



STANDARD IBOC (In-Band On-Channel)

*TECHNICAL FEATURES*

WORKSHOP RADIO DIGITAL

January 22<sup>nd</sup>, 2025

# AGENDA

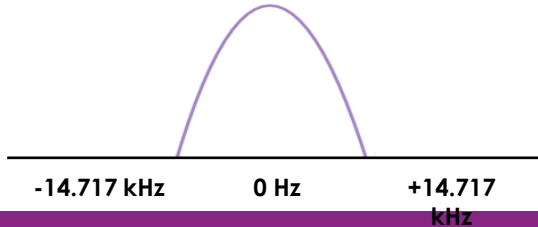
- HOW IT WORKS
- REQUERIMENTS
- HD RADIO SERVICES
- TECHNIQUES TO IMPROVE SYSTEM ROBUSTNESS
- SINGLE FREQUENCY NETWORKS (SFN) - BOOSTERS

# HD RADIO

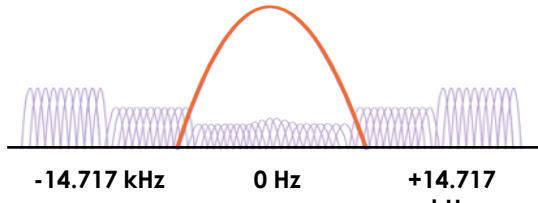
*HOW IT WORKS*

# HOW IT WORKS

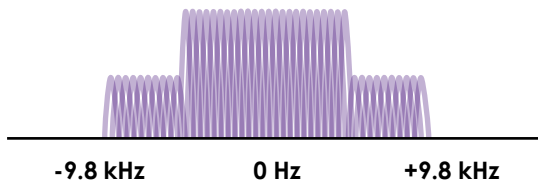
## AM ANALOG



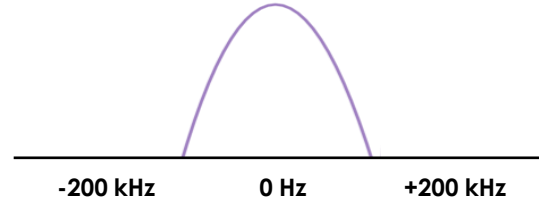
## AM ANALOG + DIGITAL



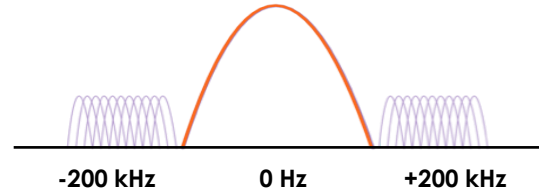
## AM ALL-DIGITAL ONLY



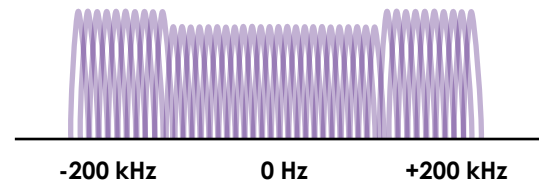
## FM ANALOG



## FM ANALOG + DIGITAL



## FM ALL-DIGITAL ONLY



## ANALOG MODE

FM has multipath distortion

AM prone to interference:

Static ⚡ | Hiss 🗣️ | Pops 🎤

## ANALOG + DIGITAL MODE

Simulcast of analog & digital signals

Digital signal free of interference

**Analog receivers function normally**

## ALL-DIGITAL ONLY MODE

Greater data capacity

Increased performance

Lower operating power

# HOW IT WORKS

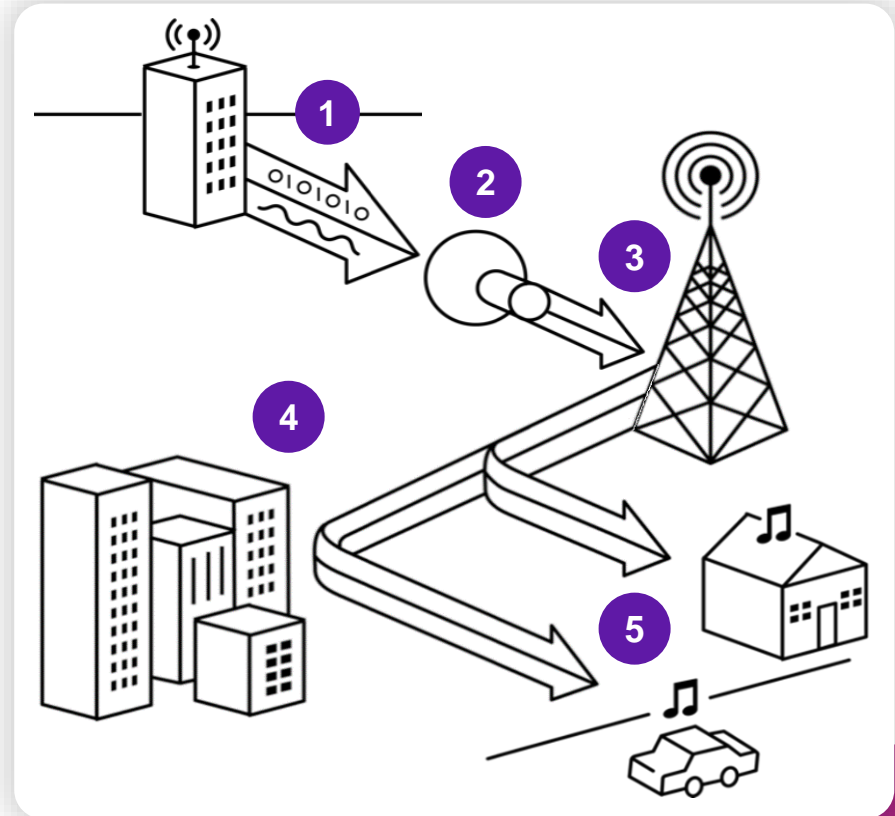
**1** Analog and digital signals are sent separately, enabling separate, unique audio content for analog and HD2/HD3/HD4 digital channels.

**2** Audio combined before transmission. Hybrid broadcast simulcasts the analog and digital content on the same frequency.

**3** Composite signals are transmitted by stations utilizing common analog and digital transmission infrastructure.

**4** Multipath distortion only affects analog signals.

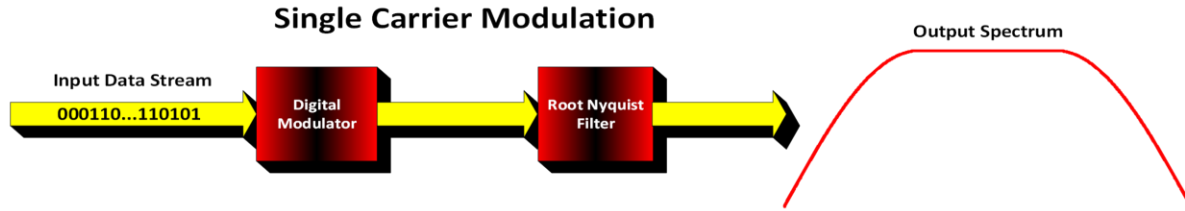
**5** Broadcast is compatible with both analog and digital radios – only digital radios can receive digital multicast channels.



