

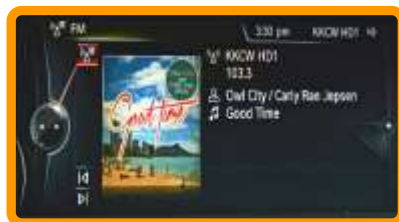


A BETTER LISTENER EXPERIENCE: HD RADIO™ TIME AND LEVEL ALIGNMENT

NAB Broadcast Engineering Conference - April 17, 2016

HD RADIO™ TECHNOLOGY AND YOUR AUDIENCE

- More of your listeners are experiencing your station in digital every day
- More than 29 million HD Radio™ Technology receivers are in the marketplace
- In several US markets 1 car in 5 already has HD Radio Technology
- Over 95% of all Americans live within the coverage area of an HD Radio signal



YOUR LISTENERS ARE PAYING ATTENTION

- Compelling Multicast Content is Attracting New Listeners
- Listeners Appreciate the Quality Improvement
- Displays and Interface are Attracting New Car Buyers
- Artist Experience is Leveling the Playing Field with Other Media

However...

- Time and Level Alignment Set Incorrectly Leads to:
 - Blend Echoes, Repeats and Level Changes
- Listener Dissatisfaction Leads to:
 - Automotive Customer Service Complaints
 - Listener Tune-Over to Your Competition
 - Listener Tune-Out to Other Media

MARKET IMPACT – NEW YORK

Market Snap-Shot

- 2.3 Million HD Radio equipped cars in market
- 6.8 million hours of weekly in-car listening HD Radio broadcasts
- 26% of stations out of alignment could impact 1.8 million hours of listening and 600,000 listeners

[illegible]

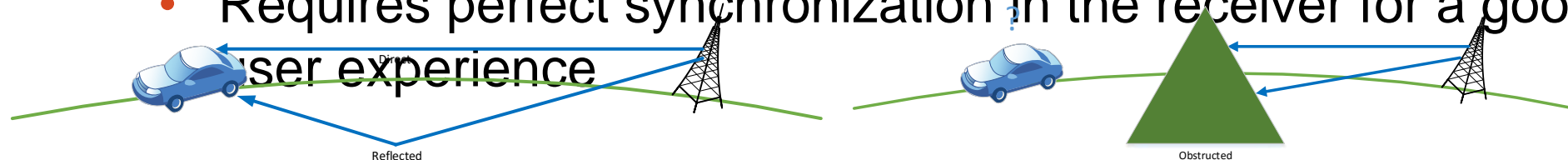
DIVERSITY DELAY

DTS' HD Radio Technology is significantly more robust than analog.

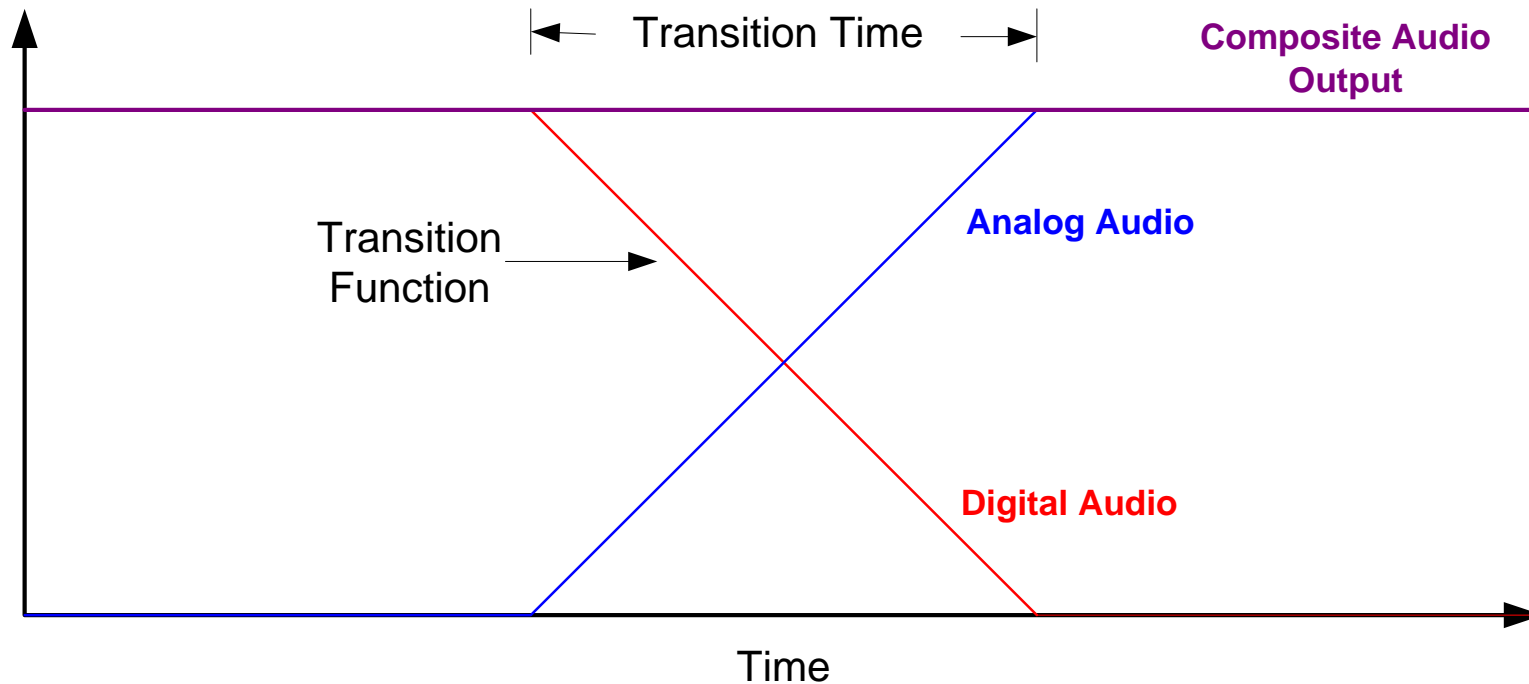
- Digital not immune to signal disruptions
 - Signal obstructions
 - Loss of digital at the edge of coverage

Time diverse transmission can help

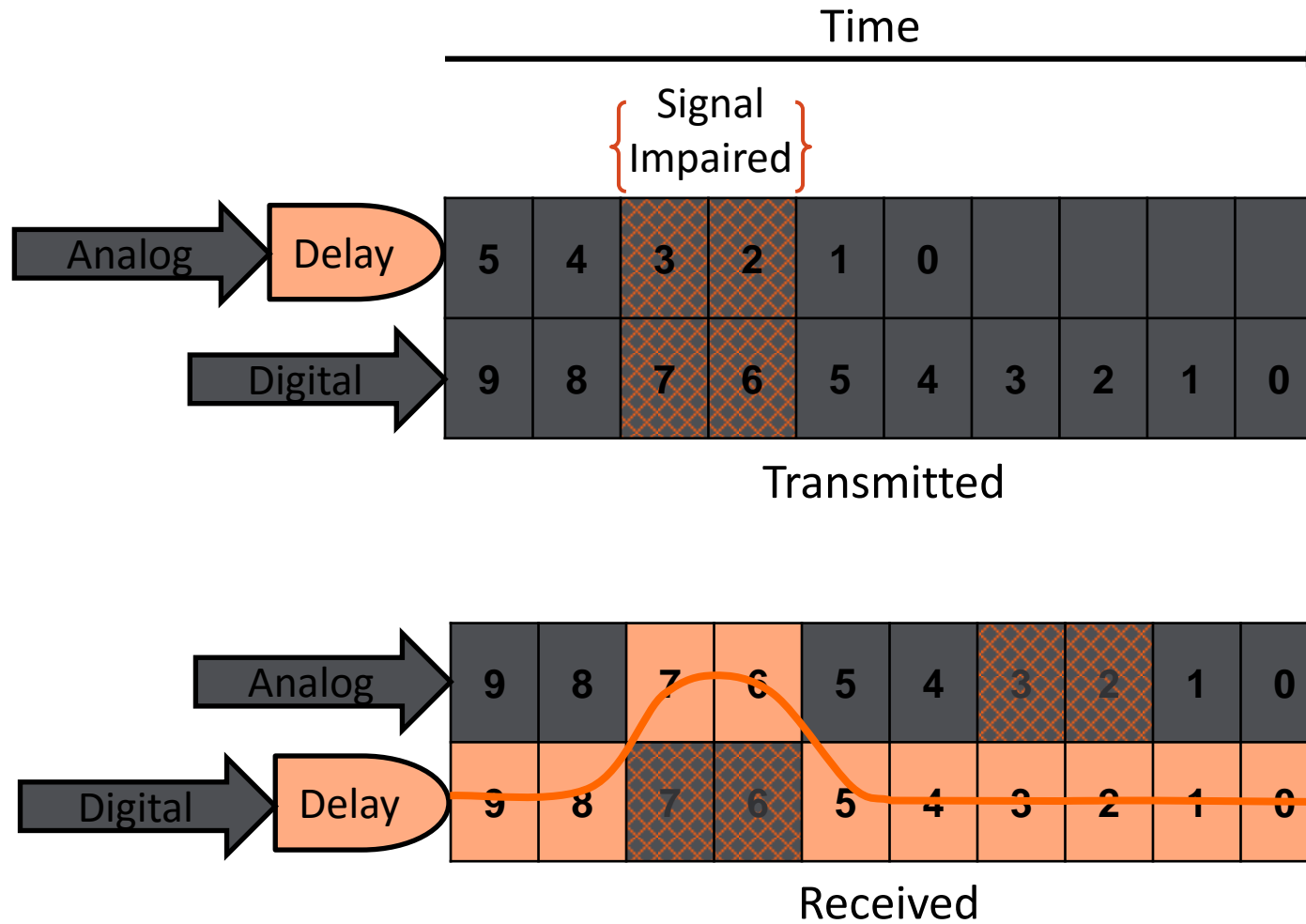
- Transmission of backup time diverse program and data channel
- Used during signal outage
- Requires perfect synchronization in the receiver for a good user experience



BLEND TRANSITION FUNCTION (CROSS-FADE)



