Design for Analog SFN

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Making Digital Broadcasting Work.

Presentation Overview

1. FM Analog Single Frequency Networks Basics
2. System metrics
3. Steps to practical SFN Design
4. New – *A better way*
5. The future

SFN: Basic Concept

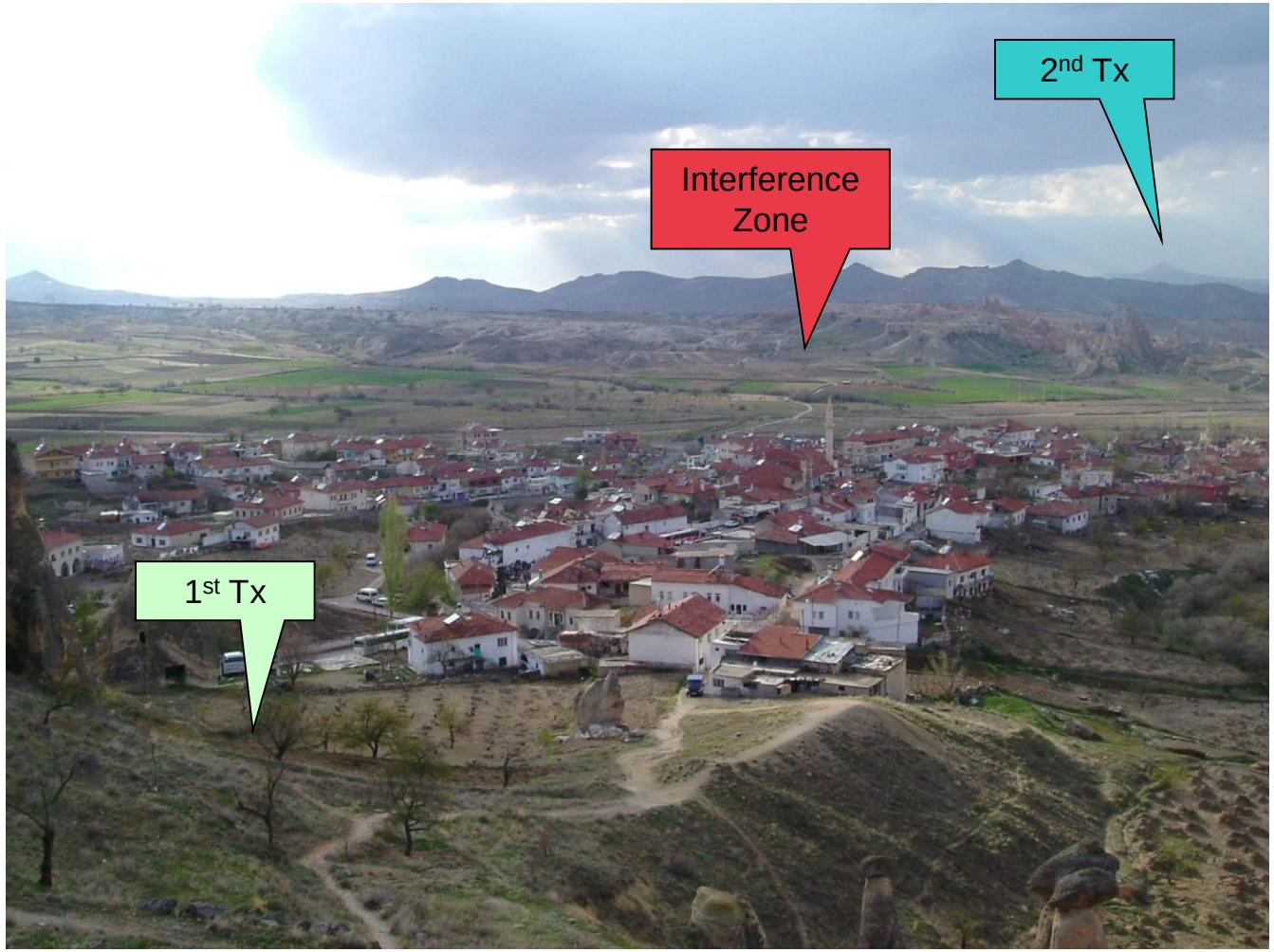
To optimize performance – synchronize everything:

- RF Carrier Frequency
- Pilot Frequency & Phase
- Audio content:
  - Amplitude
  - Phase
- Subcarriers:
  - RDS
  - SCA's

Timing is everything

The Problem: Interference Zones

Where the coverage areas overlap, and the ratios of the signal strengths approach unity, the signal quality is affected.