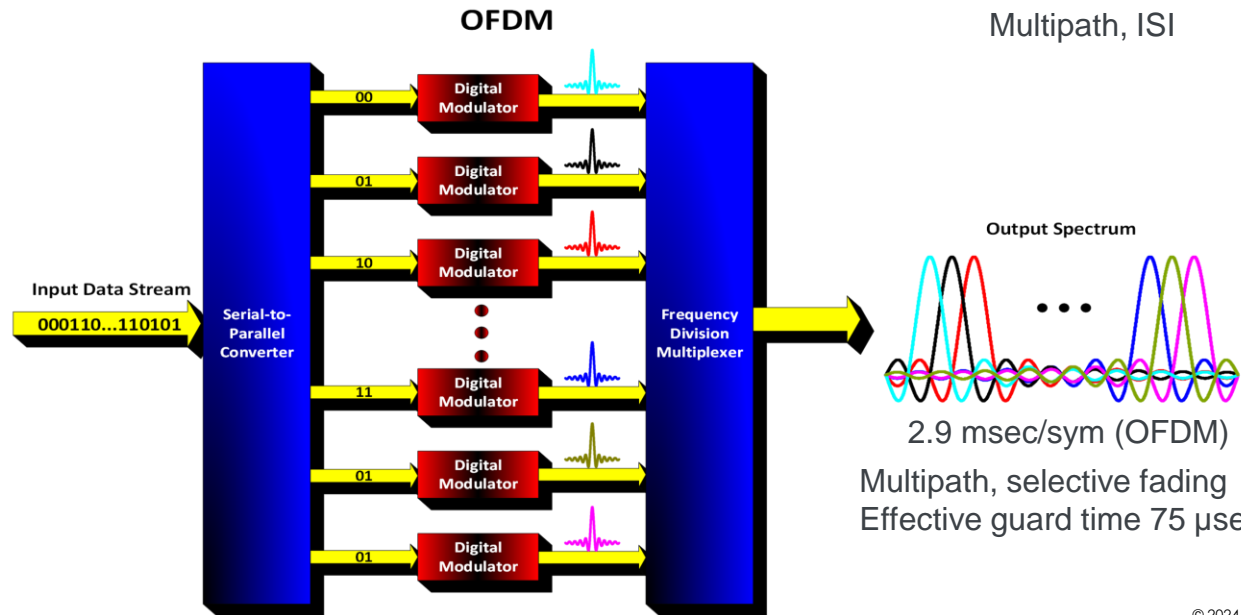
# FOUR MAIN COMPONENTS



# ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM)



4  $\mu$ sec/sym (QPSK)  
Multipath, ISI

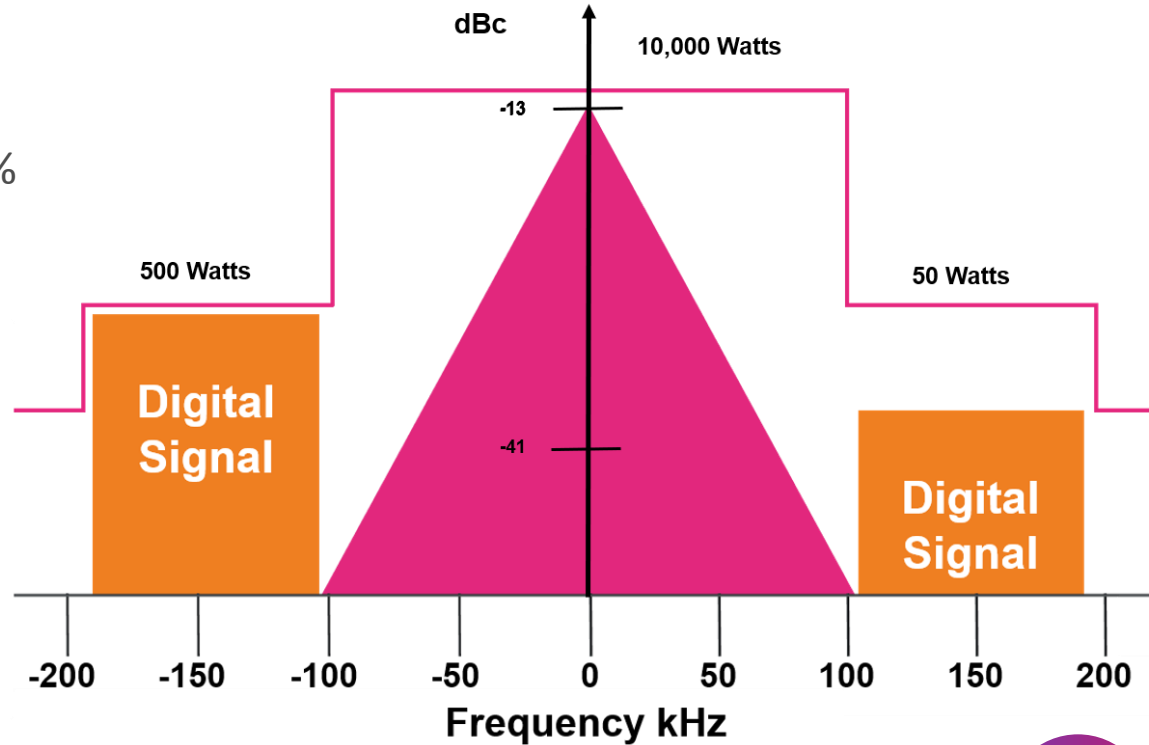


Output Spectrum

The output spectrum shows multiple overlapping waveforms of different colors, representing the frequency division multiplexing. Below the spectrum, the text reads: '2.9 msec/sym (OFDM)', 'Multipath, selective fading', and 'Effective guard time 75  $\mu$ sec'.

# HD RADIO – FM HYBRID

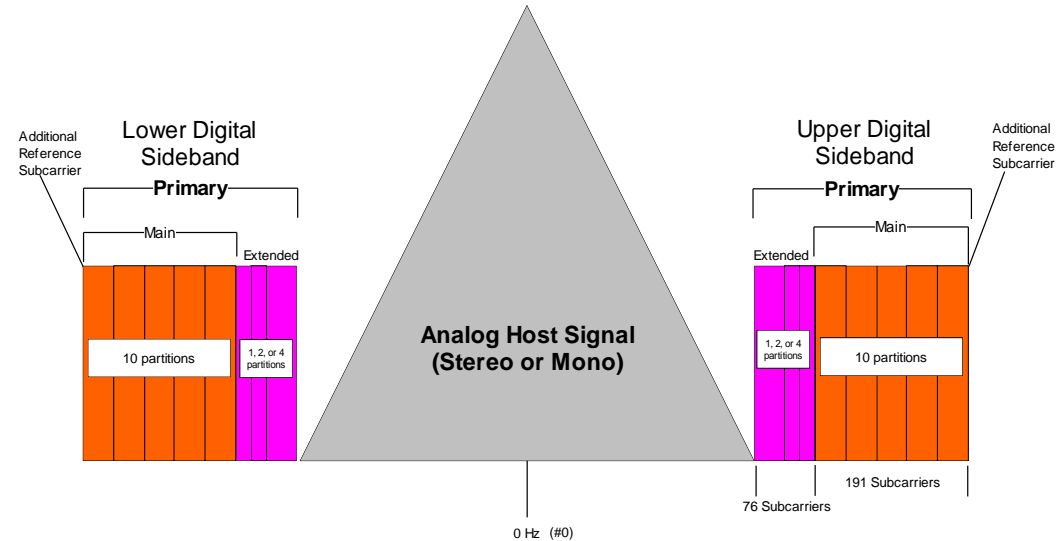
- The FM digital carriers are transmitted between 1% and 10% of the station's analog power.
- All the carriers fit within the internationally recognized emissions mask





