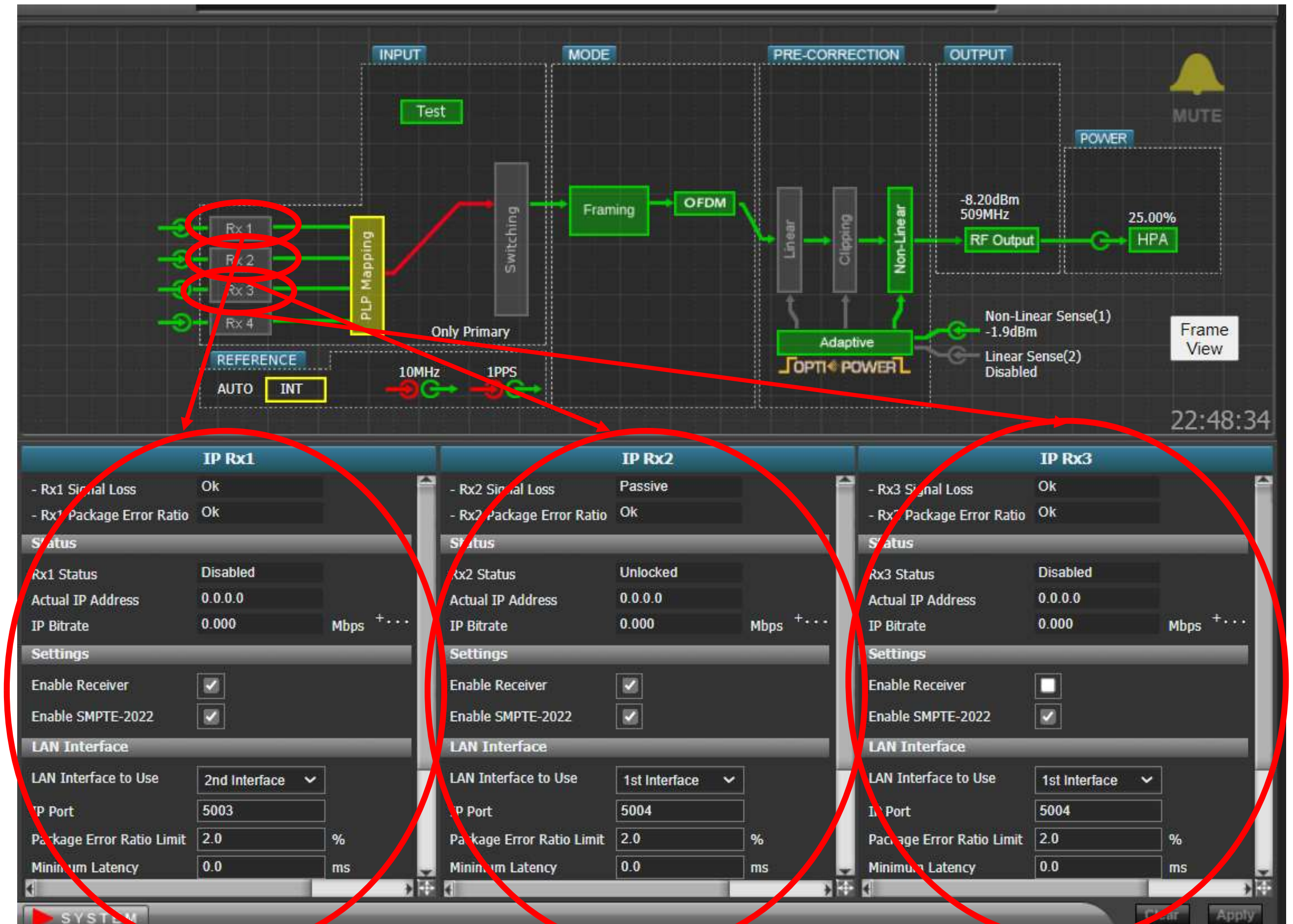
Set management IP addresses

Set the Physical input addresses to the external equipment i.e. the Encoder and the Broadcast Stream Generator

TOTAL MAPPING IS

ETHERNET PHYSICAL ->
LOGICAL LAN ->
PLP -> STREAMS

SCHEDULER – Step 2 – Map logical inputs



Now set the Logical Inputs to what you want them called inside the Scheduler

TOTAL MAPPING

ETHERNET PHYSICAL ->
LOGICAL LAN ->
PLP -> STREAMS

SCHEDULER – Step 3 – PLP mapping

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Now set the Logical LAN to the PLP (Stream 1 through Stream 7) Inputs to what you want them called inside the Scheduler.

Determine how many PLP's will be required. Although up to 64 can be selected, it is strongly recommended not to use more than 4. The reason is that it over complicates the design of the receivers and as such could delay the implementation of ATSC3.0