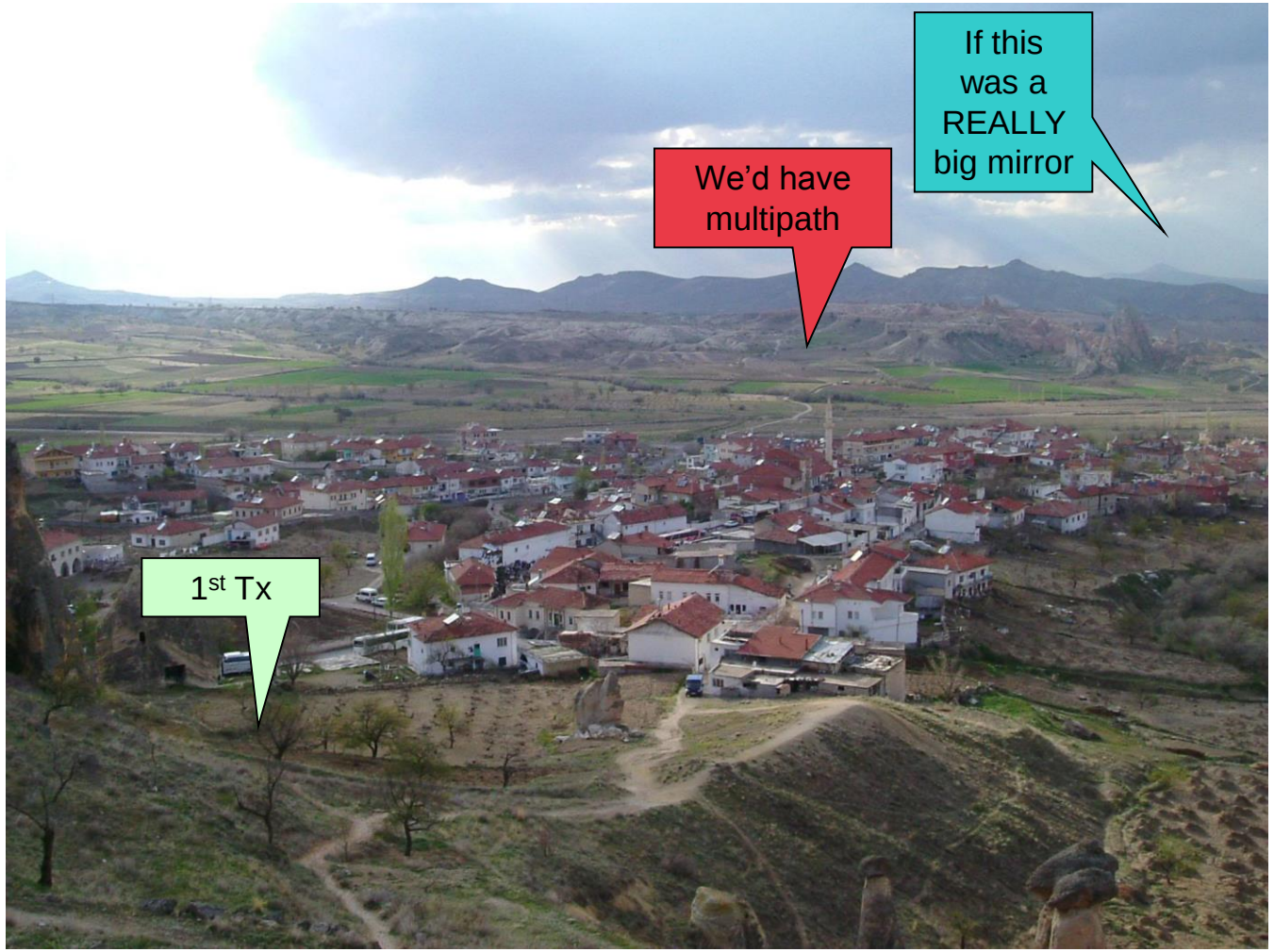


Interference Zones

- If the RF carriers are not frequency synchronized
  - terrible distortion and noise will result.
- If the audio levels are not exactly the same
  - the noise floor increases dramatically with a “white noise” which varies with the level of the audio.
- If the pilots are not synchronized
  - the pilot detector in the receiver will switch back and forth and this will be audible in the stereo signal.
- If the audio phase is not synchronized distortion results.
- If everything – audio, pilot & carrier are all synchronized, the signal will sound like a multipath condition.