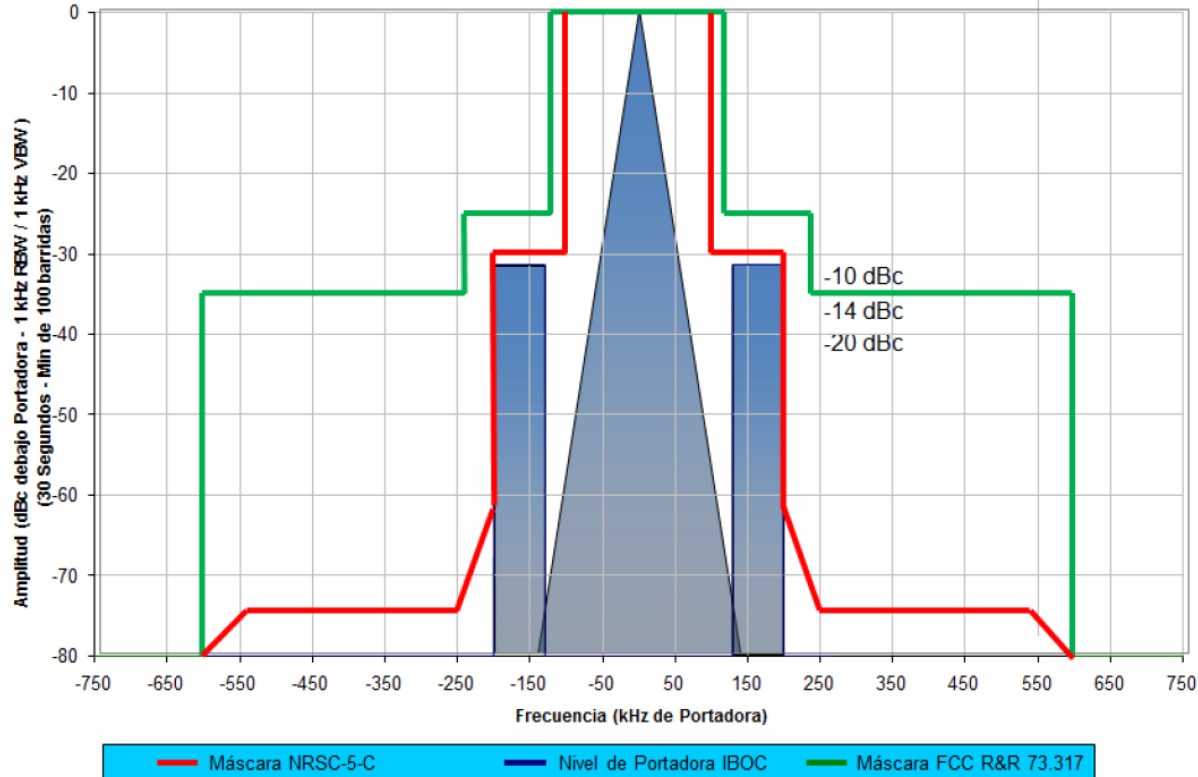
# IBOC FM SYSTEM DESCRIPTION

- ~400 QPSK carriers (phase modulated only)
- Adjacent carriers are 90 degrees out of phase and overlap.
- Their IM products are 180 degrees out of phase and cancel.
- System data throughput: 400 kbps
- 2 out of every 5 bits are used for error correction.
- This leaves ~148 kbps for audio and data.

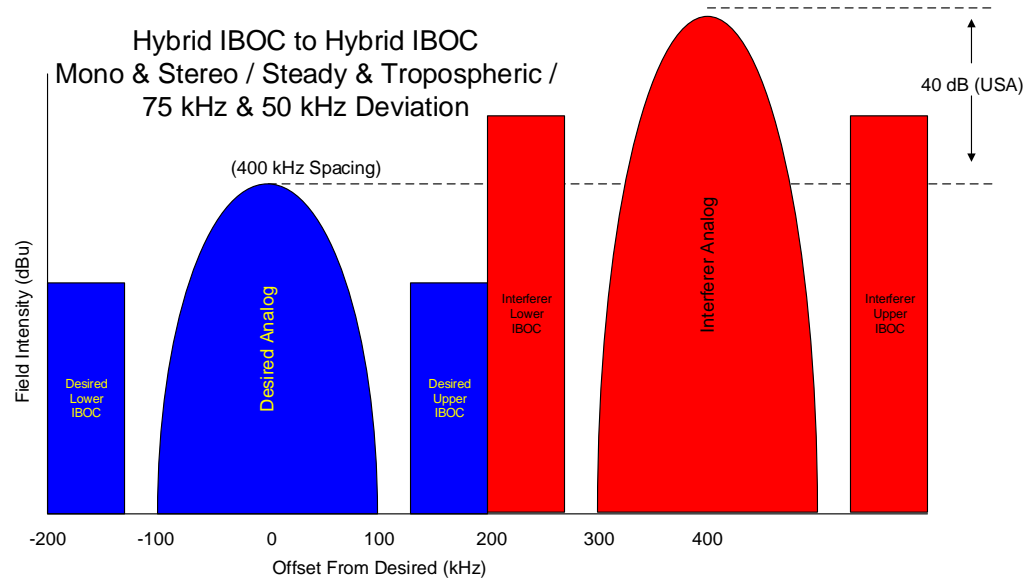


# COMPATIBILITY – NRSC-5D EMISSION LIMITS

Máscara de Ruidos Espúreos y Emisiones Tx\_SSS\_1026s Rev. E y FCC Parte 73.317 Límites de Emisiones FM



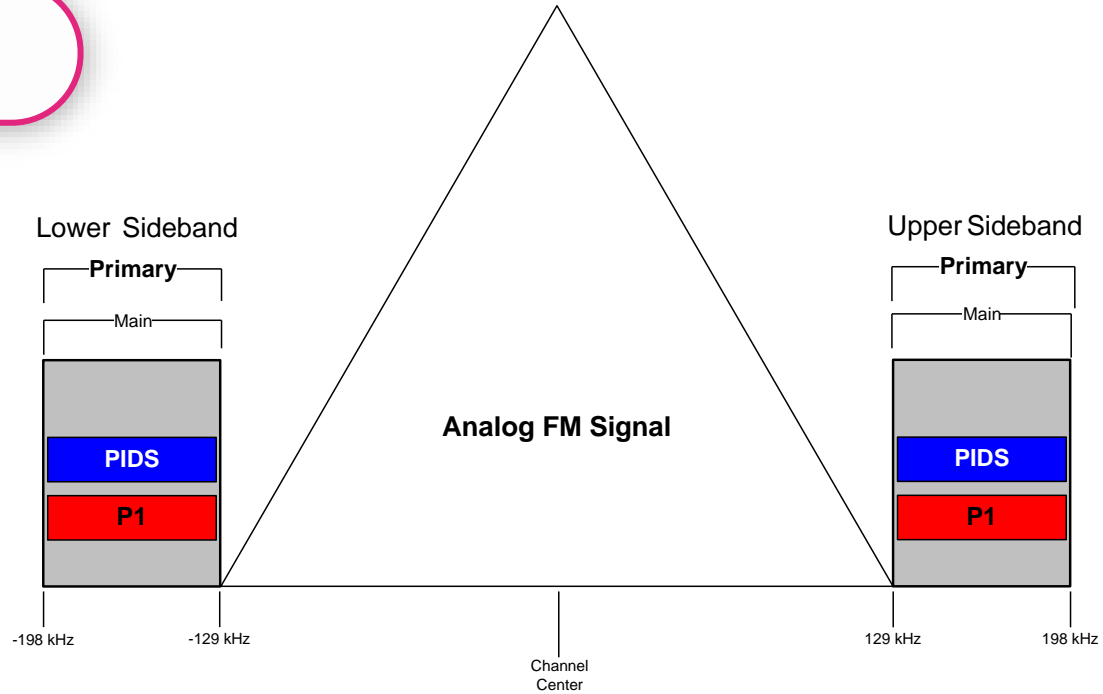
# Interference Mitigation: 2nd Adjacent (400 kHz)



75 kHz Dev.		50 kHz Dev.		Interference	D/U	Interference			Dominant Interferer	Interference Rating Scale:
Mono	Stereo	Mono	Stereo			Type	A = Analog			
Steady	Tropo	Steady	Tropo	Offset (kHz)	(dB)	Interference	Desired	Interference	A = Analog	None = No perceptible audible degradation / 0% digital dropouts
Steady	Tropo	Steady	Tropo			Interference	Desired	Interference		
				400	-20	A	A		N	No interference to analog by analog (DU is 20 dB less than USA)
						A	D		N	No analog interference to IBOC sidebands (DU is 20 dB less than USA)
						D	A		N	No IBOC interference to analog
						D	D		N	No Overlap & (DU is 20 dB less than USA)

# HYBRID TRANSMISSION MODE – MP1

✓ 96 kb/s



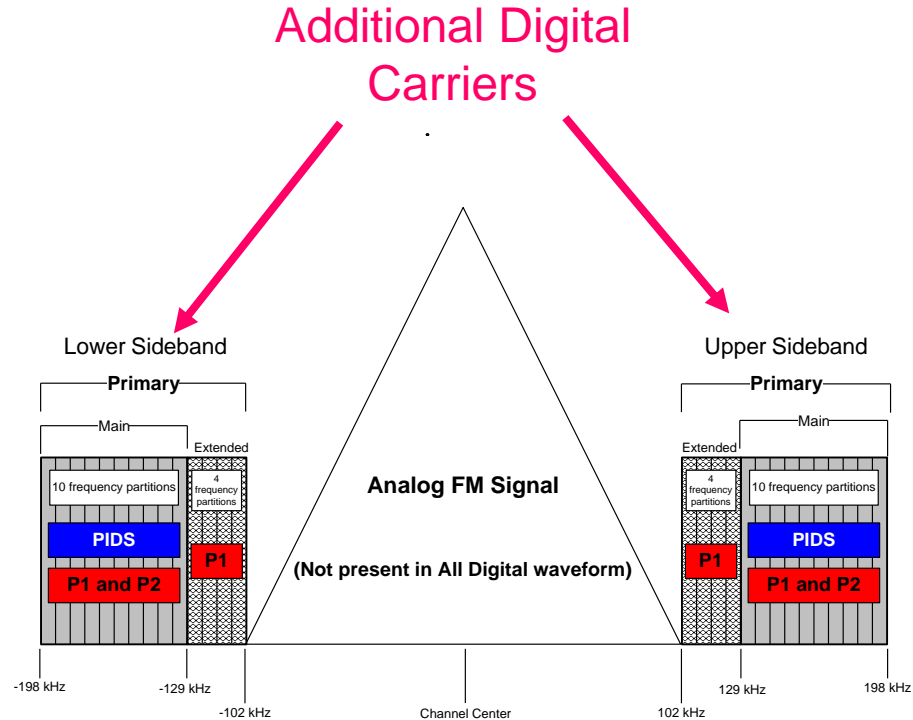
Key: MPS Audio SIS Data

# EXTENDED HYBRID MODE

✓ MP2 108 kb/s

✓ MP3 120 kb/s

✓ MP11 148 kb/s



Key: MPS Audio SIS Data

# INJECTION LEVEL – DIGITAL POWER

It is the percentage of digital power to be used concerning the authorized analog power



## **-20dBc (1% of analog radiated power)**

Its digital coverage will be lower than analog coverage, low level of penetration in buildings, little used today, and it has the lowest implementation cost.