MAPPING

ETHERNET PHYSICAL ->
LOGICAL LAN ->
PLP -> STREAMS

SCHEDULER – Step 4 – Move to FRAME VIEW

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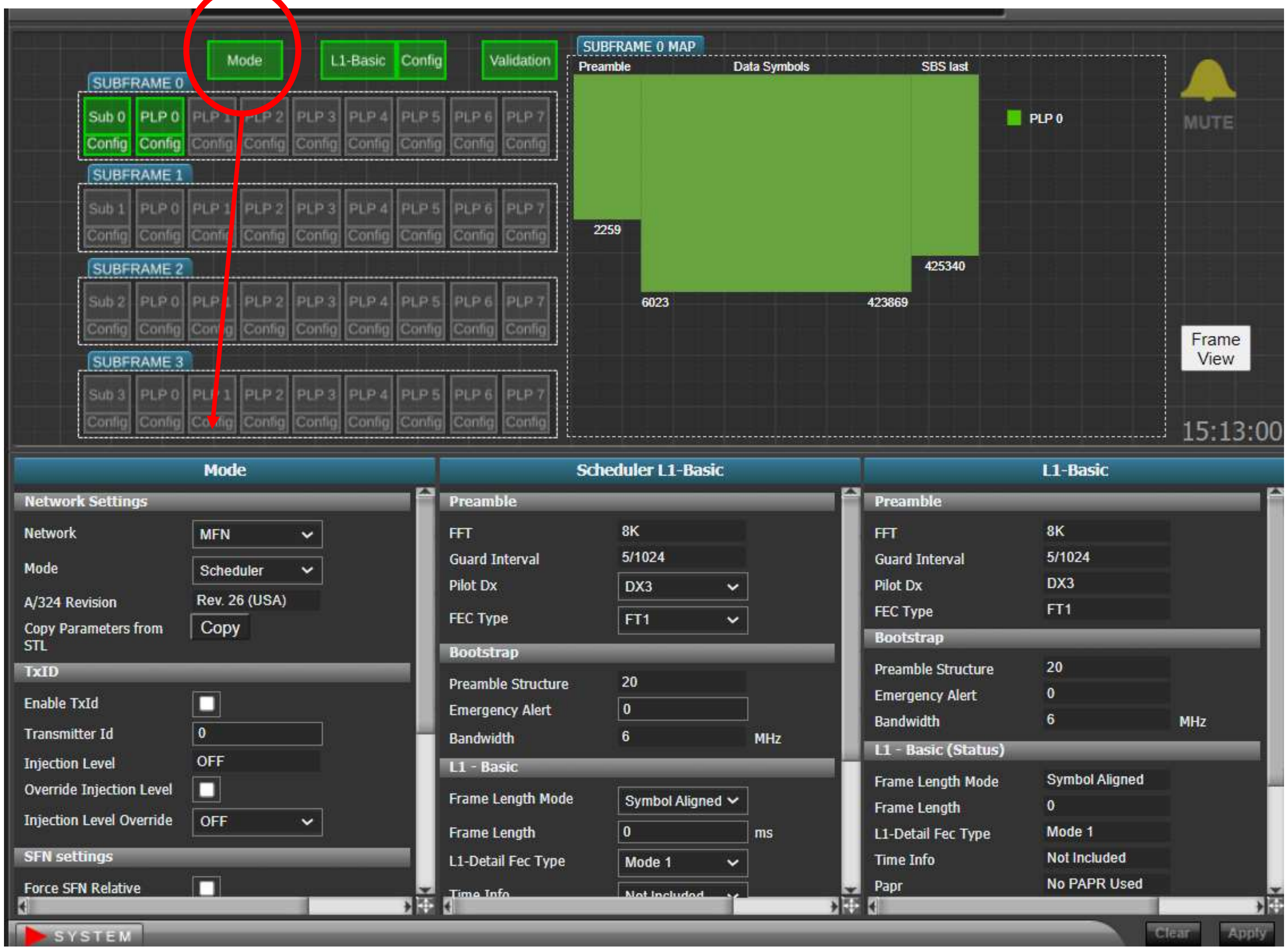
Then click FRAME VIEW

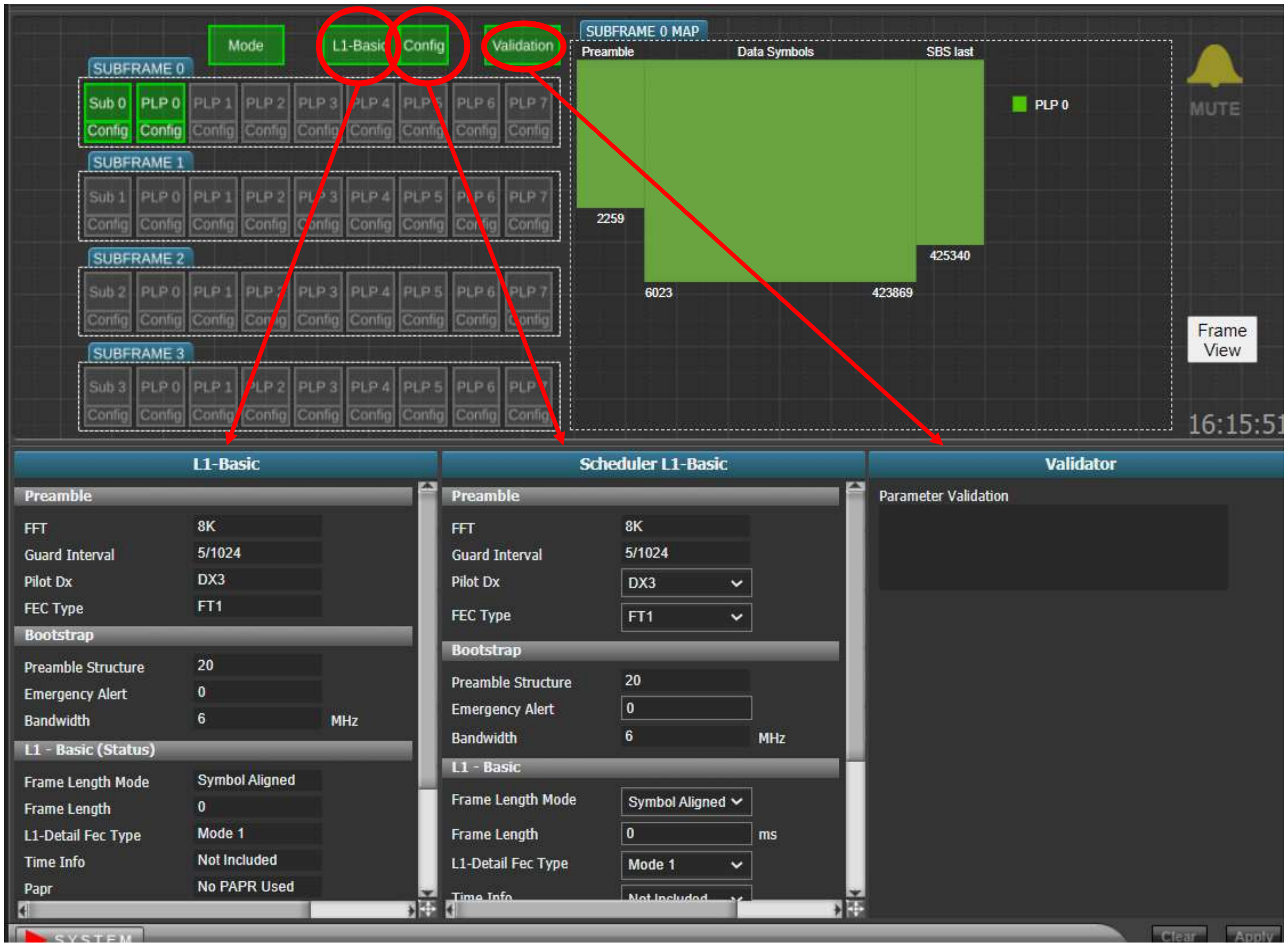
SCHEDULER – Step 4 – Set Mode information