When everything is sync'd - Multipath

If everything is perfectly sync'd, we'll have multipath where the primary and reflection have equal signal strength.



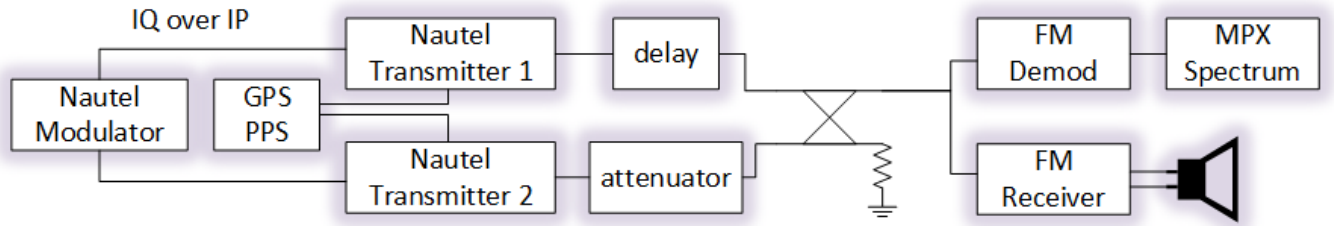
FM SFN Protection Ratios

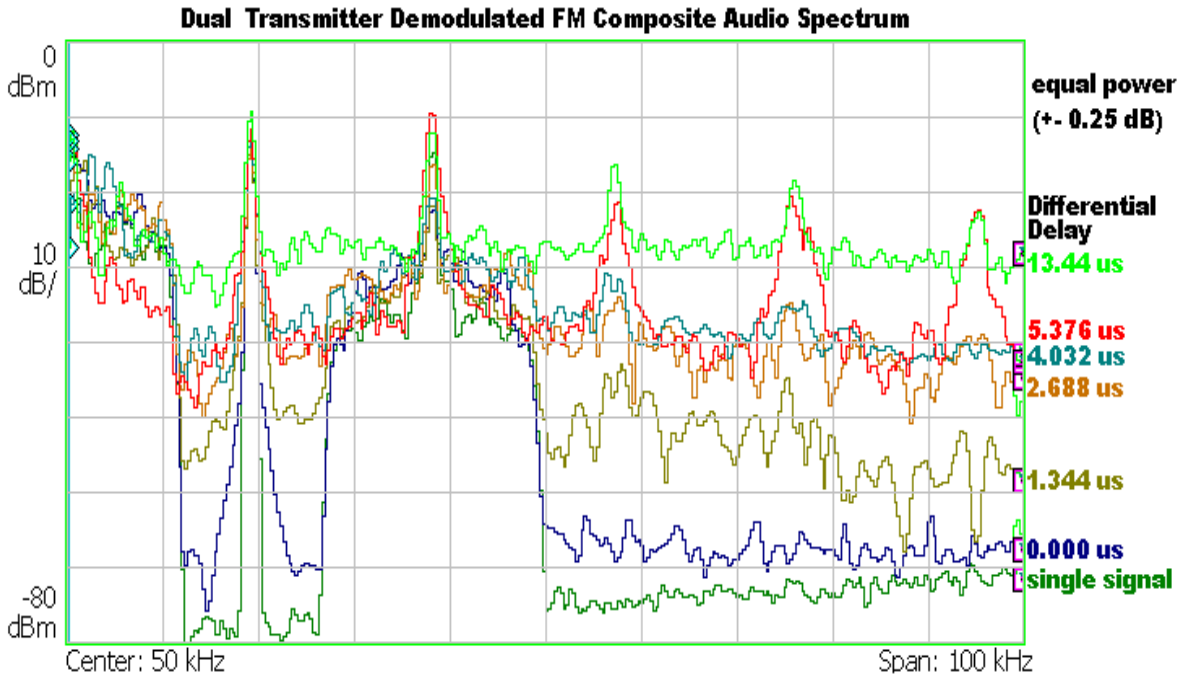
Time Delay	Mono FM		Stereo FM	
Impairment Grade	3	4	3	4
2 µs	<1 dB	1 dB	4 dB	6 dB
5 µs	1 dB	2 dB	10 dB	12 dB
10 µs	1 dB	3 dB	14 dB	16 dB
20 µs	-	11 dB	-	-
40 µs	-	20 dB	-	-