**-14dBc (4% of analog radiated power)** Many experts believe that this power level offers a good compromise between digital coverage and, at the same time, minimal possibility of causing interference.



## **-10dBc (10% of analog radiated power)**

Excellent digital coverage may have a higher implementation cost due to the need for a more powerful transmitter.

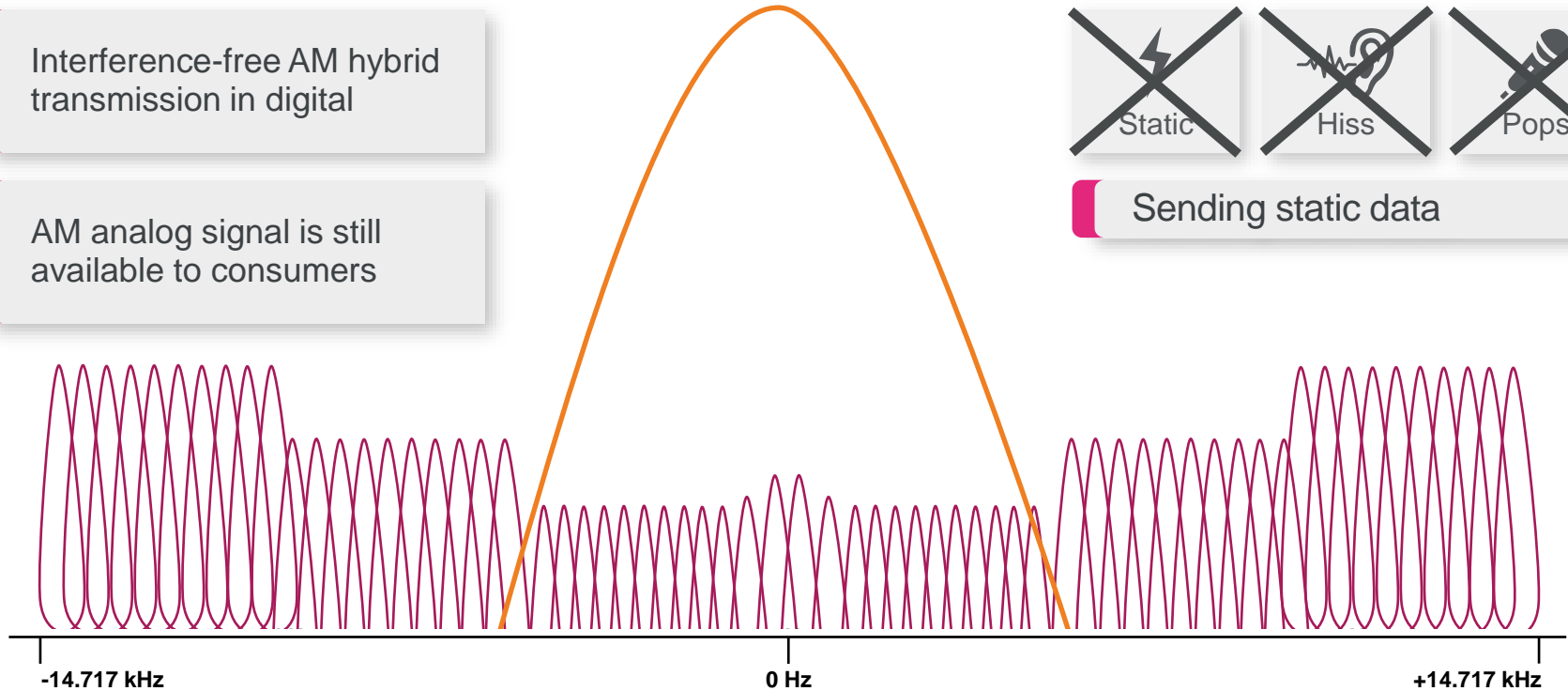
# AM HYBRID - MA1

Interference-free AM hybrid transmission in digital

AM analog signal is still available to consumers



Sending static data



# AM ALL DIGITAL –MA3

Interference- free

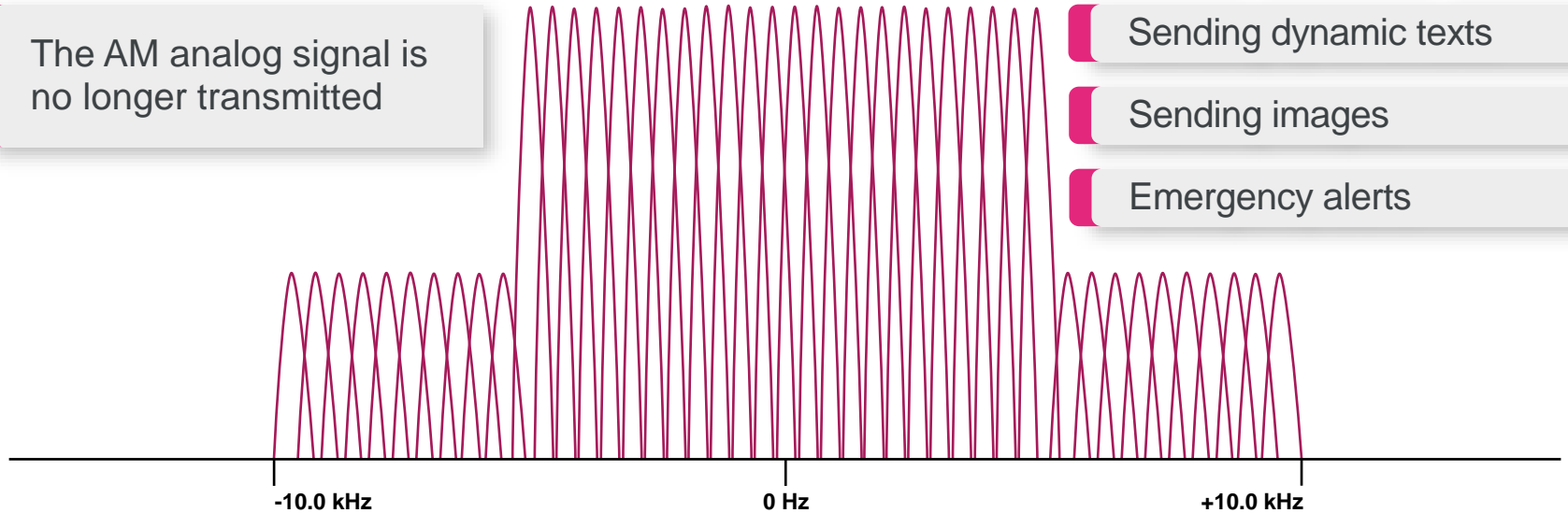
The AM analog signal is no longer transmitted