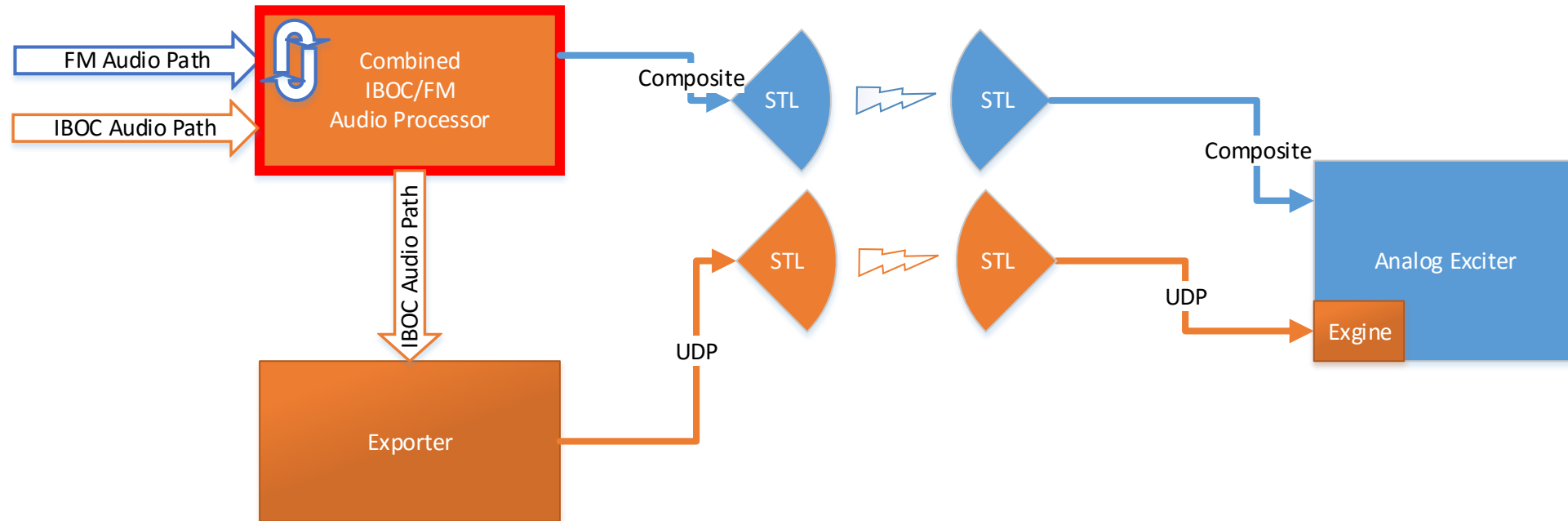
TIME-DIVERSE BLEND



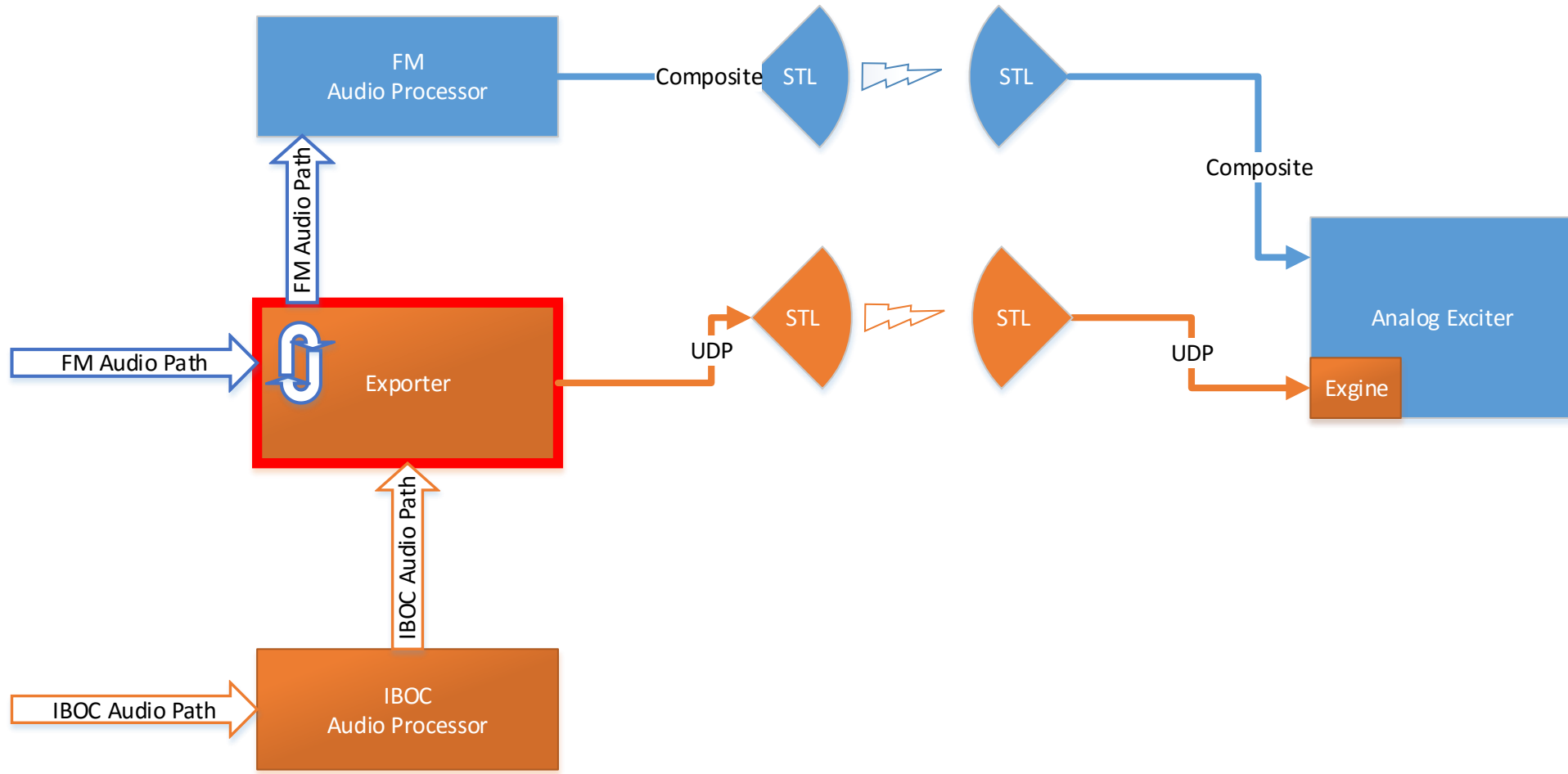
DIVERSITY DELAY OPTIONS

- Diversity Delay is added to the analog audio path
- Delay is typically controlled in one of the following locations:
 - Audio Processor
 - Exporter
 - Stand-Alone Delay Unit