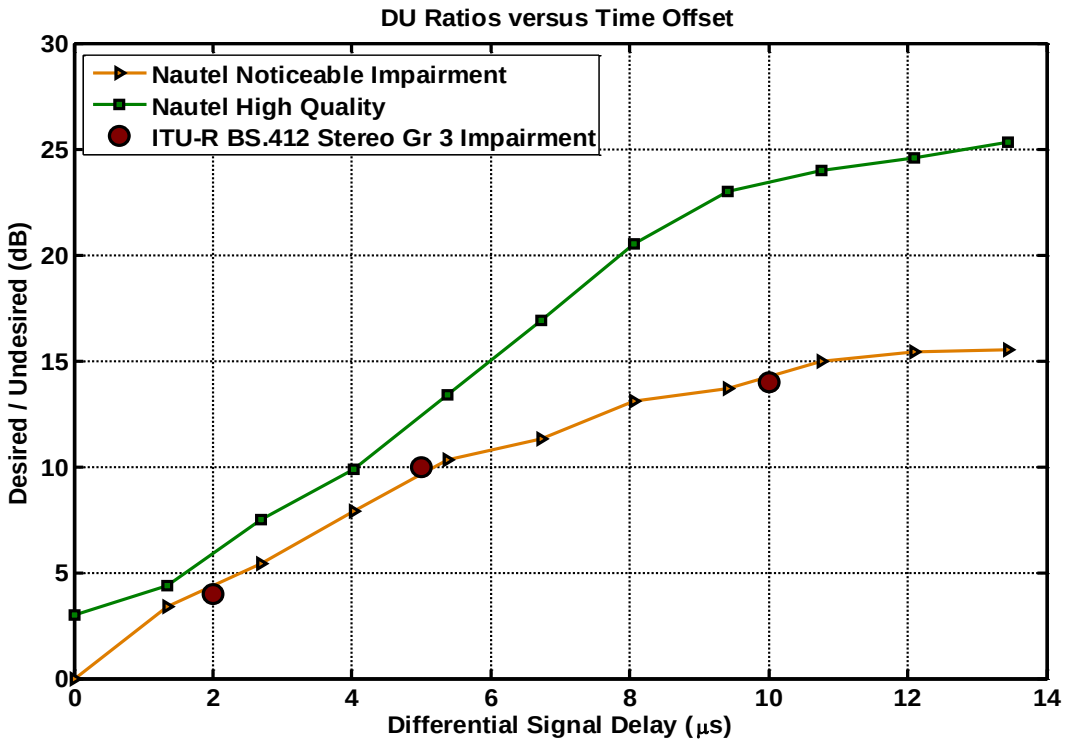
Results from ITU-R BS.412

- ITU Impairment Grades
  - 5: Excellent quality — imperceptible impairment
  - 4: Good quality — perceptible impairment, but not annoying
  - 3: Fair quality — slightly annoying impairment
- e.g. a stereo FM signal 14 dB stronger to a 10 µs delayed interferer produces grade 3 impairment.
- 10 µs represents 3 km signal flight time