In FRAME VIEW

Set MODE information,
MFN or SFN,
Scheduler Internal or External
Set any TX ID information
Set US or Korean standard

SCEDULER – Step 5 – Set Layer 1-Basic



FFT and **Guard Interval** are not adjustable

Set L1 Pilot quantity-DX n (3, 4, 6, 8, 12, 16, 24, and 32)

The lower then number the fewer the carriers and the greater the payload, The higher the number the better the robustness.

FEC Type: FT1, FT2, FT3, FT4 or FT5. The size of the Low-density Parity-check FEC inner code; Tradeoffs between robustness and latency.

SCHEDULER – Step 5 – Set Layer 1-Basic (continued)

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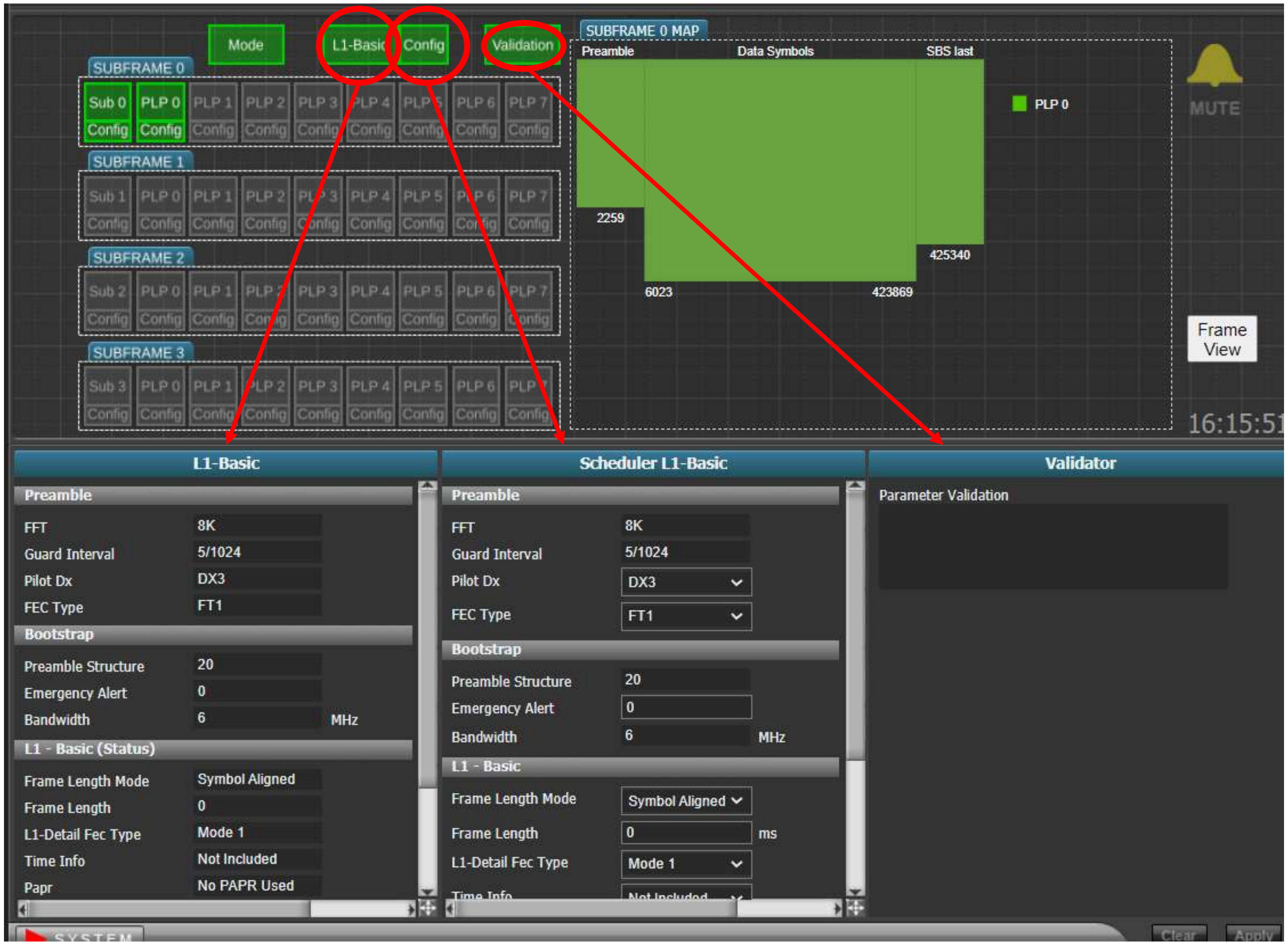