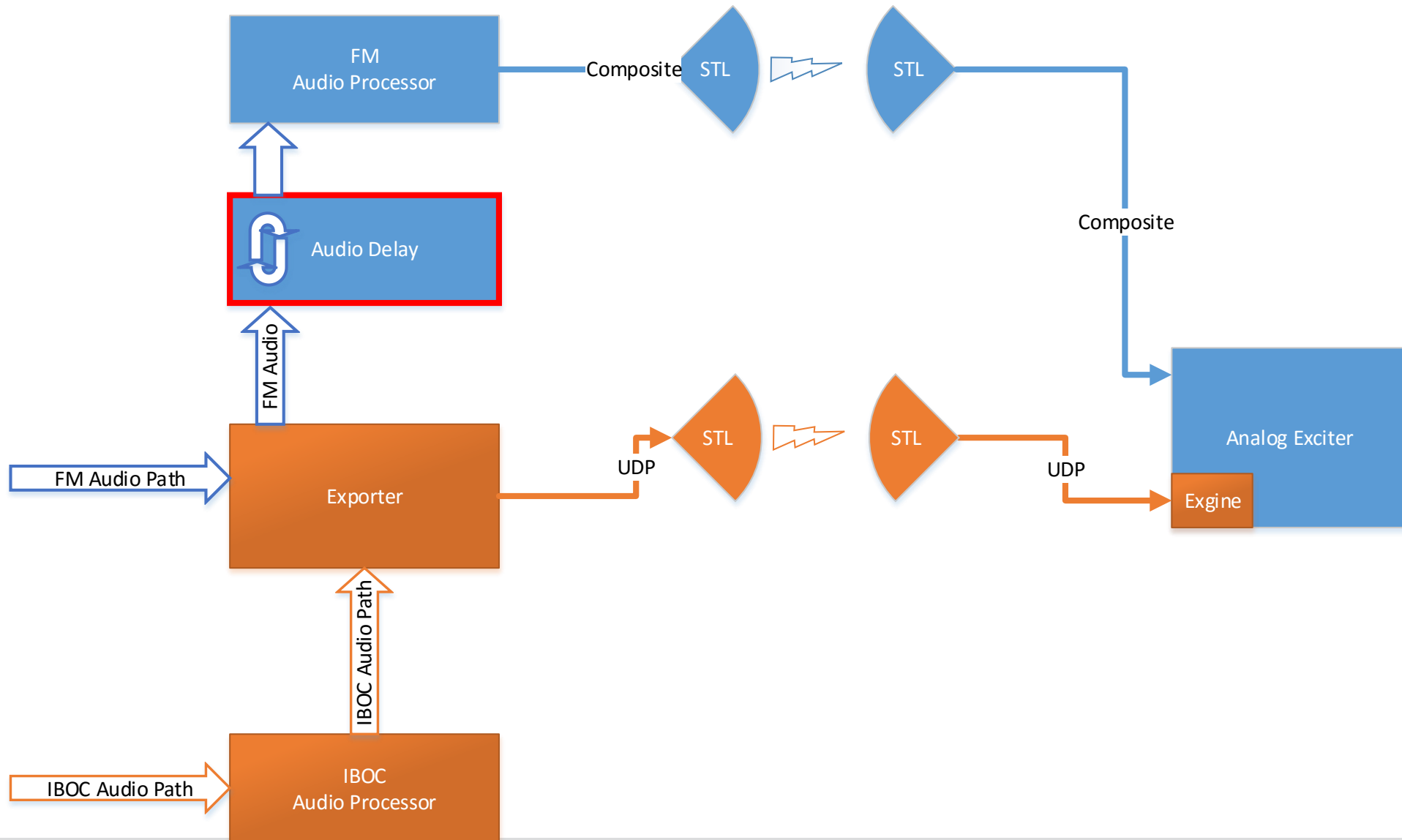
PROCESSOR - DELAY



EXPORTER - DELAY



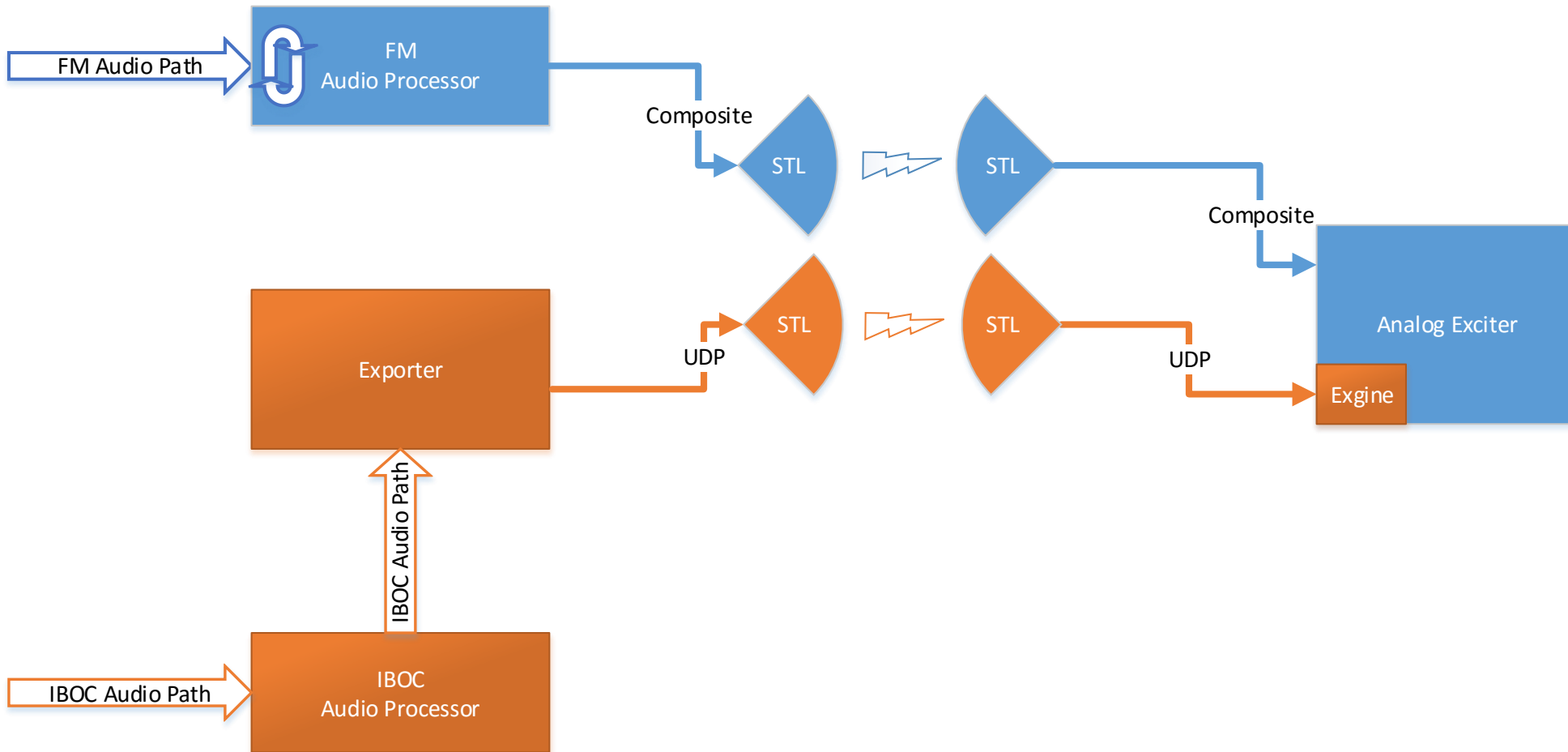
OUTBOARD - DELAY



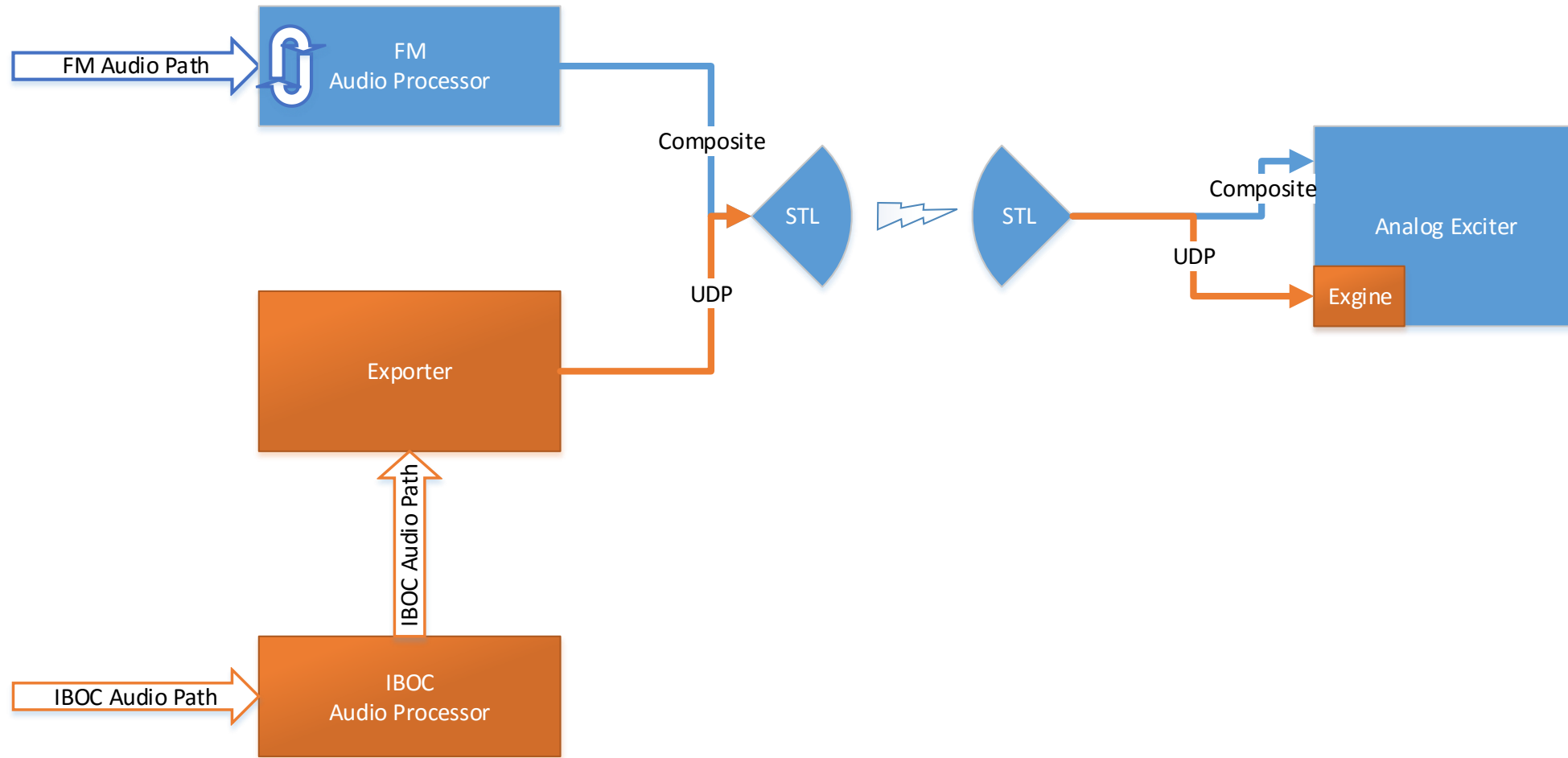
SYSTEM TOPOLOGY - ALIGNMENT PERFORMANCE

- Separate audio processing
- STL/Data circuit performance
- System synchronization

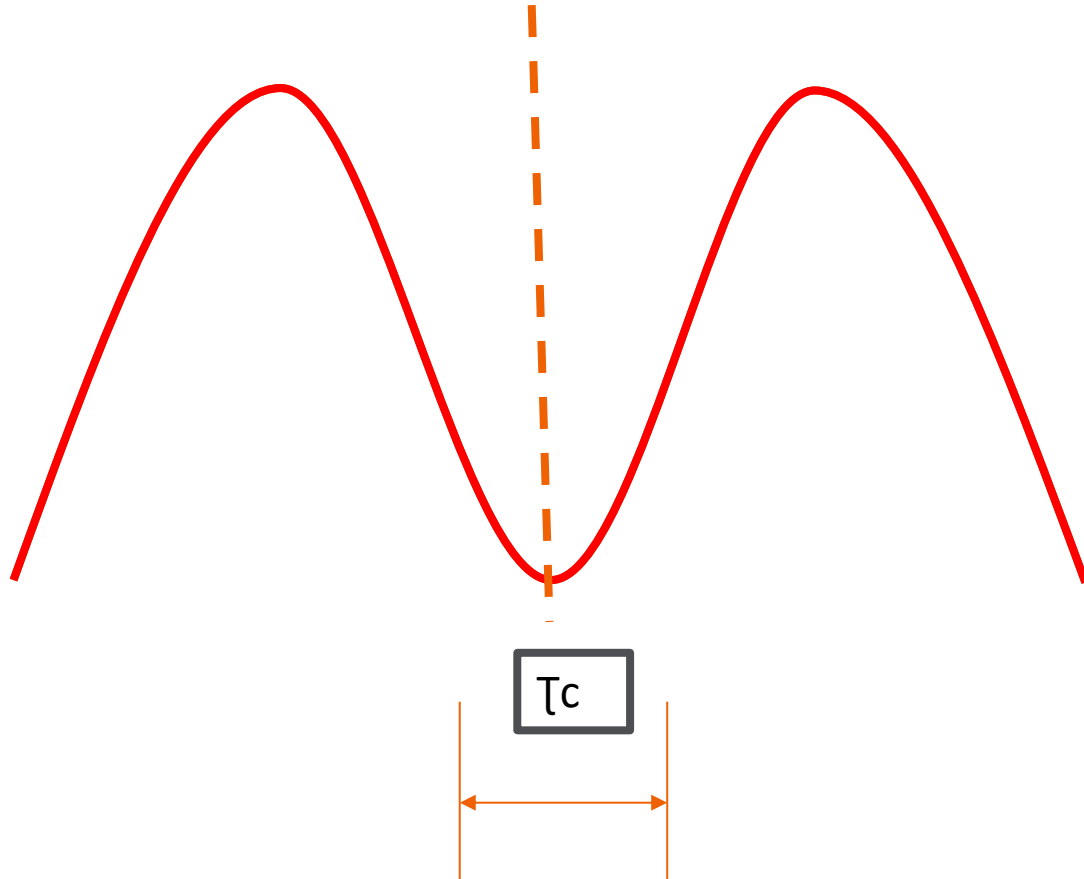
SEPARATE PROCESSOR – SEPARATE LINK



SEPARATE PROCESSOR - COMMON LINK

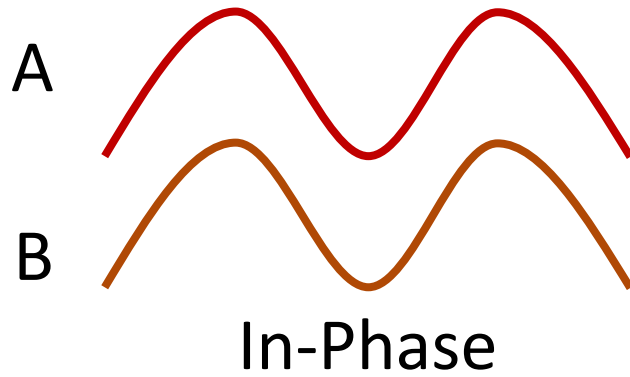


MOVING PIECES

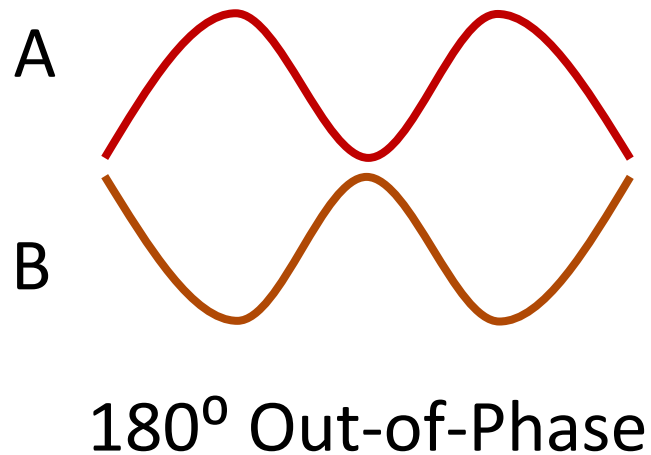
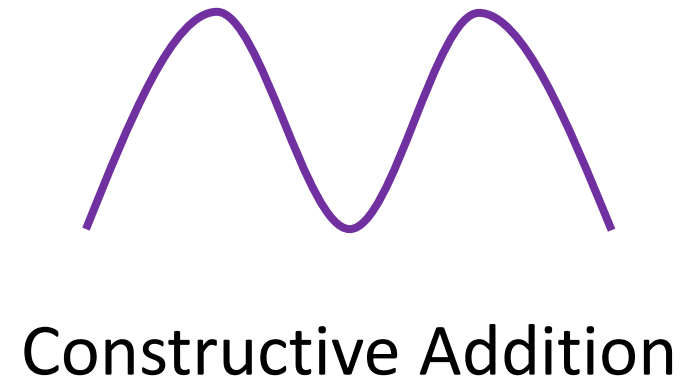