Nautel FM Stereo SFN Lab Tests







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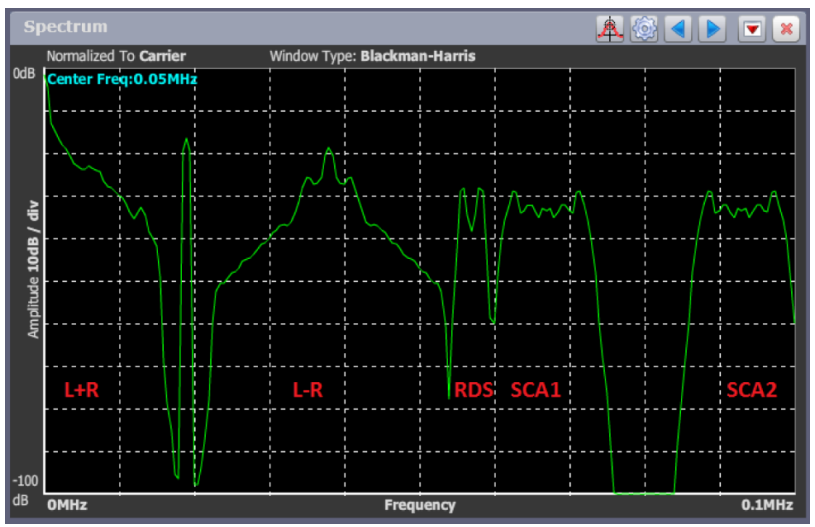
Step 1: RF Consultant

- A competent broadcast engineer with expertise in SFN installations is a must:
  - perform RF coverage simulations
  - evaluate booster locations and antenna patterns
  - identify interference zones and terrain shielding
  - determine optimal time offsets; may be different for FM and IBOC
  - handle legal matters
- Nautel only provides components, system design is the responsibility of a professional consultant.

Step 2: Synchronize the FM MPX Signal



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µMPX

MPX over IP

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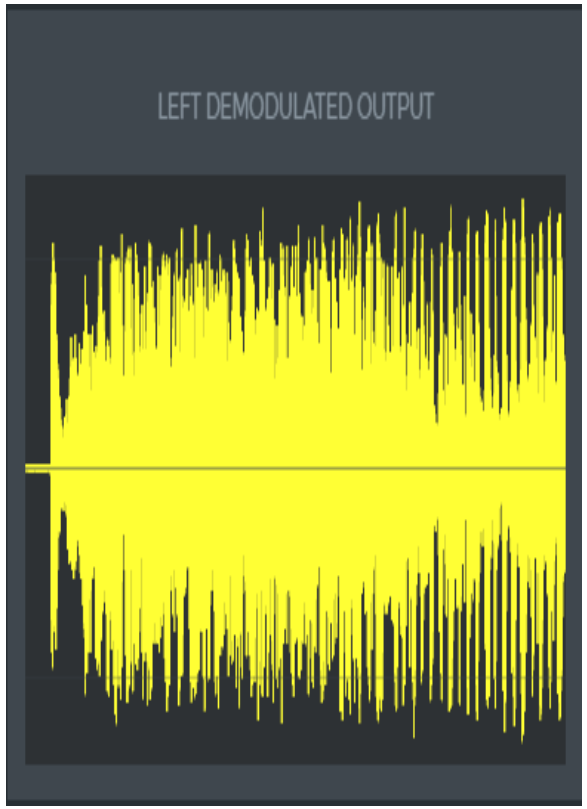
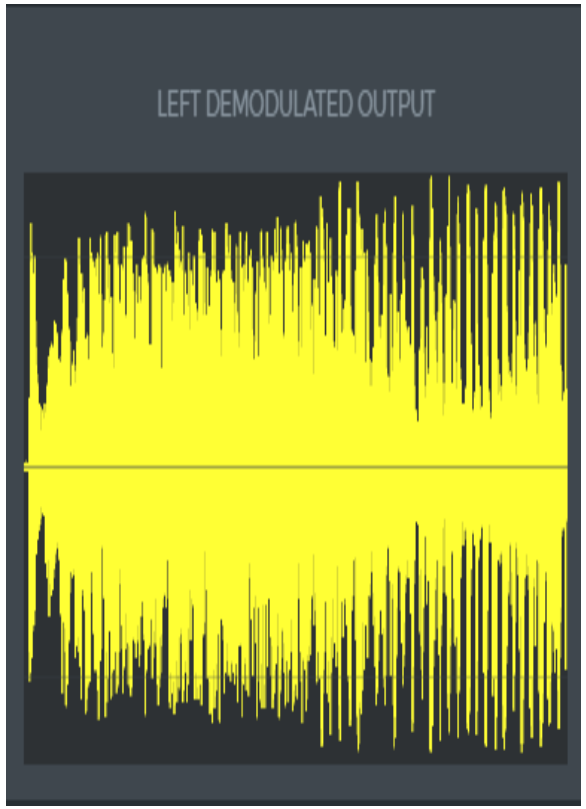
Why MPX?