Sending dynamic texts

Sending images

Emergency alerts

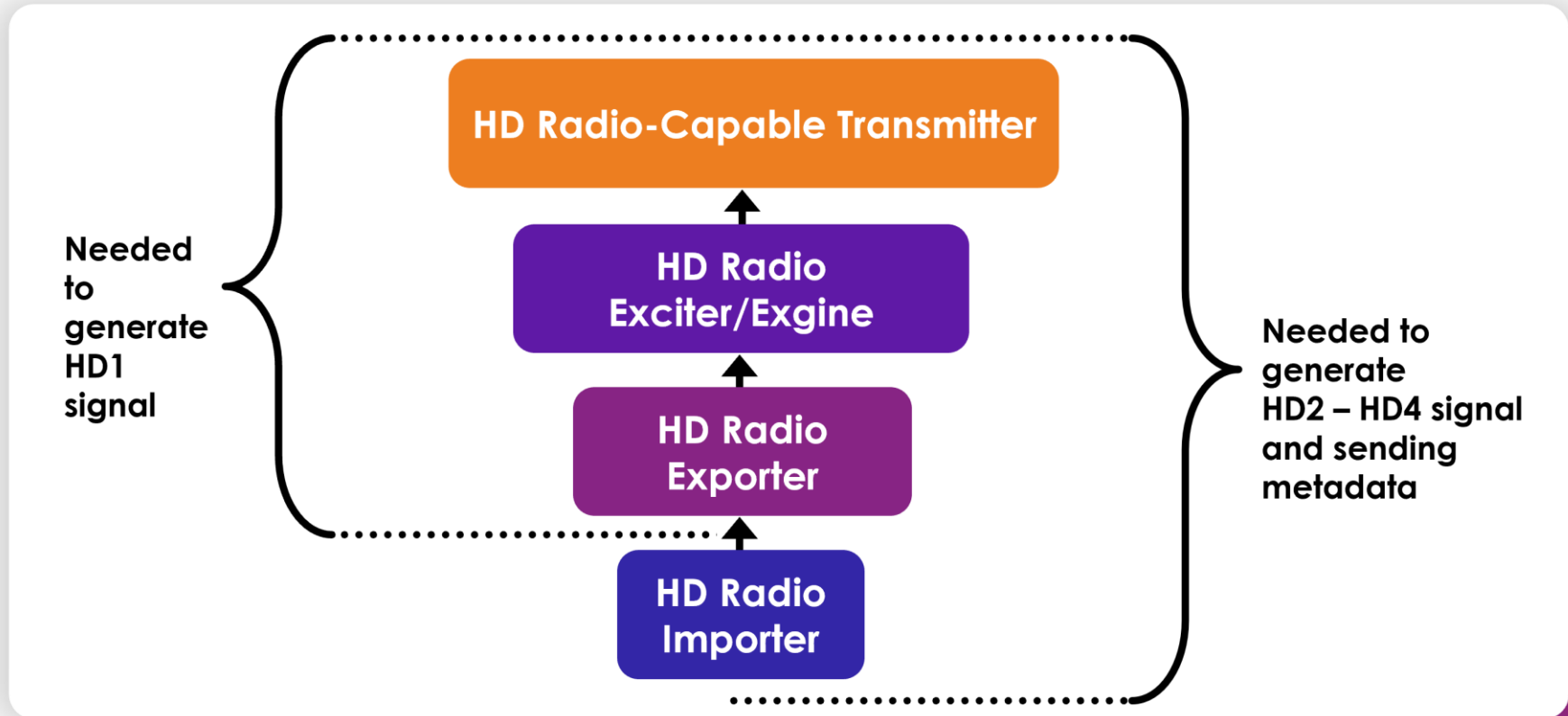




# REQUIREMENTS

*HD RADIO*

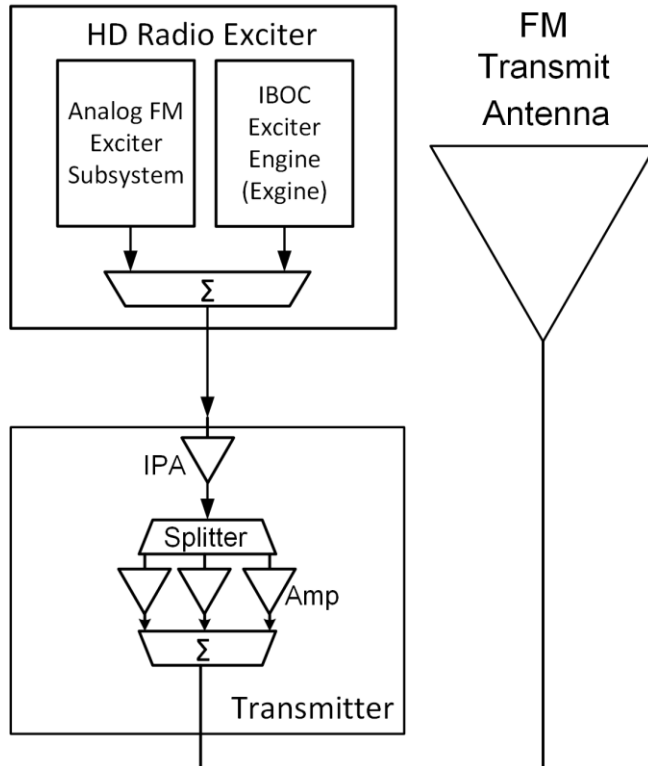
# EQUIPMENT REQUIRED TO TRANSMIT DIGITAL SIGNAL





# HD RADIO TRANSMISSION METHODS

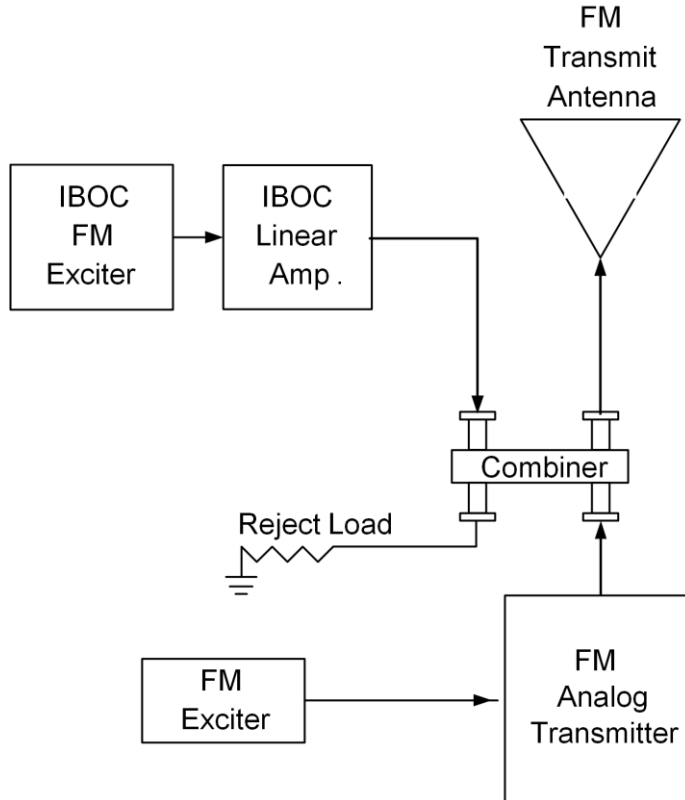
# METHODS FOR FM HYBRID IBOC TRANSMISSION



## Low Level – Common Amplification

IBOC signal created and mixed at low level with the analog FM. The combined signal is then amplified by linear amplifiers to the licensed transmitter power output

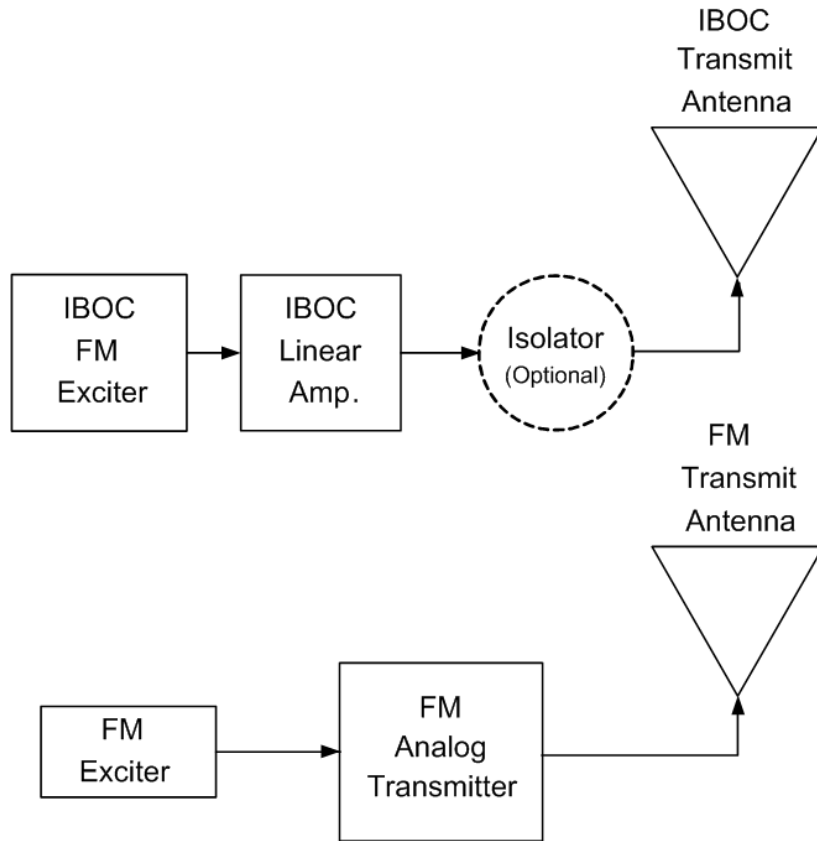
# METHODS FOR FM HYBRID IBOC TRANSMISSION



## High Level – Separate Amplification

Analog signal and digital created independently and fed to separate amplifiers. Host uses existing analog RF equipment. The digital signal is fed to a linear amplifier. The signals are then combined using an injector/combiner.