- Dissimilar Processing
- Lack of AES WordClock

AES PHASE REVERSAL EFFECT ON BLEND



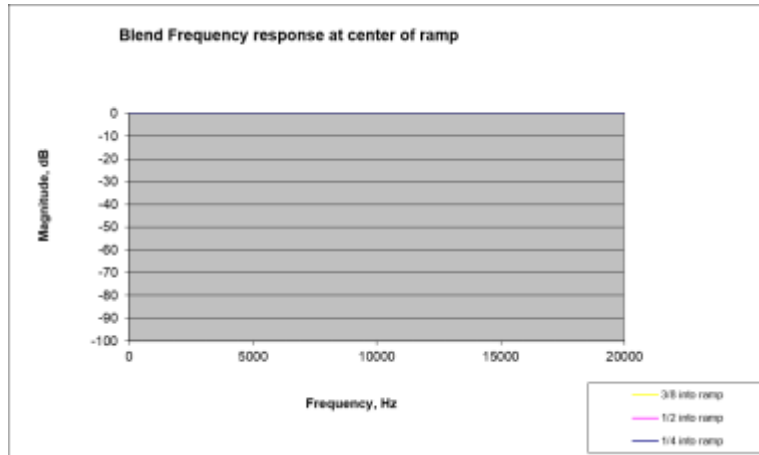
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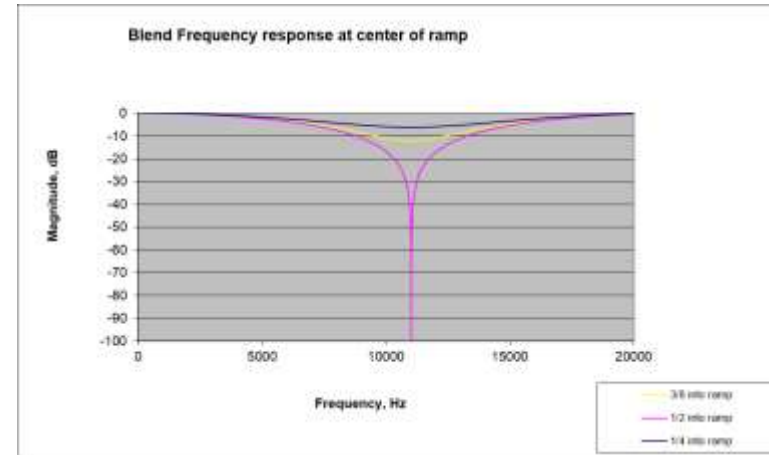
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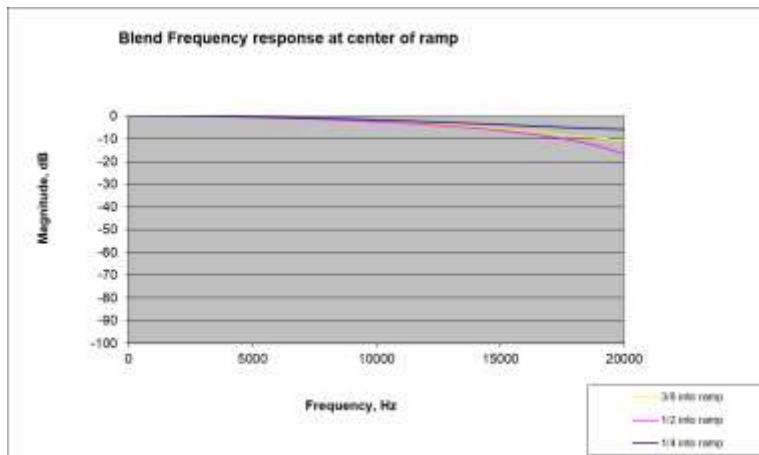
SAMPLE OFFSET IMPACT TO AUDIO AT BLEND



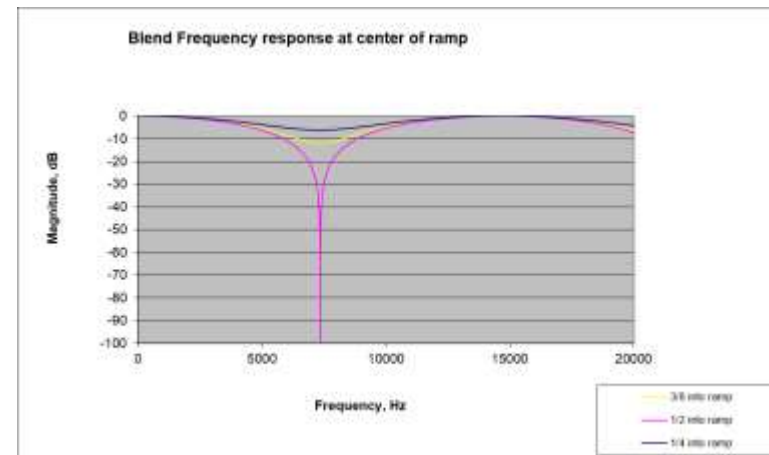
Aligned - 0 Samples



2 Sample Offset

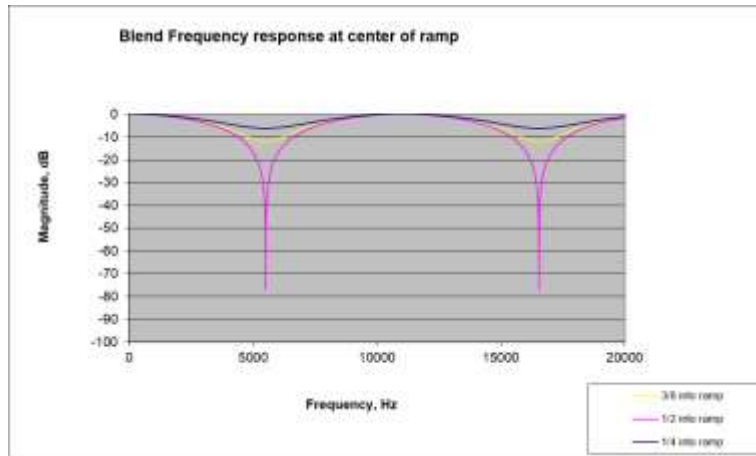


1 Sample Offset

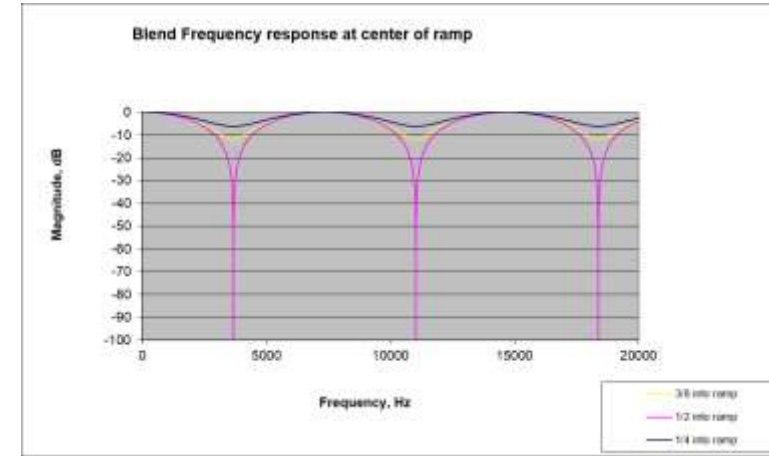


3 Sample Offset

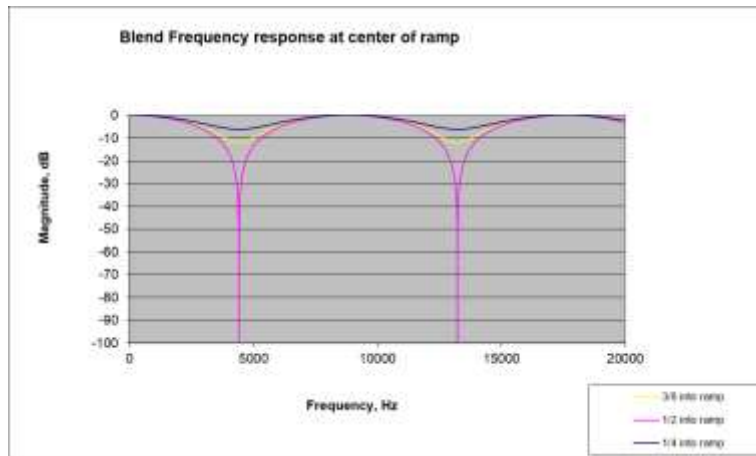
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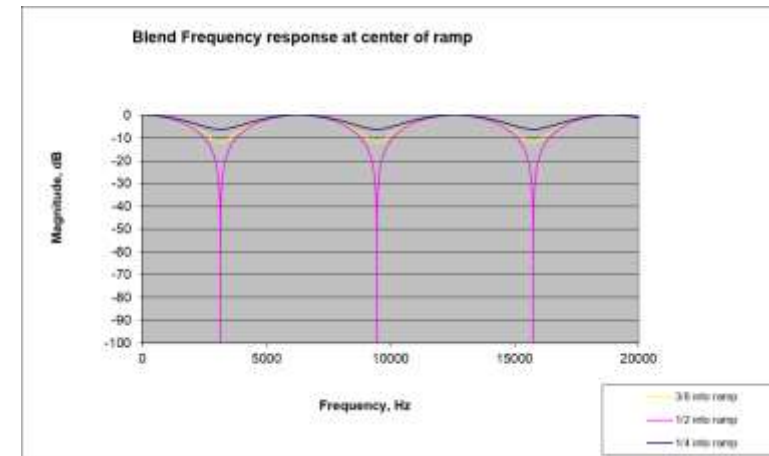
4 Sample Offset