L/R clipping



Composite clipping

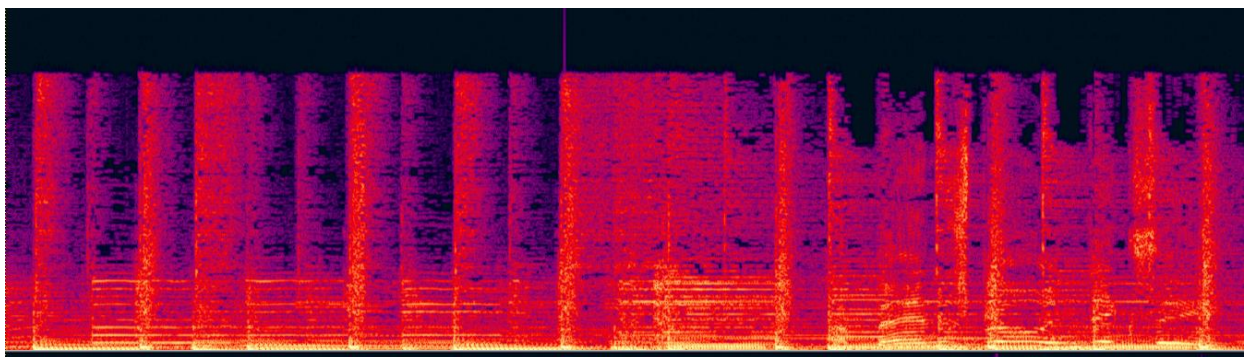


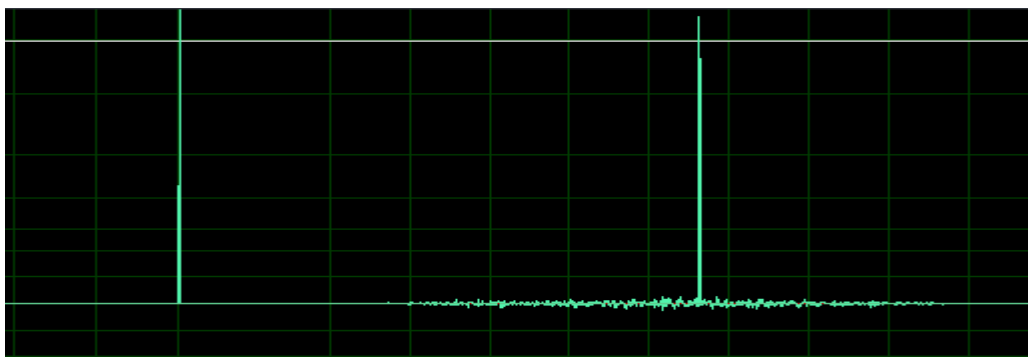
Dynamic SSB/DSB

- Louder (2-3 dB)
- More dynamic
- Better reception

µMPX: What is it?

- Full MPX with pilot/RDS at 320 kbit/s
- Codec made for FM:
  - Adds white noise, no MPEG-like artifacts
  - Perfect peak control
  - Doesn't affect reception (multipath)



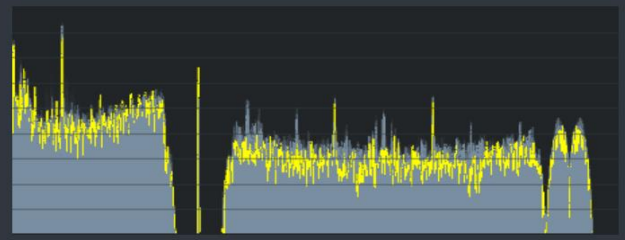


Typical traditional codec artifacts: Gaps in spectrum and pre- and post-ringing

STREAM STATUS

WAVEFORM

MPX



µMPX

µMPX

Stream

Port

8854

Delay

1.317 sec

Backup player

Backup file

Backup timeout

60 sec

µMPX: Streaming features

- Point-to-point or multipoint (multicast)
- Uni-directional
- Compatible with digital STL's
- Forward error correction (FEC)
- Redundant paths via multiple connections