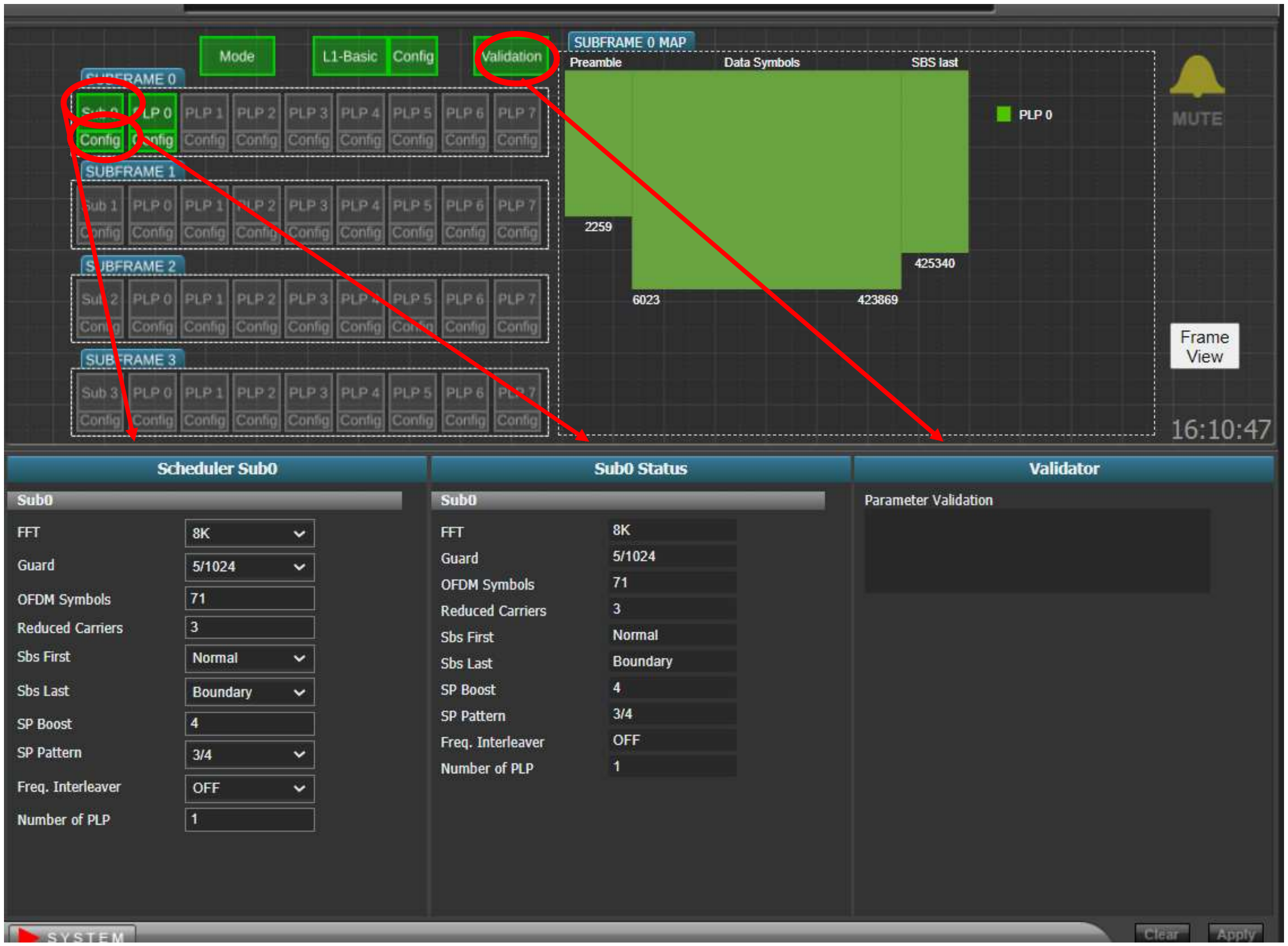
Select PARP (Peak to Average Power level) – Three options TR, TR + ACE, ACE and NONE

PAPR Reduction - modifies the ODFM signal via Tone Reservation (TR) and/or Active Constellation Extension (ACE) to reduce the peak power requirements of the ATSC 3.0 transmission.

It often decreases in out of band emissions but decreases in band CNR. Often a compromise between the both.

Improves marginally efficiency of transmitter.

SCHEDULER – Step 6 – Set Sub0



FFT (8, 16, and 32)
This sets the number of carriers. The greater the number the more signal payload but less robust

Guard: 1/192, 2/284, 3/512, 6/1536, 7/2048, 8/2432, 9/3072, 10/3684, 11/4096, and 12/4864

SCHEDULER – Step 6 – Set Sub0 (continued)

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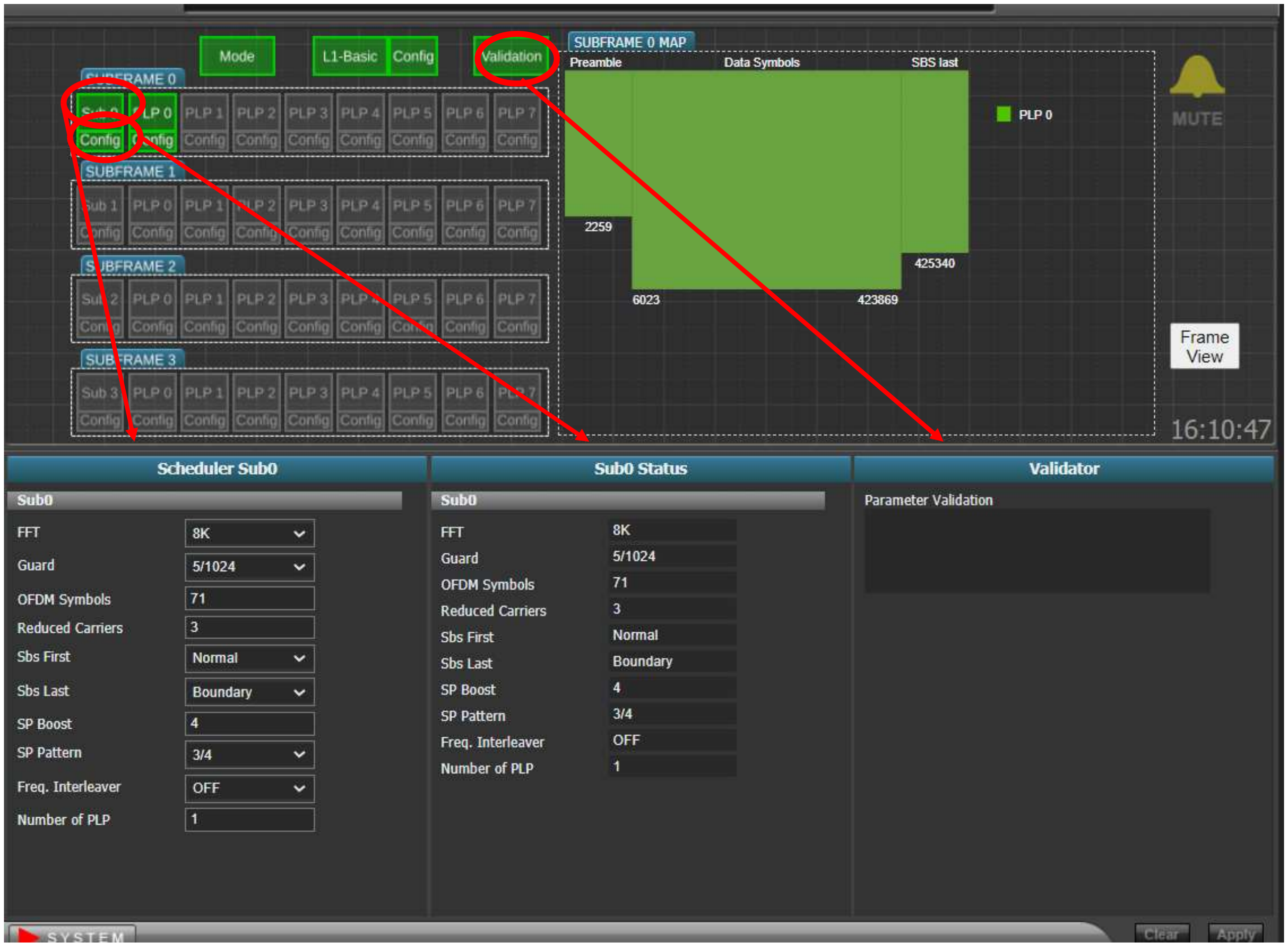