6 Sample Offset

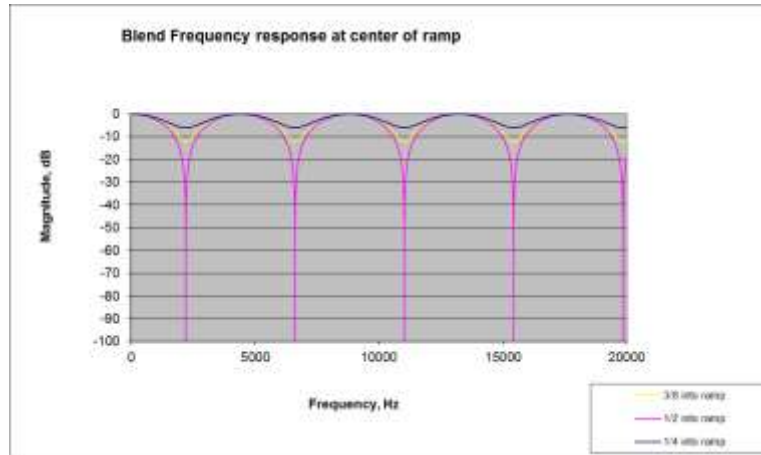


5 Sample Offset

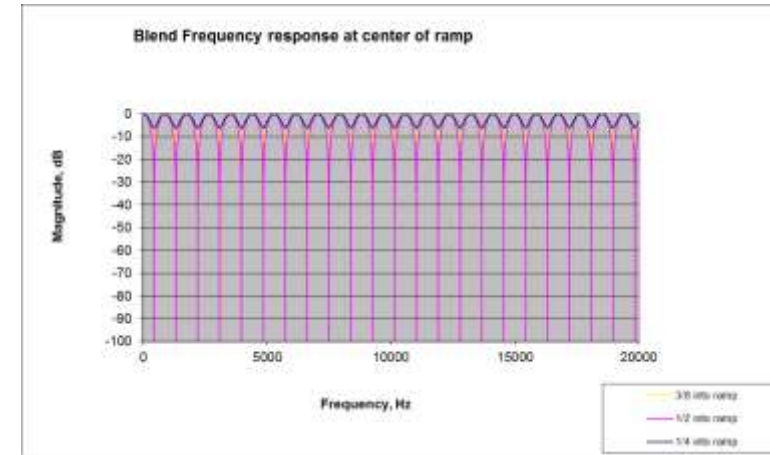


7 Sample Offset

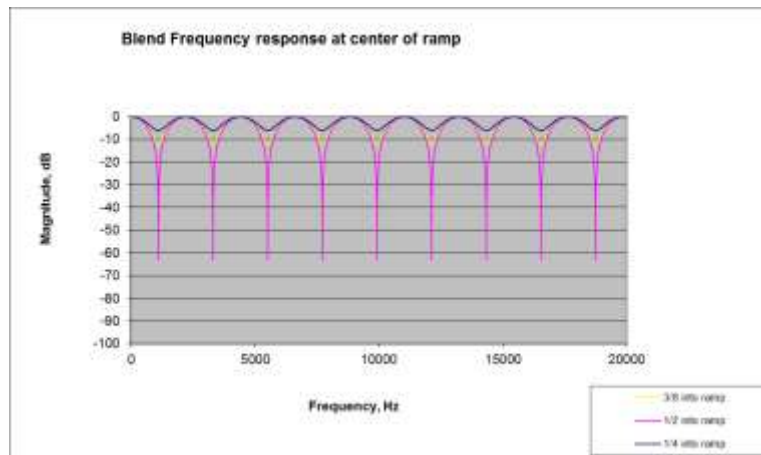
SAMPLE OFFSET IMPACT TO AUDIO AT BLEND



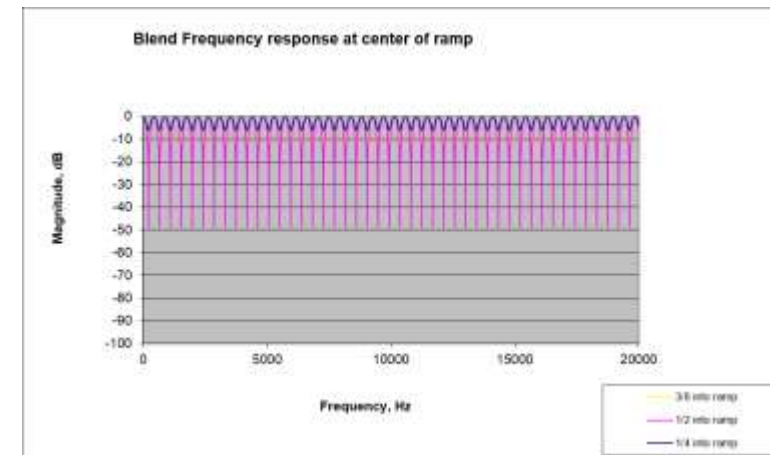
10 Sample Offset



50 Sample Offset

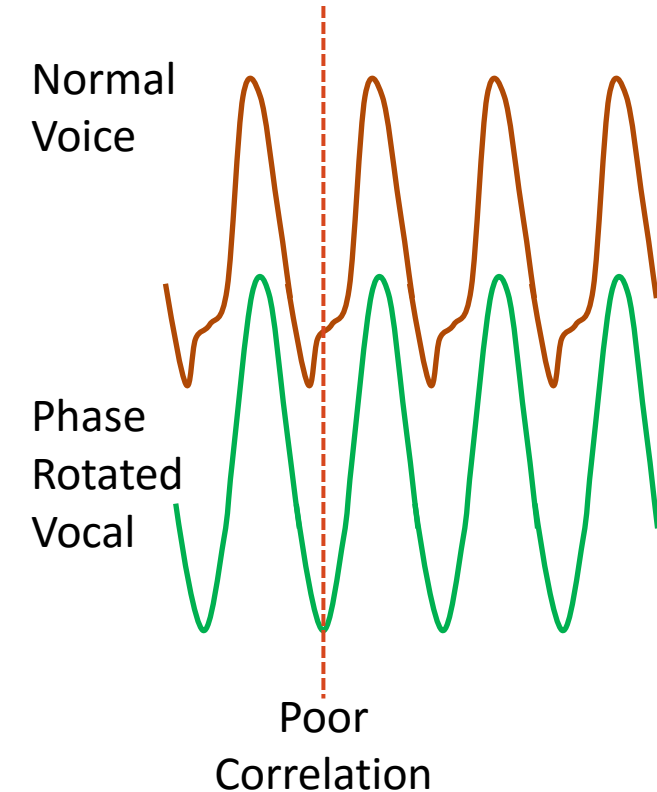
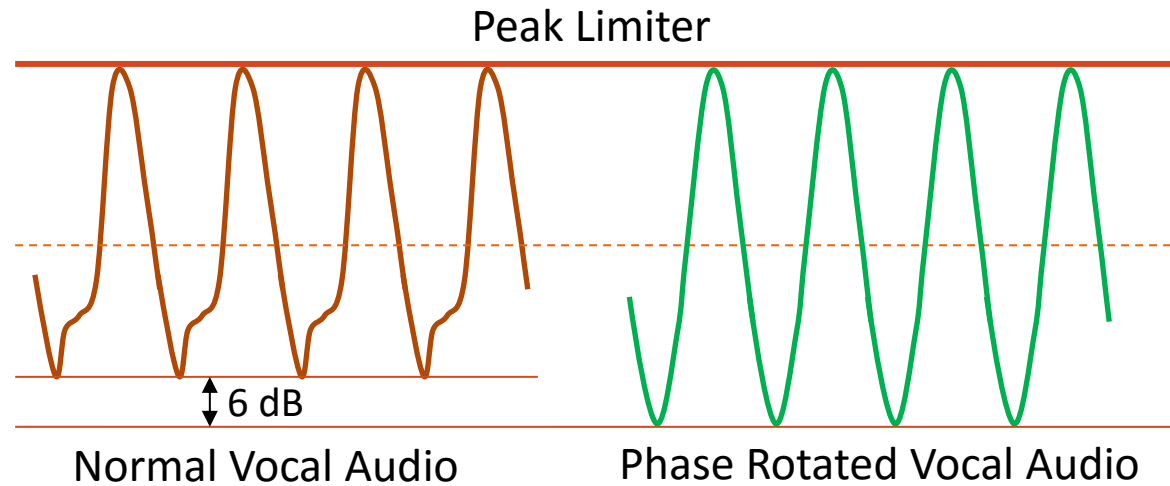


20 Sample Offset



100 Sample Offset

PHASE ROTATORS EFFECT ON TIME CORRELATION



SYSTEM TOPOLOGY - ALIGNMENT PERFORMANCE

- Separate audio processing
- STL/Data circuit performance
- System synchronization

PERFORMANCE

STL

- System Needs To Provide Coherent Analog And Digital Program Paths
- Variable Delay In Any Part Of STL System Will Translate Into Alignment Issue