# METHODS FOR FM HYBRID IBOC TRANSMISSION



## Separate Antenna – Space Combined

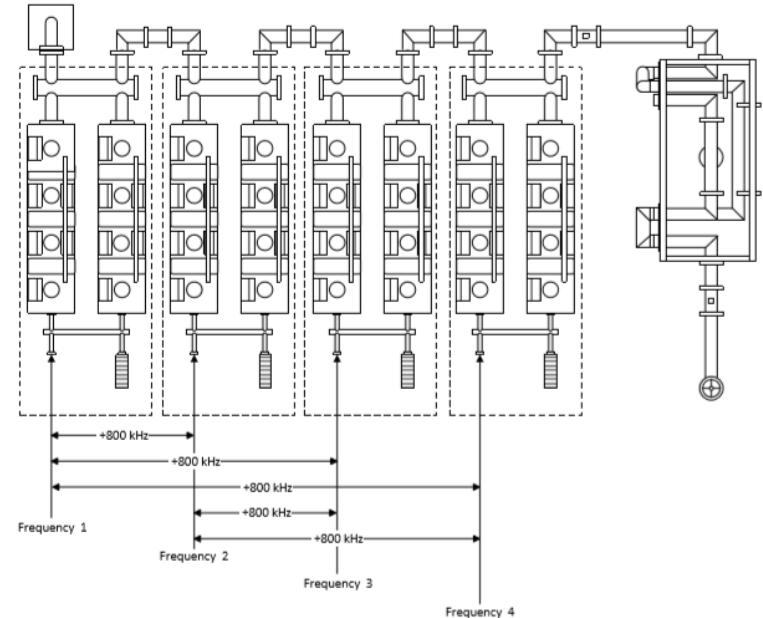
IBOC signal and analog FM amplified and transmitted through independent paths.

# MULTI-STATION FM COMBINERS

## PROPER DESIGN WILL ALLOW HD RADIO TO CO-EXIST WITH ANALOGUE

- Typical combiner configuration supports minimum 800kHz frequency spacing
- Spacing closer than 800kHz may result in compromise to analog and digital performance and will be expensive to implement correctly

Call Letters	Frequency	Transmission
WNYL	92.3MHz	Analog + Digital
WNYC	93.9MHz	Analog + Digital
WXNY	96.3MHz	Analog + Digital
WSKQ	97.9MHz	Analog + Digital
WEPN	98.7MHz	Analog
WFAN	101.9MHz	Analog
WNEW	102.7MHz	Analog + Digital
WAXQ	104.3MHz	Analog + Digital
WWPR	105.1MHz	Analog + Digital
WLTW	106.7MHz	Analog + Digital
WBLS	107.5MHz	Analog + Digital



# HD RADIO SERVICES





# HD RADIO SERVICES

The HD Radio system allows for different services so that stations can offer a more enriching experience.



Station  
Information  
Service (SIS)



Main Program  
Service (MPS)



Supplemental  
Program  
Services (SPS)



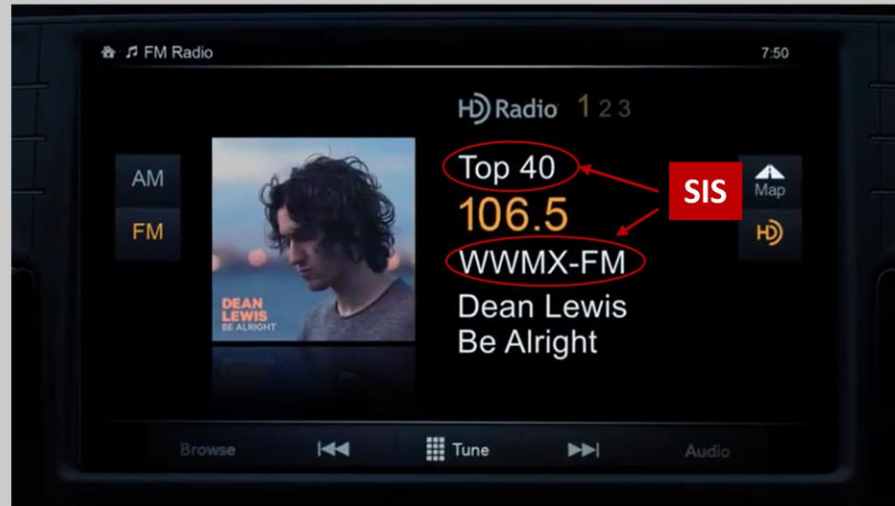
Advanced  
Application  
Services (AAS)

# HD RADIO SERVICES - STATION INFORMATION SERVICE



## EXPORTER - System Setup/Information.

- The call ID are placed in the "Short name" section.



# HD RADIO SERVICES – MAIN PROGRAM SERVICE



## PSD Messages – Dynamic or Fixed Program Service Data

- Song name, artist, album, etc.



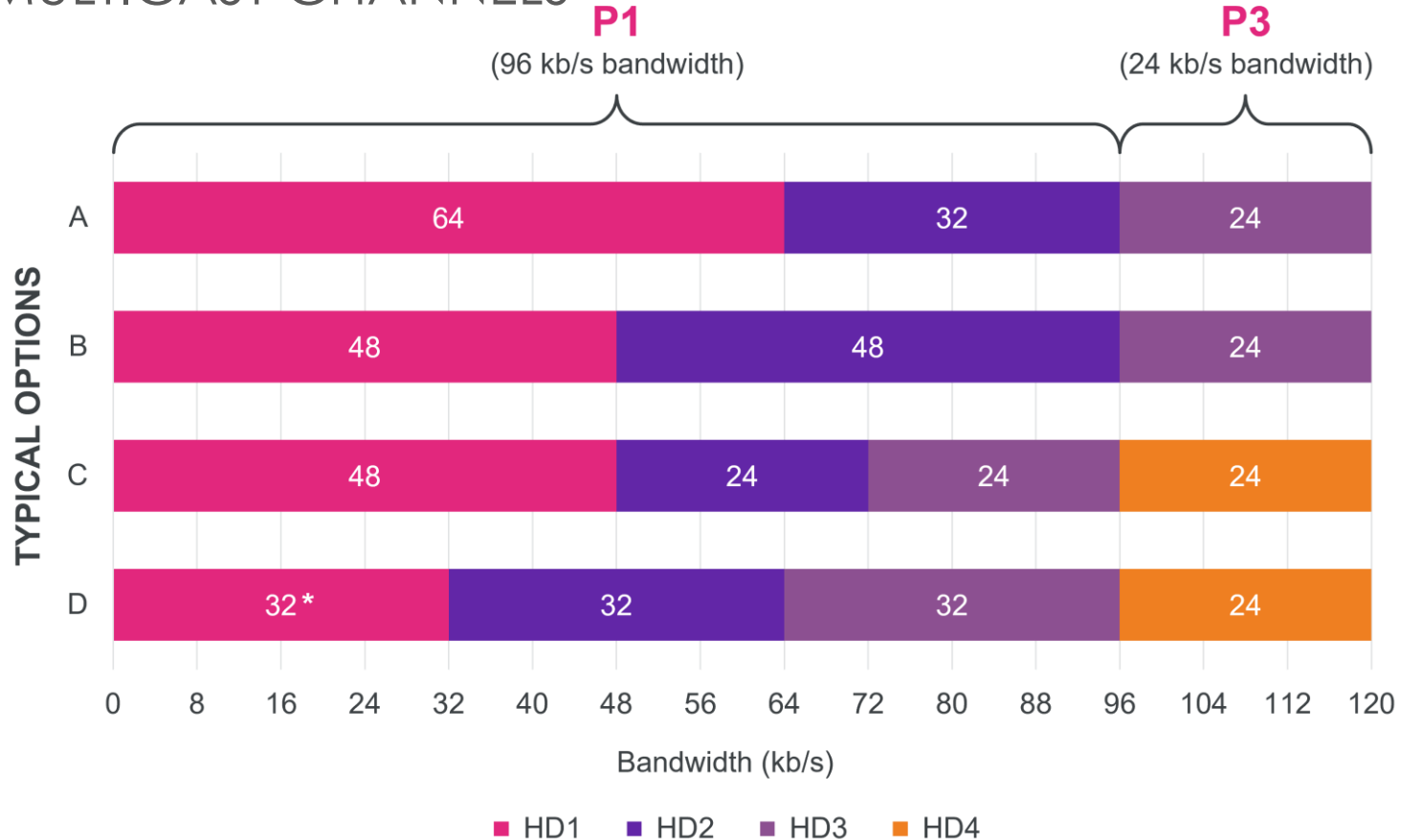
# HD RADIO SERVICES – SUPPLEMENTAL PROGRAM SERVICES



PSD Messages – Dynamic or Fixed Program Service Data  
Song name, artist, album, etc.