SP First (Normal or Boundary)
SP Last (Normal or Boundary)
SP Boost (1-7) The higher the Pilot carrier boost the better the reception, but in turn reduces payload.

SP (Scattered Pilot)**:** 3/2, 3/4, 4/2, 4/4, 6/2, 6/4, 8/2, 12/2,12/4,16/2 16/4, 24/2, 24/4, 32/2 and 32/4
Added to aid receiver channel synchronization and estimation. The higher the numerator the less payload but more robust.

Frequency Interleaver (On, Off)

SCHEDULER – Step 7 – Set PLP0

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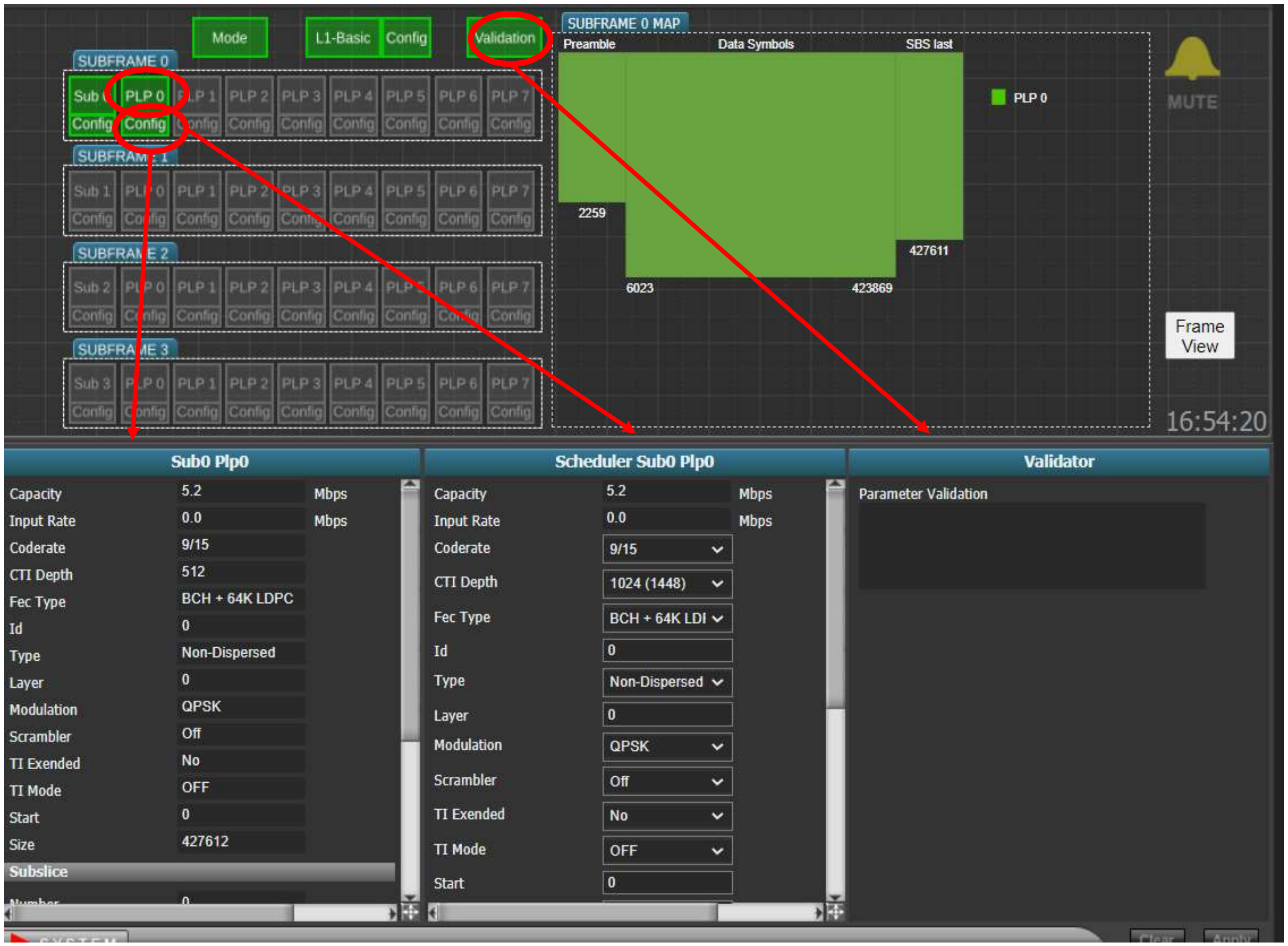

Note the **Capacity** and **Input Rate**

Code Rate 2/15 – 13/15. The higher the numerator determines the amount of repetition (duplication) of the information, which means more robustness but less bandwidth (payload)

CTI Depth 512, 724, 887 and 1024 (Convolutional Time Interleaver) - a means by which the data is pseudo-randomized to reduce the negative effects of random noise bursts in a transmission system. It is enabled when there is only a single PLP or when LDM is used with a single core-layer PLP. The higher the number the more robust.