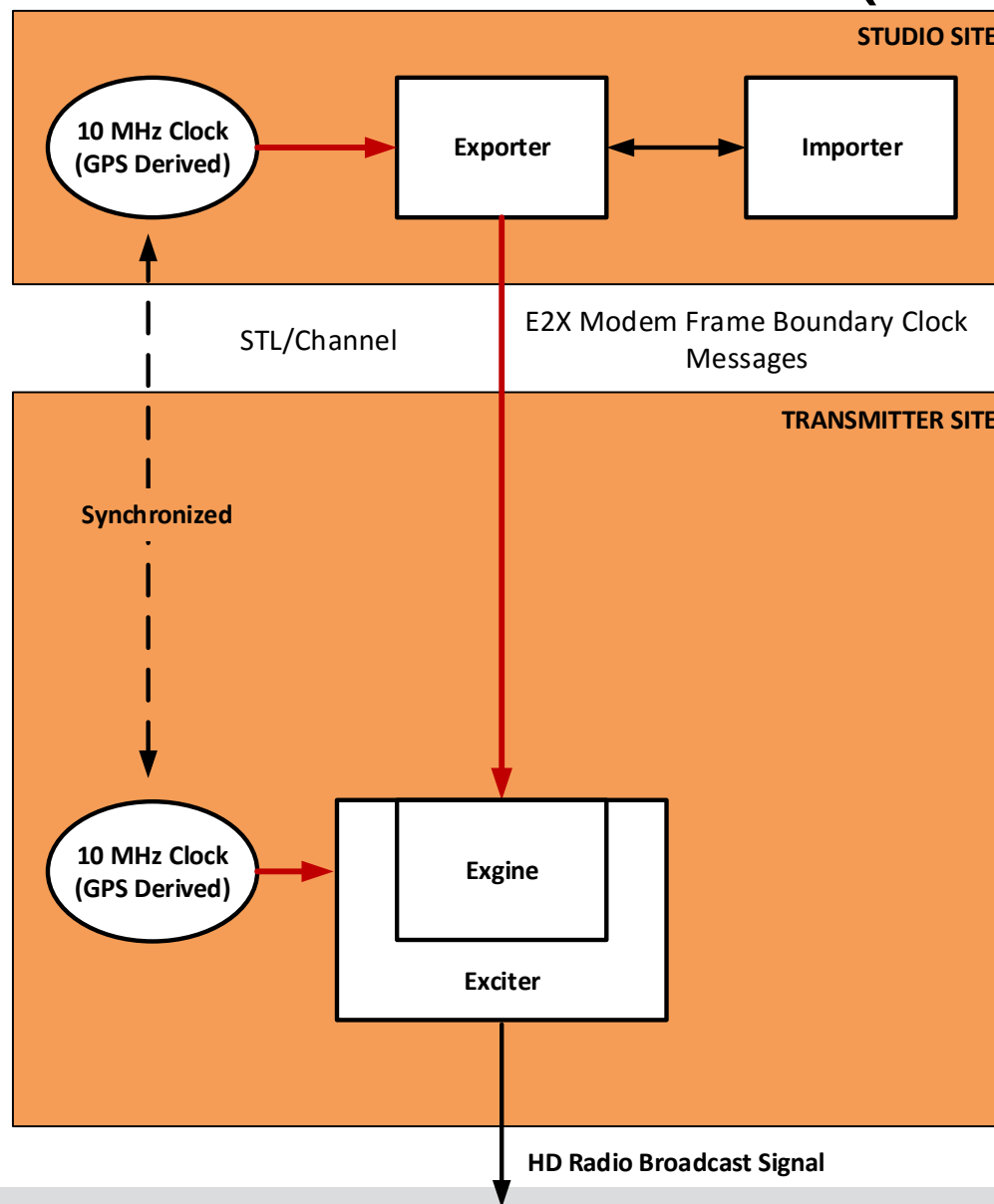
Protocols

- UDP
 - Path Loss Translates Into Digital Signal Outage
- TCP/IP
 - Protocol Resolves Intermittent Outages
 - Cannot Correct More Packet Errors Than Are Held In Buffer
 - Buffer Size Determines Recovery Period

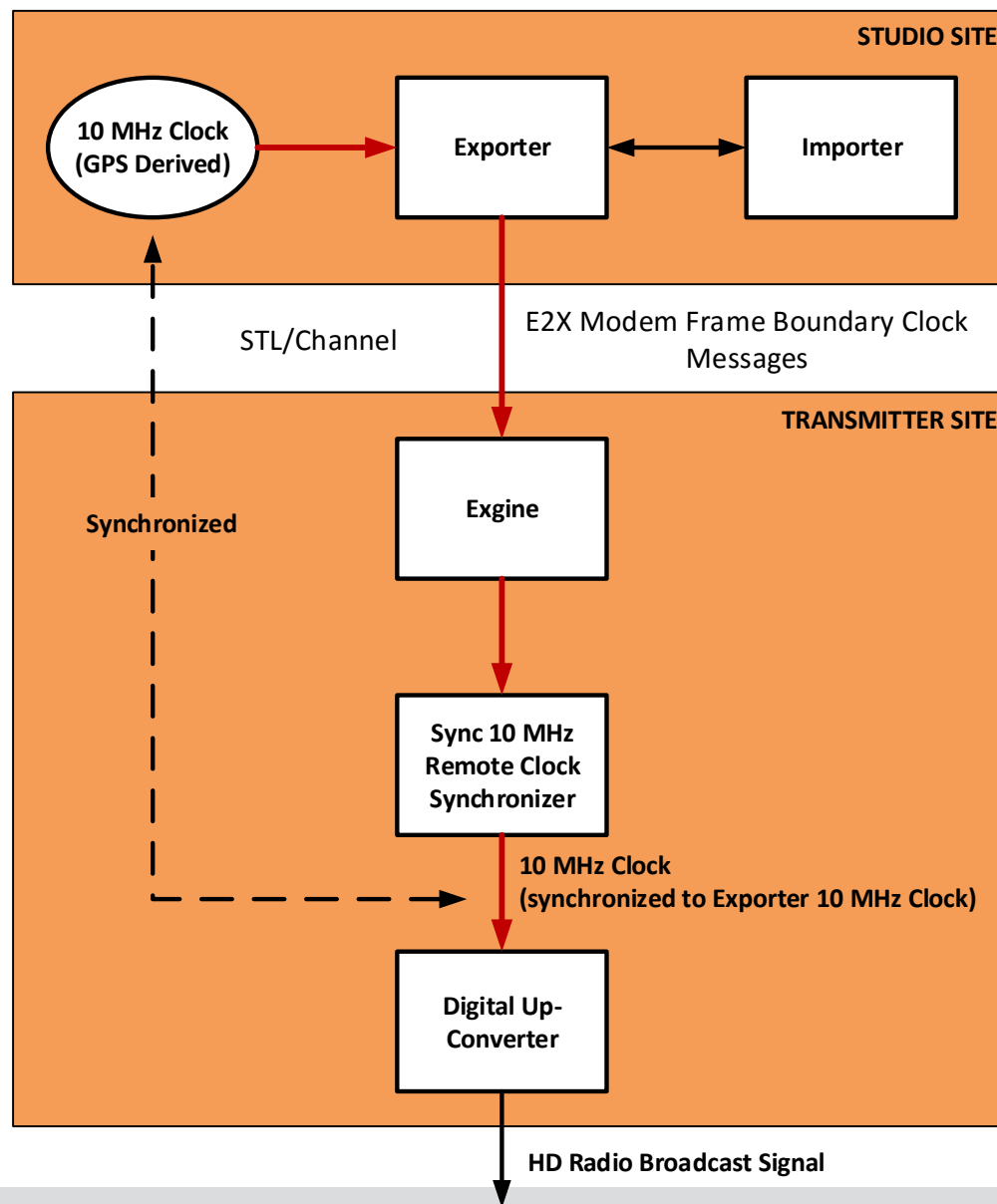
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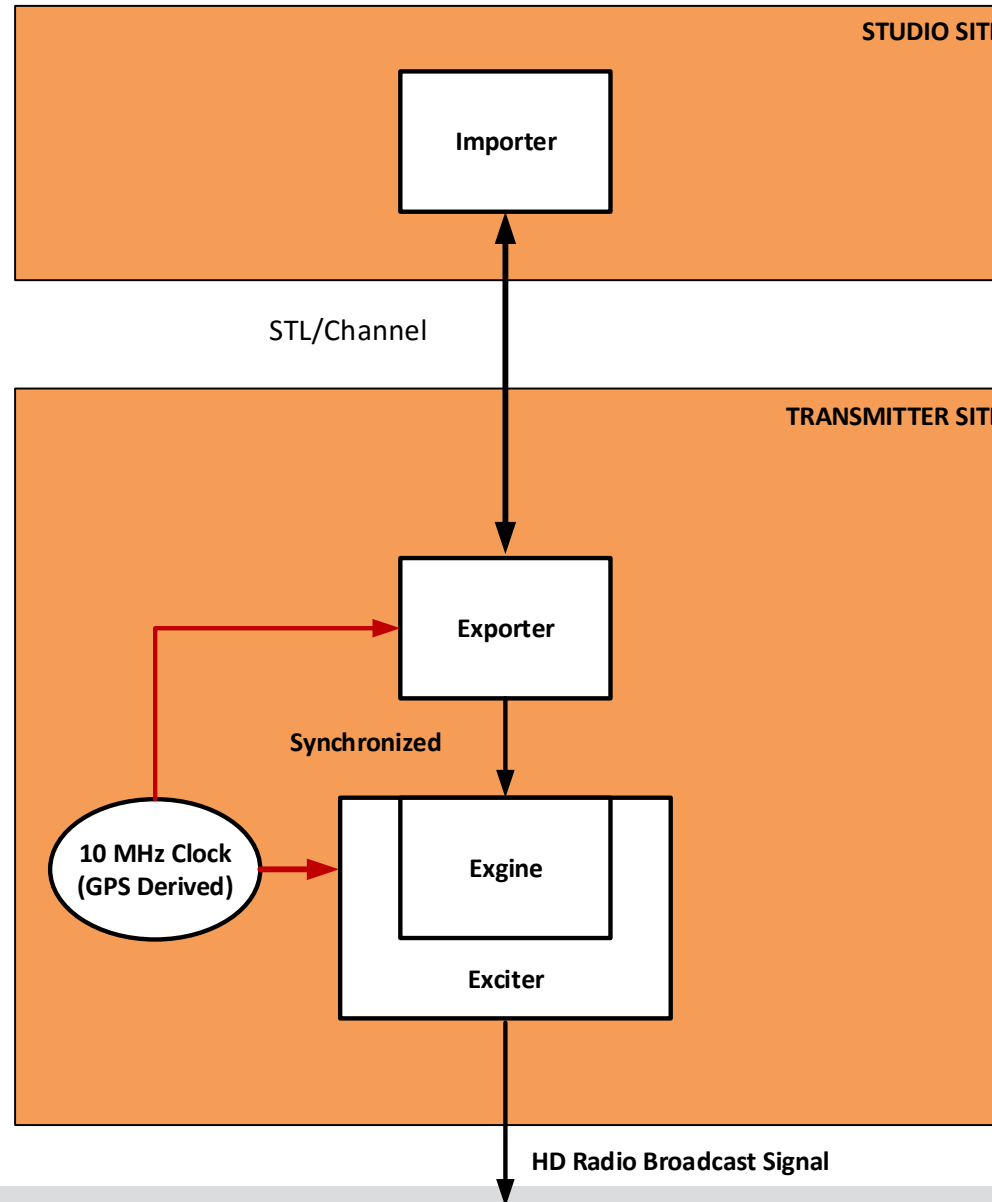
SYNCHRONIZATION – GPS (STUDIO & TX)



SYNCHRONIZATION CONVEYED OVER STL LINK



SYNCHRONIZATION - COLLOCATED



NETWORK OVERVIEW

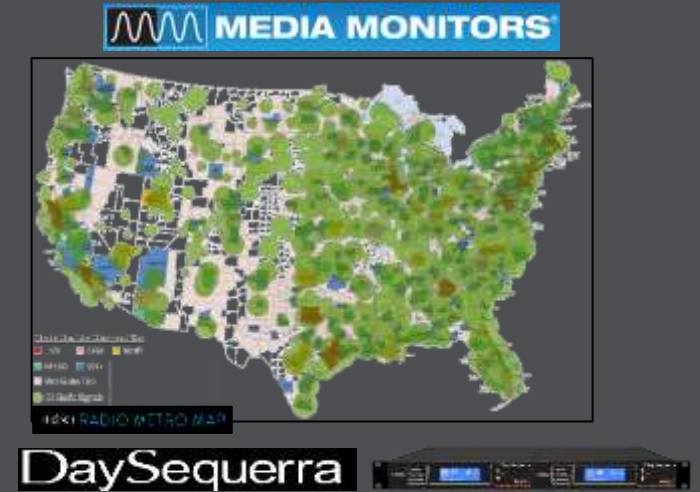


HD Radio Monitoring and Reporting System

- Real-time market observations
- Web-based interface
- Automated trouble ticketing and email notifications*
- Historical and trend analysis
- Monitoring and reporting on:
 - Time and level alignment
 - Program information and HD2/HD3/HD4 audio services
 - All advanced services - images, traffic, etc.