# MULTICAST CHANNELS



# HD RADIO SERVICES – ADVANCED APPLICATION SERVICES



**Traffic and weather  
information**



**Content on demand**



**Advanced Applications**



AM  
FM



HD Radio 1 2 3

Top 40  
106.5  
WWMX-FM  
Dean Lewis  
Be Alright

Map  
HD

**HD RADIO  
METADATA  
SERVICES**

Browse



Tune



Audio

A photograph of a man and a woman driving in a car. The man is in the driver's seat, wearing a blue denim shirt and light-colored pants, with his arms raised in excitement. The woman is in the passenger seat, also smiling. The car's interior is visible, including the steering wheel and seats. A large, semi-transparent pink shape is overlaid on the left side of the image, containing the text.

# TECHNIQUES TO IMPROVE SYSTEM ROBUSTNESS



# 1. HD RADIO CODECS

The codec must be very efficient to perceptually encode audio at low bit rates.

Below 128 kbps, the perceived audio quality of most codecs begins to degrade significantly.

**A codec achieves efficiency by:**

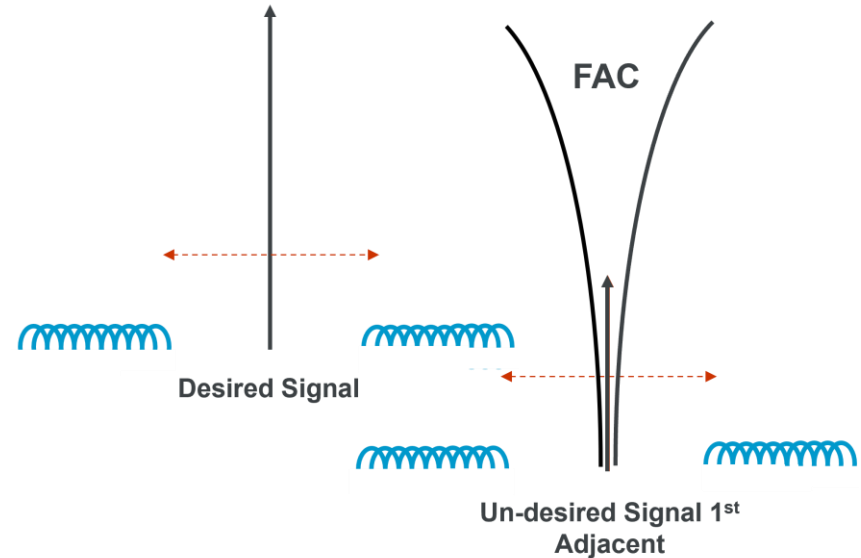
Reducing the audio bandwidth and/or modifying the stereo image

**A codec achieves efficiency by:**

Allowing coding errors

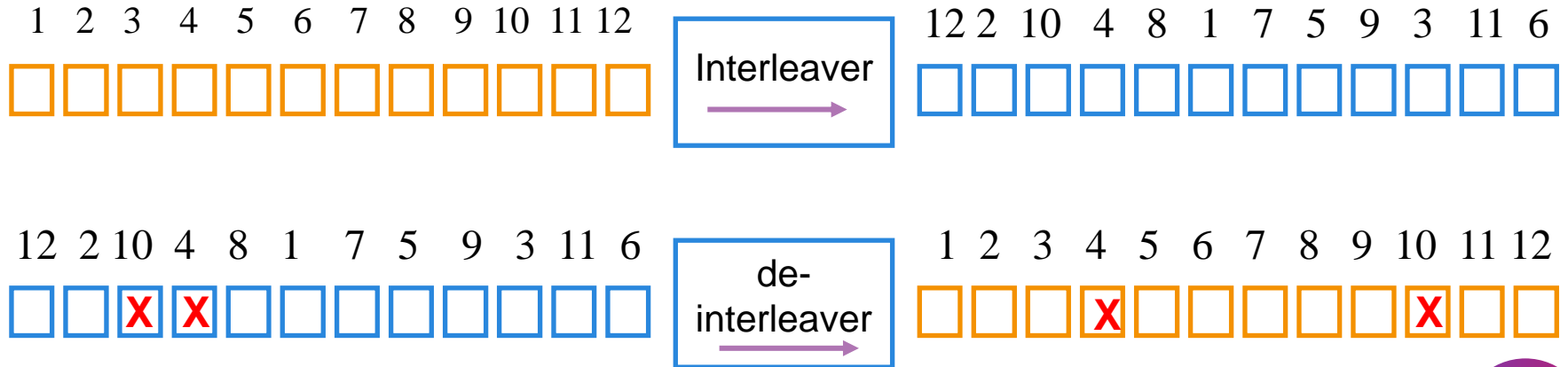
## 2. FIRST ADJACENT CANCELER

- An analog station on the first adjacent channel interferes with the digital carriers.
- The FAC notch filter instantly cancels the analog FM carrier.

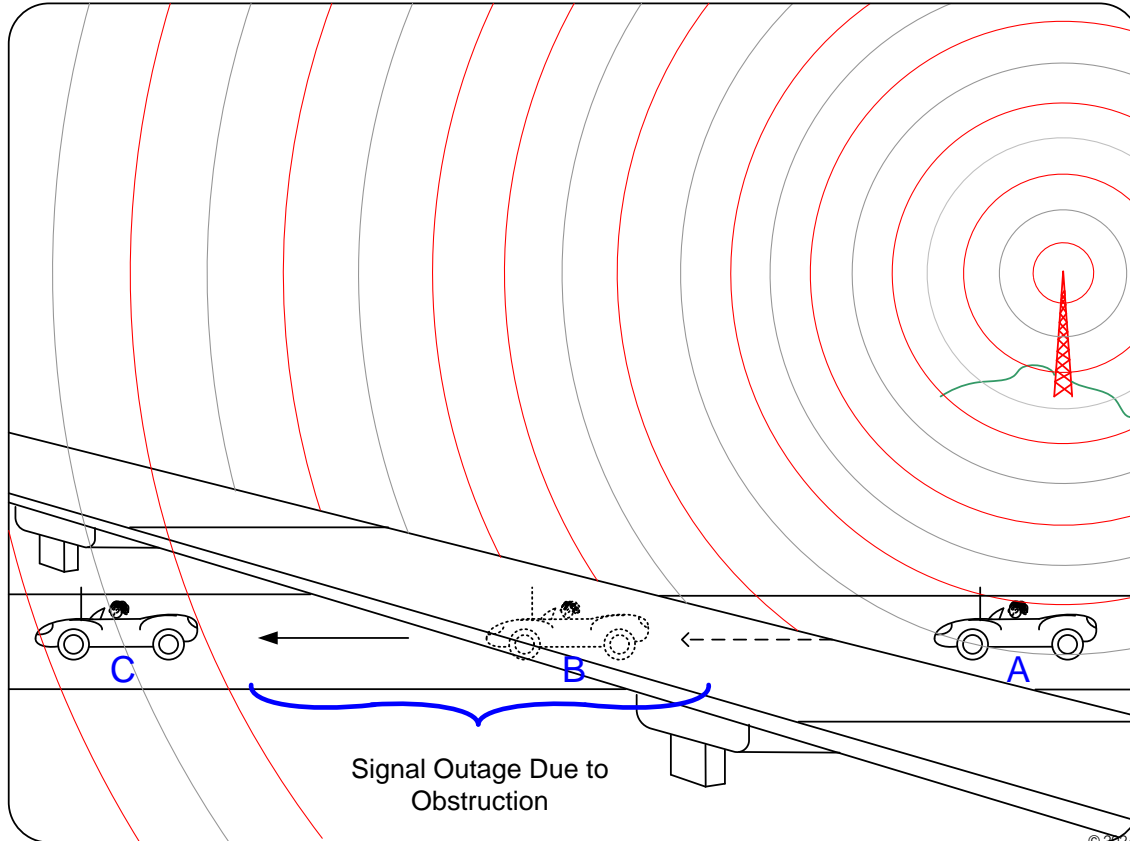


### 3. “INTERLEAVING”

- “Interleaving” is a technique that scrambles the bits during transmission.
- “Interleaving” disperses the errors caused by interference and reception problems.
- The Objective: To avoid successive lost bits



# 3. DIVERSITY DELAY



# TIME ALIGNMENT

## Reasons to align analog and digital signals

- “Smooth” transition between signals.
- Reduces echo and repeated audio.
- Reduces the effects of transition at the edge of digital coverage.
- Ensures the proper experience for the listener.
- Reduces complaints towards car brands.