SCHEDULER – Step 7 – Set PLP0 (continued)

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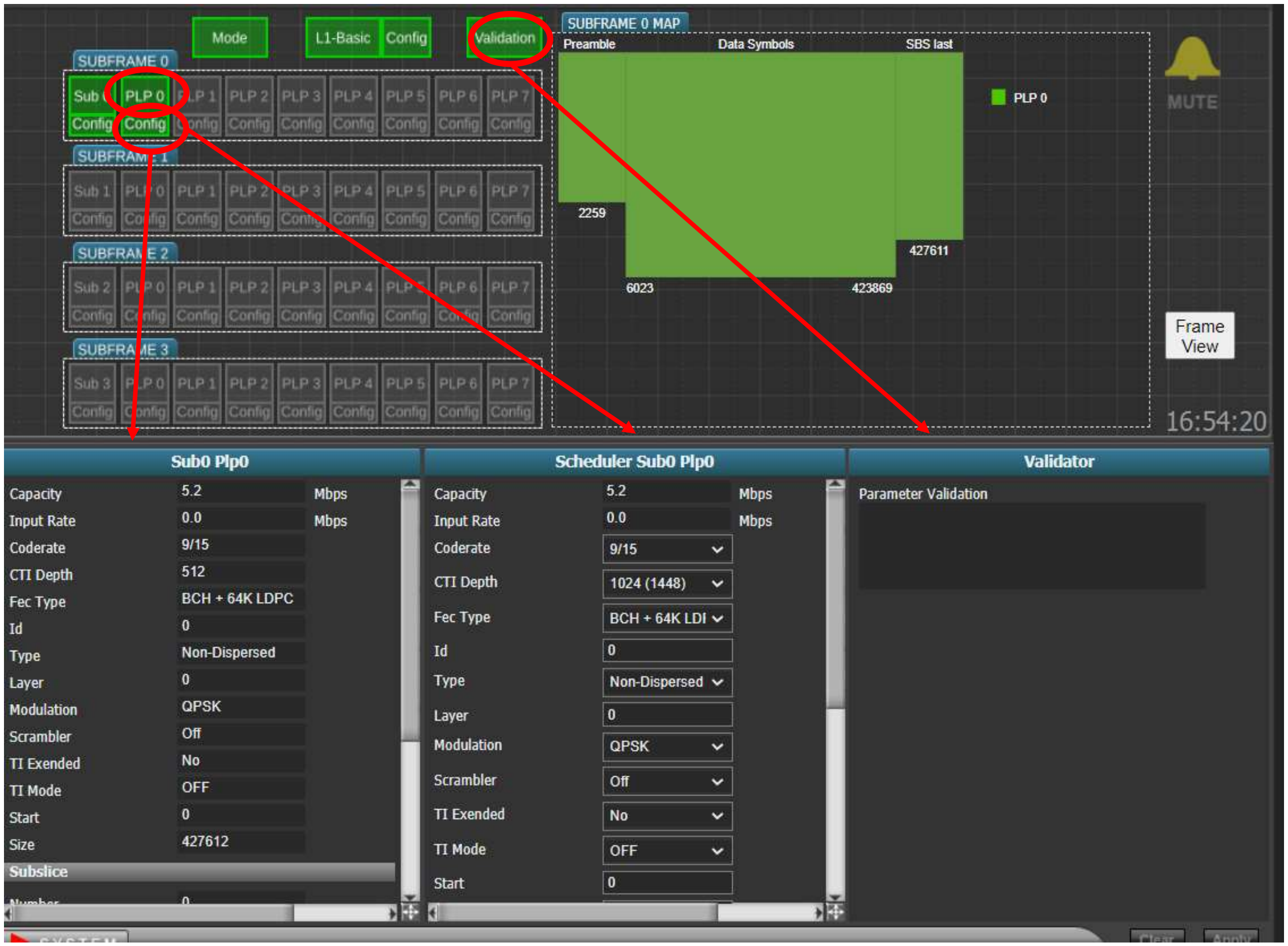

FEC Type 64K LDPC, 16K LDPC, CRC + 64K, CRC + 16K and BCH + 64K and BCH + 16K.

BCH (Bose, Chaudhuri, Hocquenghem) **-** linear error coding used in the processing block for outer code correction A 12-bit BCH provides for both error detection and correction capabilities.

CRC (Cyclic Redundancy Check) A 32-bit CRC provides only error detection with no error correction capabilities.

64K more robust
16K more payload

LDPC = Low Density Parity Check

SCHEDULER – Step 7 – Set PLP0 (continued)