DTS Centralized Data Analytics Platform



50 Markets Currently Monitored

Scheduled Q1 2016

Top 50 markets + Calgary, Vancouver, and Mexico City

HD RADIO MONITORING NETWORK

- Real-Time Market Observations



On-Line

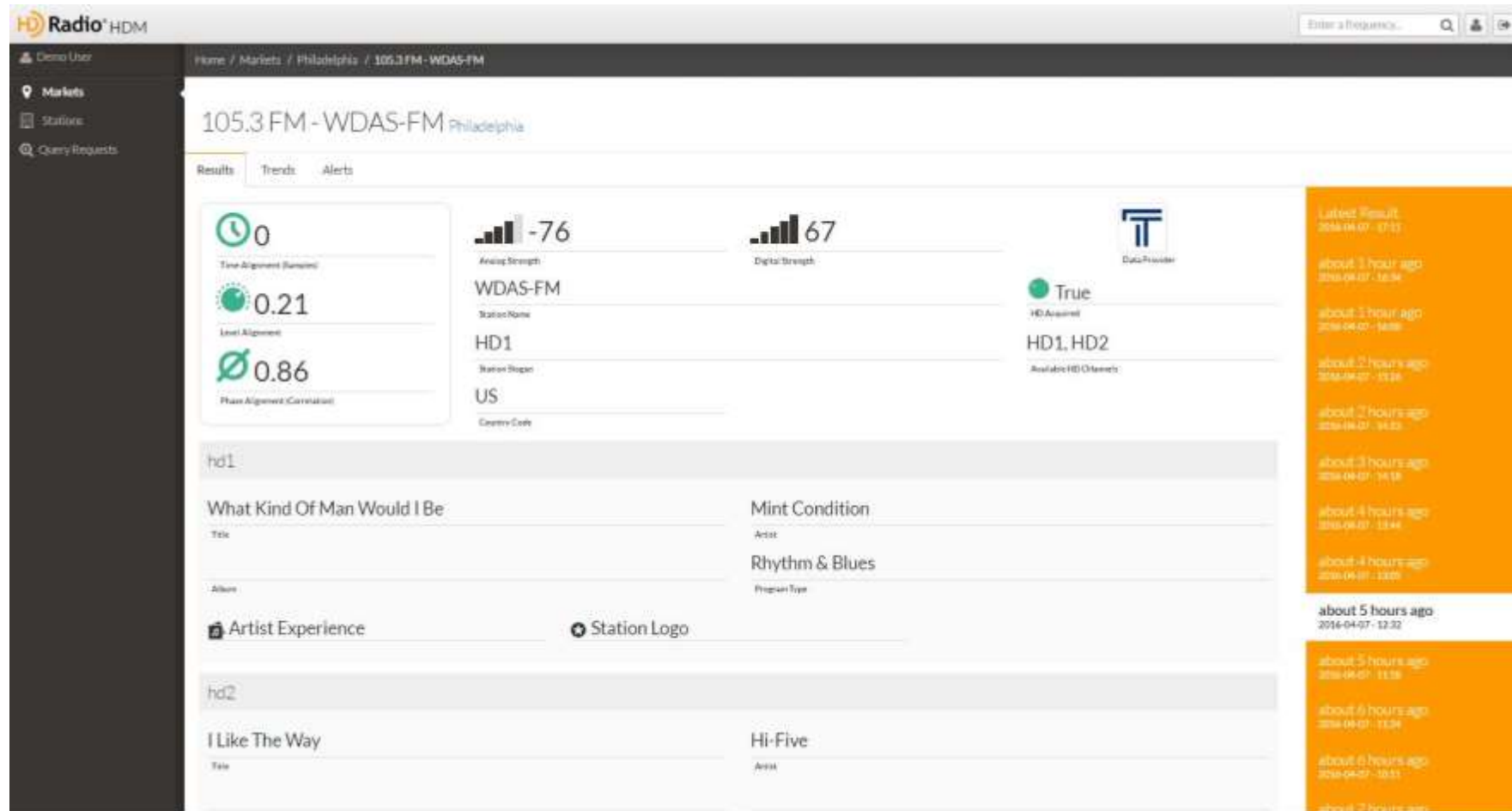


Scheduled 2016 – Top 50 U.S.; 6 Canadian Markets; Mexico City

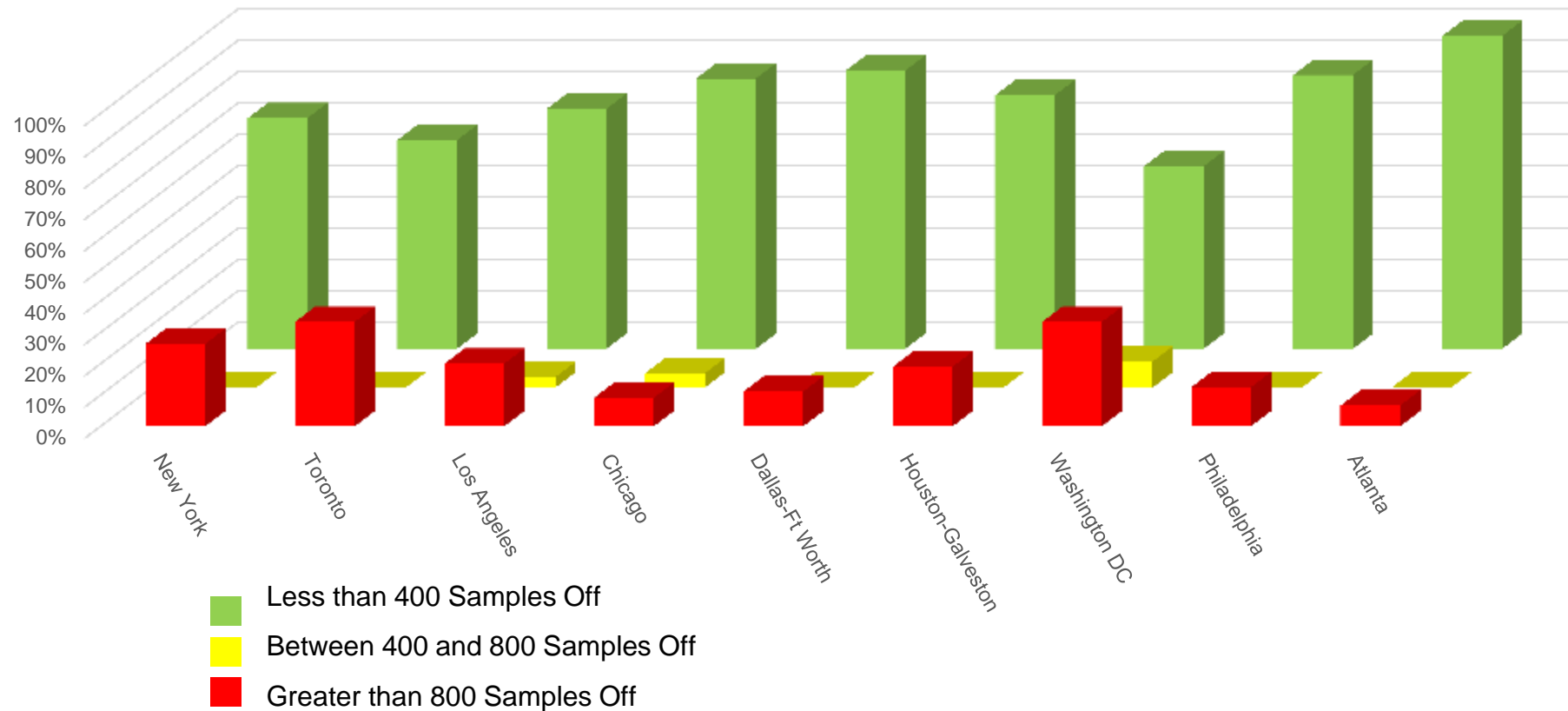


- 50 Markets currently monitored
- 685 Monitored Digital Stations
- 1,340 Monitored Digital Channels
- 20.9 Million HD Radio-Equipped Cars
- 58.0 million hours of weekly listening
- 70% of all in-car Digital Radio listening

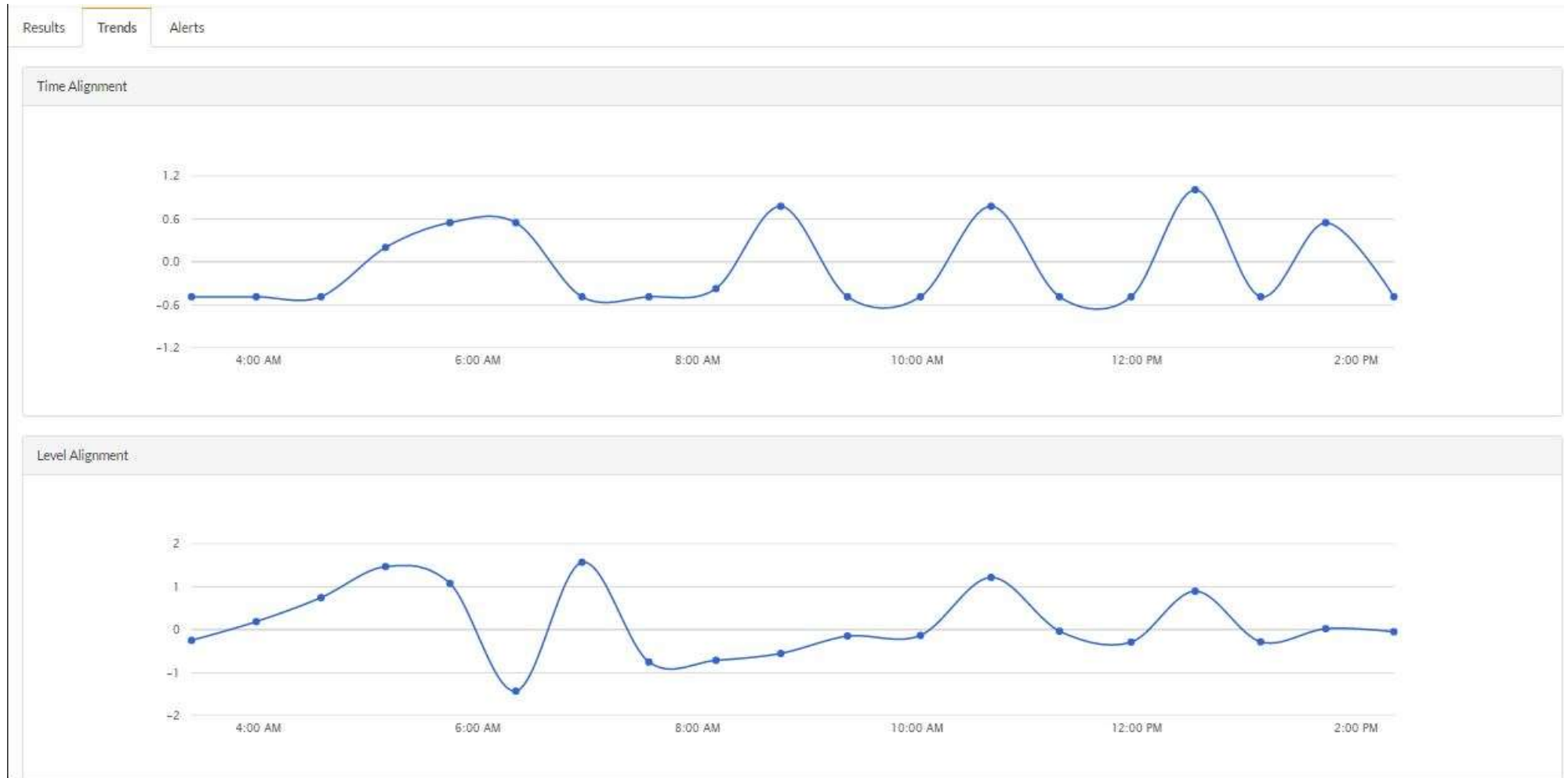
MONITORING- TIME ALIGNMENT STATION DETAIL