# TIME ALIGNMENT - EQUIPMENT



**EXPORTER**



**AUDIO PROCESSOR**



**SPECIALIZED EQUIPMENT AND TRANSMITTERS**

# HD RADIO

*SINGLE FREQUENCY NETWORKS*

# WHAT ARE SINGLE FREQUENCY NETWORKS?

A MAIN TRANSMITTER AND ONE OR MORE COMPLEMENTARY ONES.

## MAIN REASONS TO USE THEM



### **To cover shadow areas**

When the geographical conditions of the terrain do not allow an adequate signal level.



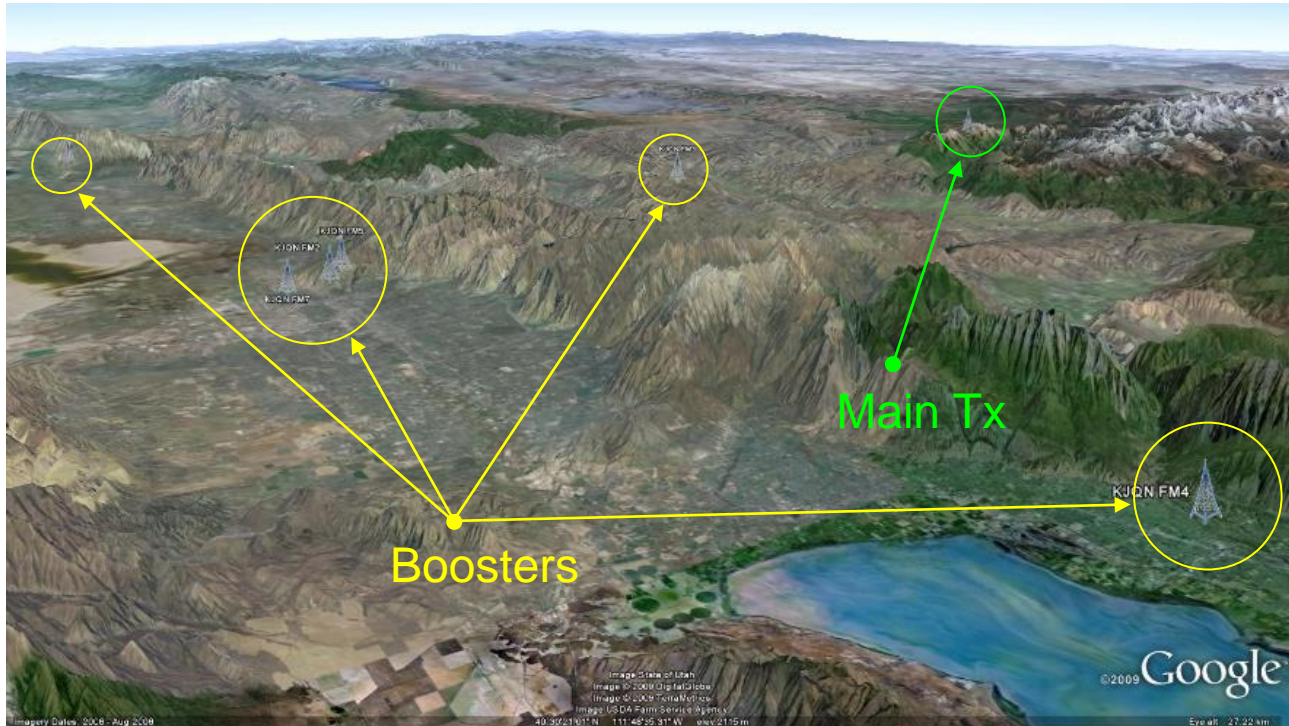
### **Covering long distances**

Covering reception throughout the journey, for example on a highway, without the listener having to change the channel

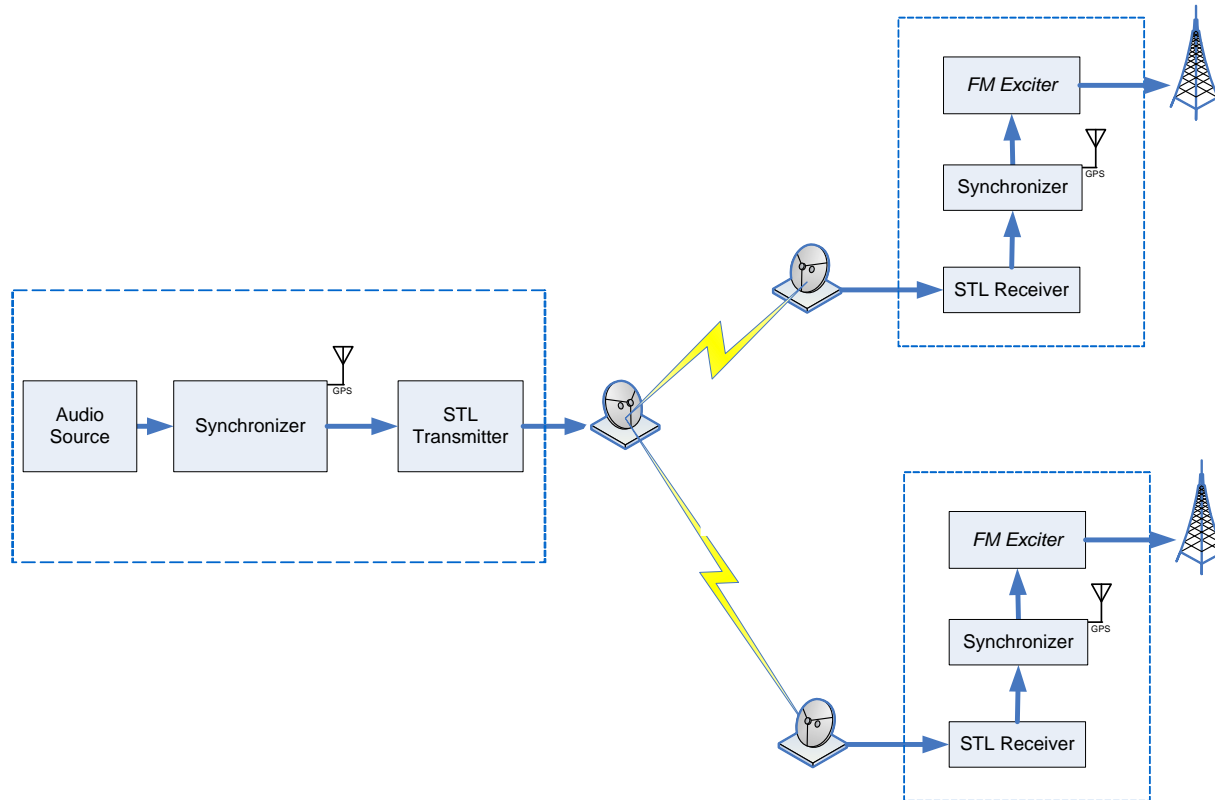


# SINGLE FREQUENCY NETWORK - BOOSTERS

## TYPICAL TERRAIN CHALLENGES FOR A RADIO STATION



# CONCEPTUAL VIEW OF SFN BROADCAST SYSTEM



The background features a central dark purple area with four rounded, overlapping shapes extending towards the corners. The top shape is a gradient from light green to dark green. The bottom shape is a solid purple. The left and right shapes are a gradient from dark purple to bright pink. The word "Thanks." is centered in the dark purple area.

Thanks.