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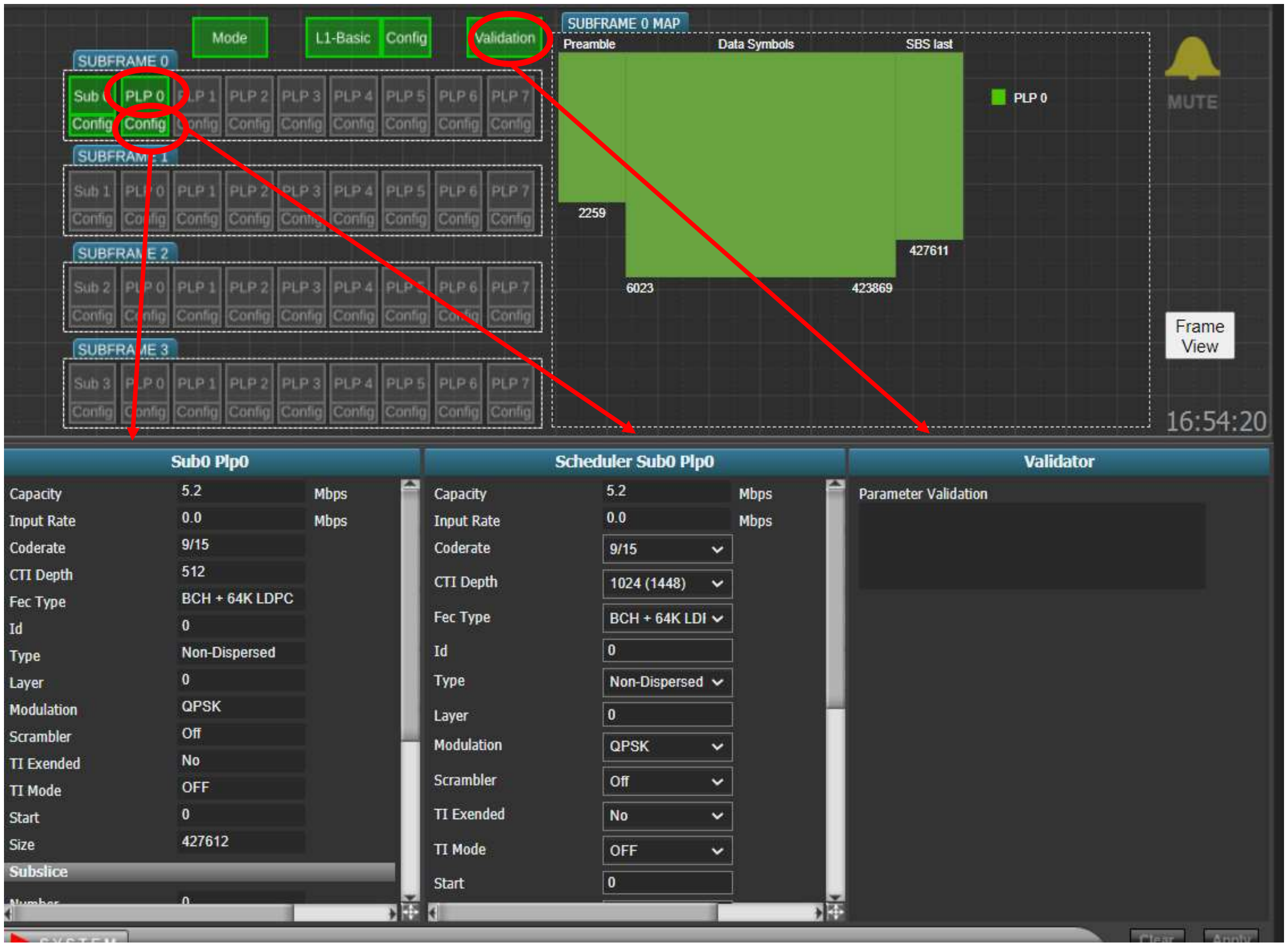

Modulation QPSK, 16 QAM, 64 QAM, 256 QAM 1024 QAM and 4096 QAM. Higher the symbol rate the more capacity but lower ruggedness

HTI (Hybrid Time Interleaver) – ON or OFF
data is pseudo-randomized to reduce the effects of random noise bursts in a transmission system that utilizes the multiple-PLP mode.

LDM – (Layer Division Multiplexing) On or off and the level set. Recommended at -5.0dB, however unlikely to be implemented in the near future.

PLP SETTINGS – HIGH CAPACITY

Parameter	High Capacity
Capacity	25MB/s
Robustness	Low
CN (dB)	17.26
PLP	0
Type	S-PLP, SISO
FFT	32K
Pilot Pattern	24_2
Pilot Boost	1
Guard Interval	G5_1024
Pre-ample Mode	Detail: 3, Pattern Dx=12
Frame Length	246 mSec
Time Inter-leaver	Conv. 1024
Modulation	256 QAM
Code Rate	9/15
Code Length	64K

High (bandwidth) Capacity

- Roof Top Antenna reception
- Large Bandwidth ~ 25MB/s
- Low Robustness (2dB worse than ATSC1.0)

- 4K or even 8K

- Up to 16 HD's, 8 UHD's etc…

PLP SETTINGS – MID CAPACITY

Parameter	Medium Capacity / Robustness
Capacity	16MB/s
Robustness	Medium High
CN (dB)	15.5
PLP	0
Type	S-PLP, SISO
FFT	16K
Pilot Pattern	12_4
Pilot Boost	1
Guard Interval	G5_1024
Pre-amble Mode	Detail: 3 Pattern Dx=6
Frame Length	201 mSec
Time-Interleaver	Conv. 1024
Modulation	256QAM
Code Rate	8/15
Code Length	64K

Mid (bandwidth) Capacity

- Indoor/Outdoor reception
- Mid Bandwidth ~ 16MB/s
- Mid Robustness (Same as ATSC1.0)

- Ideal for good coverage to match existing ATSC coverage

- Up to 8 HD's

PLP SETTINGS – LOW CAPACITY

Parameter	Robust / Low Capacity
Capacity	8MB/s
Robustness	High
CN (dB)	0.2
PLP	0
Type	S-PLP, SISO
FFT	8K
Pilot Pattern	6_2
Pilot Boost	4
Guard Interval	G5_1024
Pre-amble Mode	Detail: 1 Pattern Dx =3
Frame Length	201 mSec
Time-Interleaver	Conv. 1024
Modulation	QPSK
Code Rate	5/15
Code Length	16K

Low (bandwidth) Capacity

- Mobile reception or Indoor Antenna through second wall
- Bandwidth ~ 16MB/s
- High Robustness (Almost zero dB CNR)

- Ideal for mobile reception or very difficult to reach areas

- Up to 2 HD's, or 10-20 mobile or very low bit rate services

PLP SETTINGS – TWO PLP's

Parameter	Low	Medium
Capacity	3MB/s	18MB/s
Robustness	Very High	Medium High
CN (dB)	5.9	17.9
PLP	0	1
Type	SISO	SISO
FFT	8K	16K
Pilot Pattern	6_4	12_4
Pilot Boost	4	4
Guard Interval	G5_1024	G5_1024
Pre-amble Mode	Detail: 3 Pattern Dx= 3	Detail: 3 Pattern Dx=3
Frame Length	155 mSec	155 mSec
Time-Interleaver	16 FEC Blocks	64 FEC Blocks
Modulation	16QAM	256QAM
Code Rate	7/15	10/15
Code Length	64K	64K

Low and medium (bandwidth) Capacity

- Good starting point for most stations
- Bandwidth ~ 18MB/s and 3MB/s
- Robustness of 18dB and 6dB CNR

- Ideal for targeting both mobile, indoor and UHD

- Up to 16 HD's, or 30-50 SD's
  &
- 10 mobile or very low bit rate services

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THANK YOU FOR YOUR ATTENTION

QUESTIONS ?