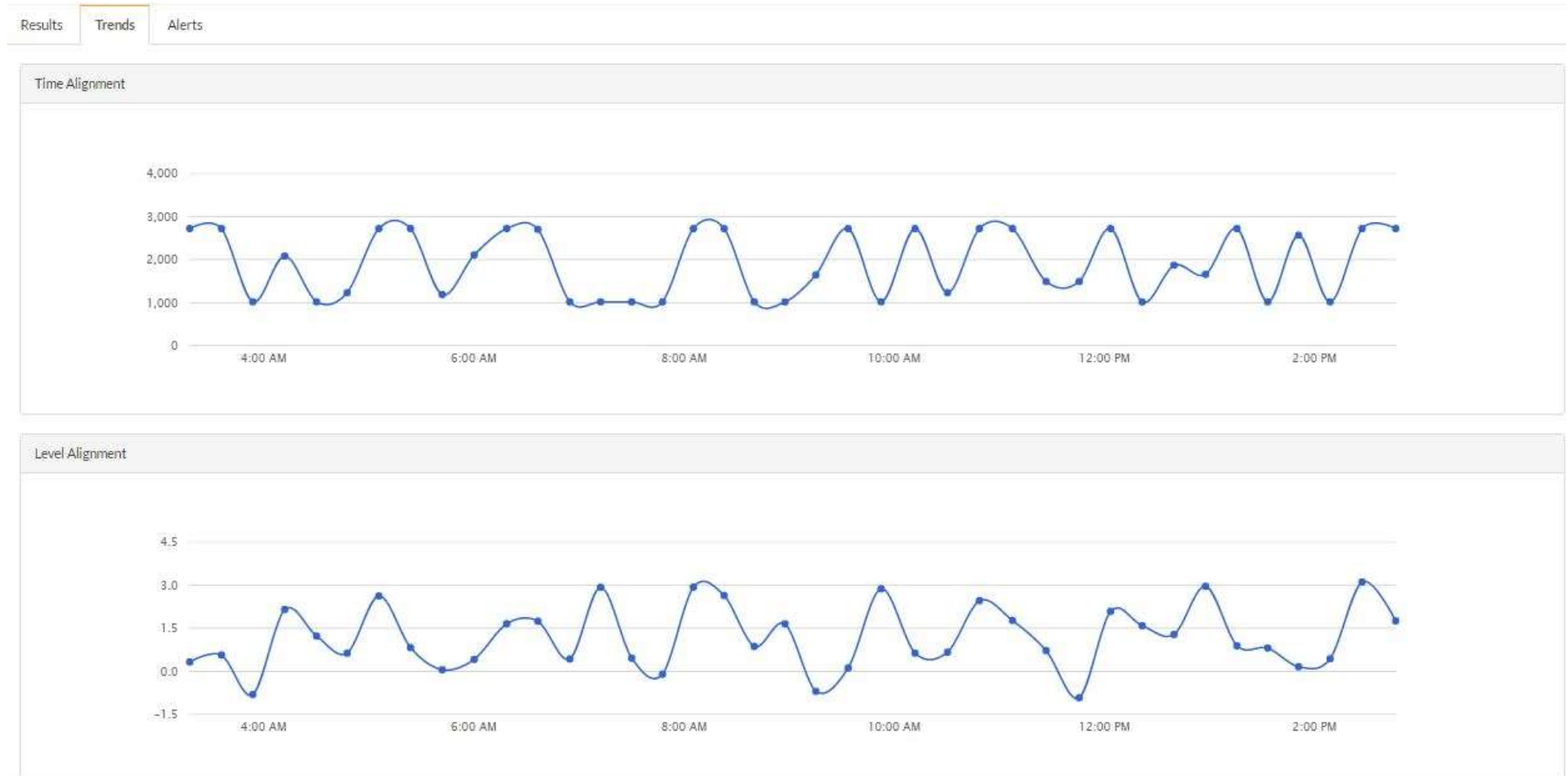
SNAPSHOT OF STATIONS OPERATING WITHIN PARAMETERS



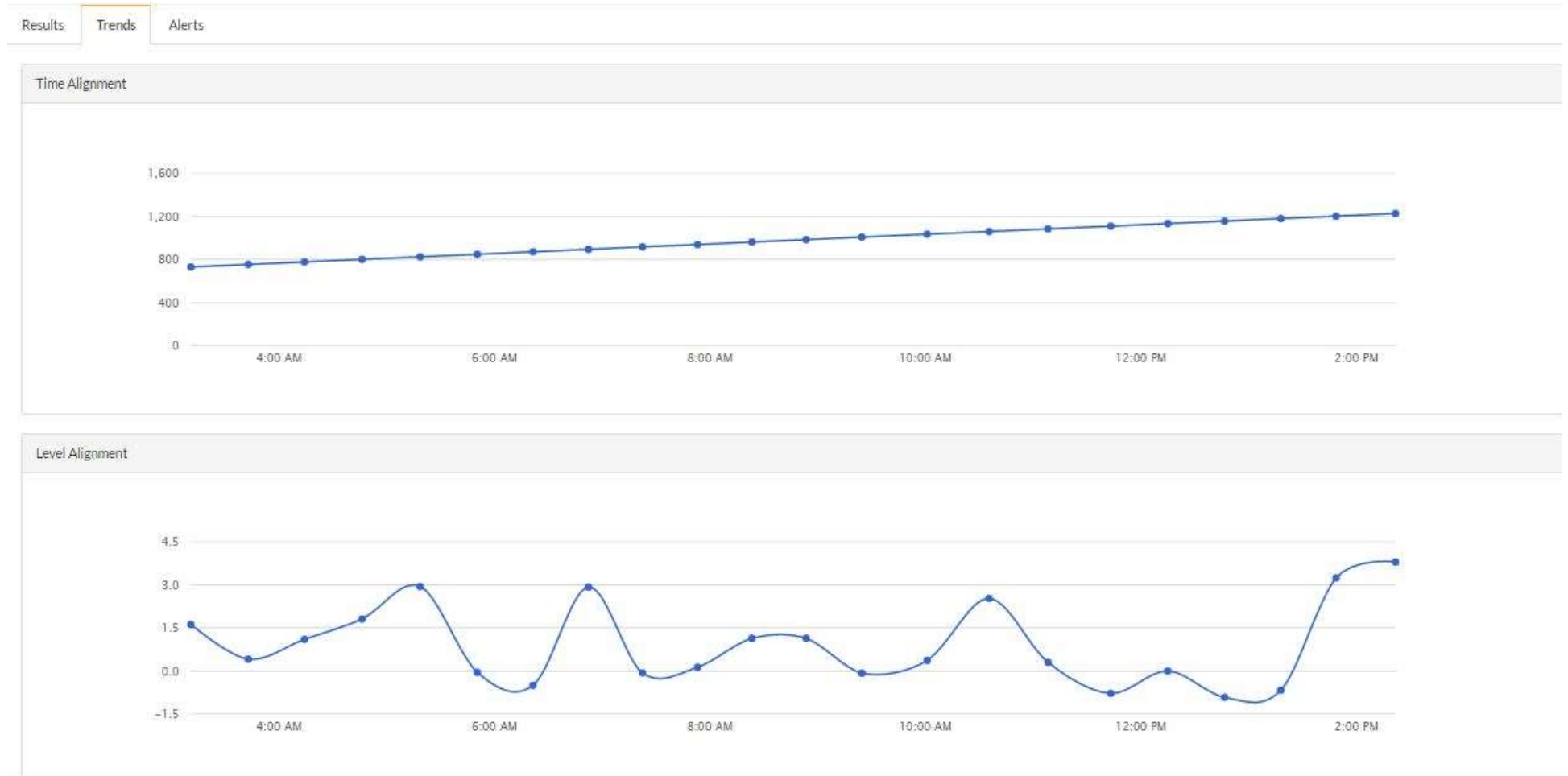
TIME ALIGNMENT – WITHIN 3 SAMPLE SPEC.



TIME ALIGNMENT – SAMPLES OFF & VARIABLE



TIME ALIGNMENT – SAMPLES OFF & VARIABLE



AUTOMATED ALIGNMENT TOOLS – AVAILABLE TODAY

BELAR FMHD-1

- Delay monitor
- Correlates received audio
- Offset correction to external audio buffer (exciter, audio processor)
- Time alignment to +/- 1 sample
- Alarms



DAY SEQUERRA M4DDC

- In-chain audio alignment
- Correlates received audio
- Time alignment to +/- 1 sample
- Level alignment
- Phase alignment
- Alarm functions



INOVONICS JUSTIN 808

- In-chain audio alignment
- Correlates received audio
- Time alignment to +/- 1 sample
- Level alignment
- Phase alignment
- Alarm functions



CONCLUSIONS

- Use Common Dual Output Processor
- If Separate Processing: Match Analog and Digital As Closely As Possible
- Both AES Audio Paths Must Use Common Wordclock
- Collocate Exporter and Exgine When Possible
- If Not Collocated; GPS Lock both Exporter and Exgine
- Automate Time and Level Alignment



THANK YOU

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