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QUESTIONS - TRANSMITTERS

a. Can an existing ATSC 1.0 transmitter be used for ATCS 3.0?

YES

b. If so, what is involved?

Most likely not too much.. Exciter and a quick check to see if it is linear or not. Also, a quick sweep of the filter or investigation into its specs.

c. Is it as simple as an exciter swap-out?

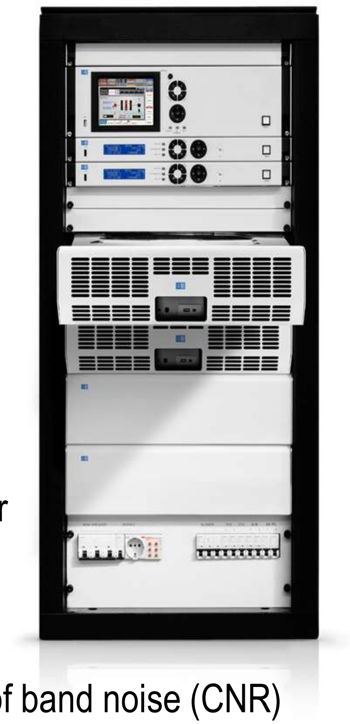
YES.. Most likely

d. Must the output power be de-rated due to OFDM vs. 8-VSB modulation? If so, by how much?

20% difference in power. However, your transmitter still might have the capacity.

e. Define PAPR /Crest Factor and explain why it is relevant in ATSC 3.0.

Like an “Audio Clipper”.. Reduces out of band noise (CNR) because the amplifier runs more linear but increases in-band noise. Typically, a compromise, in practice there is an improvement in TPO capability but not sufficient in most cases to make any difference.



QUESTIONS - ANTENNAS

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a. Can an existing ATSC 1.0 Antenna be used for ATCS 3.0?

Curtesy of Alive Telecom

YES

However, to take advantage of what ATSC3.0 has to offer it is very important that the antenna be circular polarized or at least elliptically polarized.

It may also require to provide higher signal strengths for “indoor nomadic portable and mobile devices” (such as PC’s and cell phones).

Signal strengths maybe required to be increased and can be accomplished either by:

1. Increase transmitter power. 2. Increase null fill or beam tilt. 3. Add a single frequency network (SFN). 4. Provide diversity gain though MISO.

QUESTIONS – SFN and Translators

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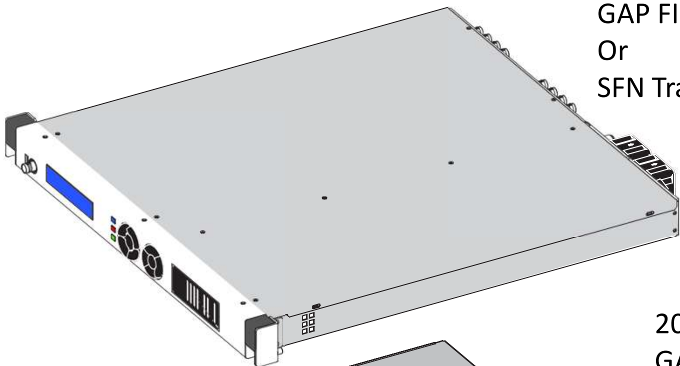
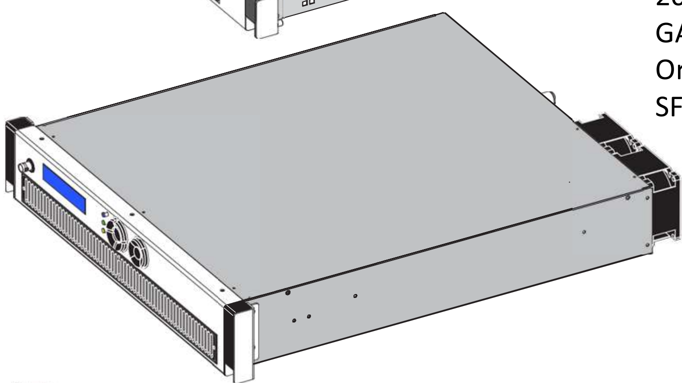
a. Discuss implementation of SFNs in detail.
b. a. What is involved in deploying an SFN?
c. i. Null-fill
d. ii. On-channel translators

30W
GAP FILLER
Or
SFN Transmitter



200W
GAP FILLER
Or
SFN Transmitter



SFN is much easier with ATSC3.0 (than ATSC1.0), and there is a good chance that it will actually work!

A simple gap filler might be the best choice. It is an RF in – RF out device with no other connections. No synchronization and no adjustments – fully automatic.

By adding Gap-fillers you can increase the CNR, thus decreasing the need for many FEC's, Pilot patterns and decreased carriers. This allows a higher payload.

Alternatively, a Synchronized SFN can be selected, but with this comes the disadvantage of increasing Guard Intervals and decreasing payloads.

ACRONYMS and LINK TO ATSC Standards

ALP – ATSC 3.0 Link-Layer Protocol
ASL – American Sign Language
CAP – Common Alerting Protocol
CC – Closed Captions
CSS – Cascading Style Sheets
DASH – Dynamic Adaptive Streaming over HTTP
DNS – Domain Name System
EAS – Emergency Alert System
ESG – Electronic Service Guide
HDMI – High-Definition Multimedia Interface
HEVC – High Efficiency Video Coding
HTML – Hyper-Text Markup Language
HTTP – Hyper-Text Transfer Protocol
PSIP – Program and System Information Protocol
ROUTE – Real-time Object delivery over Unidirectional Transport
ROUTE-DASH – Real-time Object delivery over Unidirectional Transport / Dynamic Adaptive Streaming over HTTP
SEI – Supplemental Enhancement Information
SFN – Single Frequency Network
SNR – Signal-to-Noise Ratio
STL – Studio-to-Transmitter Link
TS – Transport Stream

ATSC Standard: 3.0 Standards Archives - ATSC : NextGen TV