In Development

- Stream password protection
- SFN support

Multiple transmitters

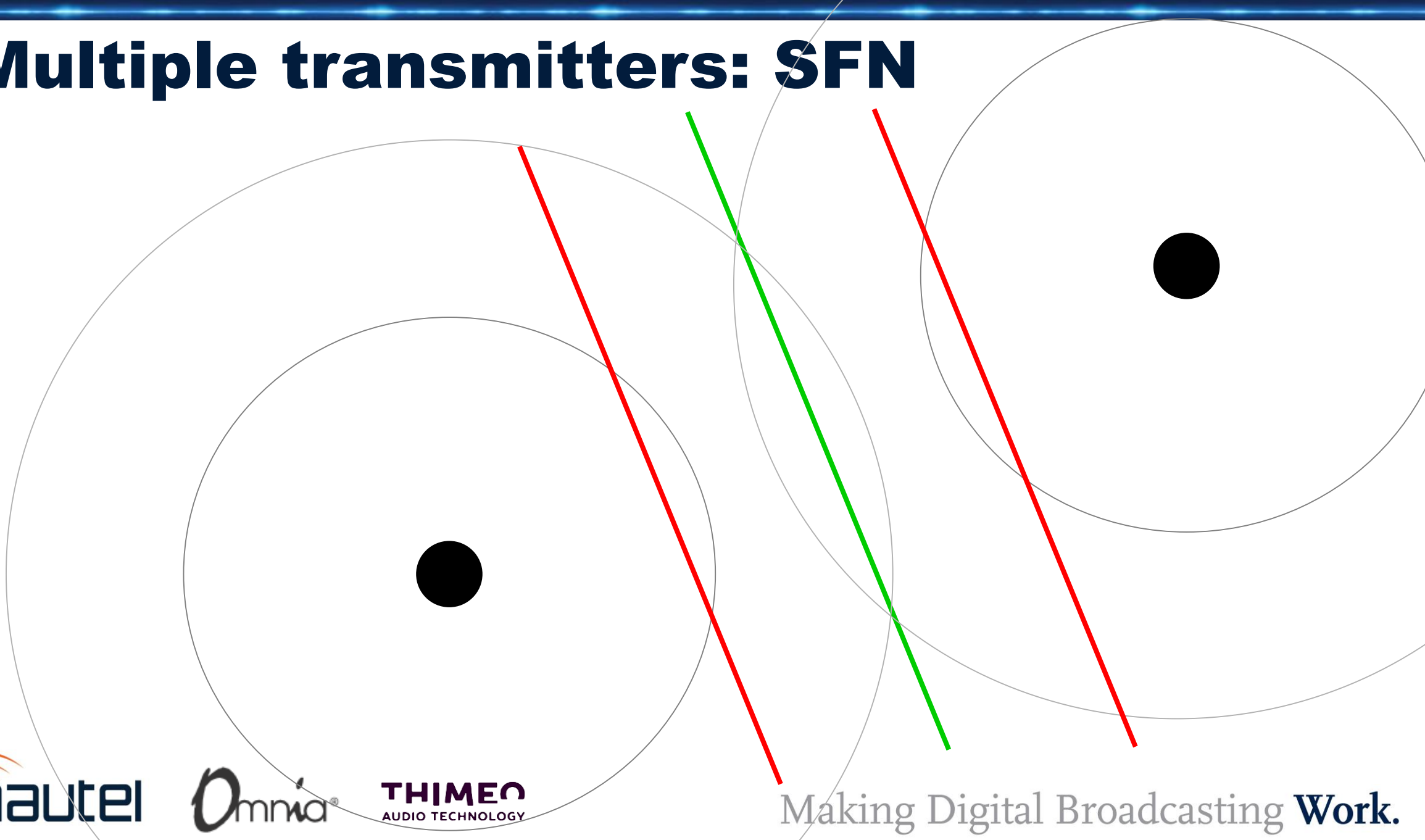
RDS TA switching

- ~ 10 ms drift acceptable
- µMPX does that without issues.

SFN Challenges

- < ~ 1 µs (0.000001 second) drift needed
- Very precise *shared* clock needed

Multiple transmitters: SFN



µMPX: Streaming features: SFN

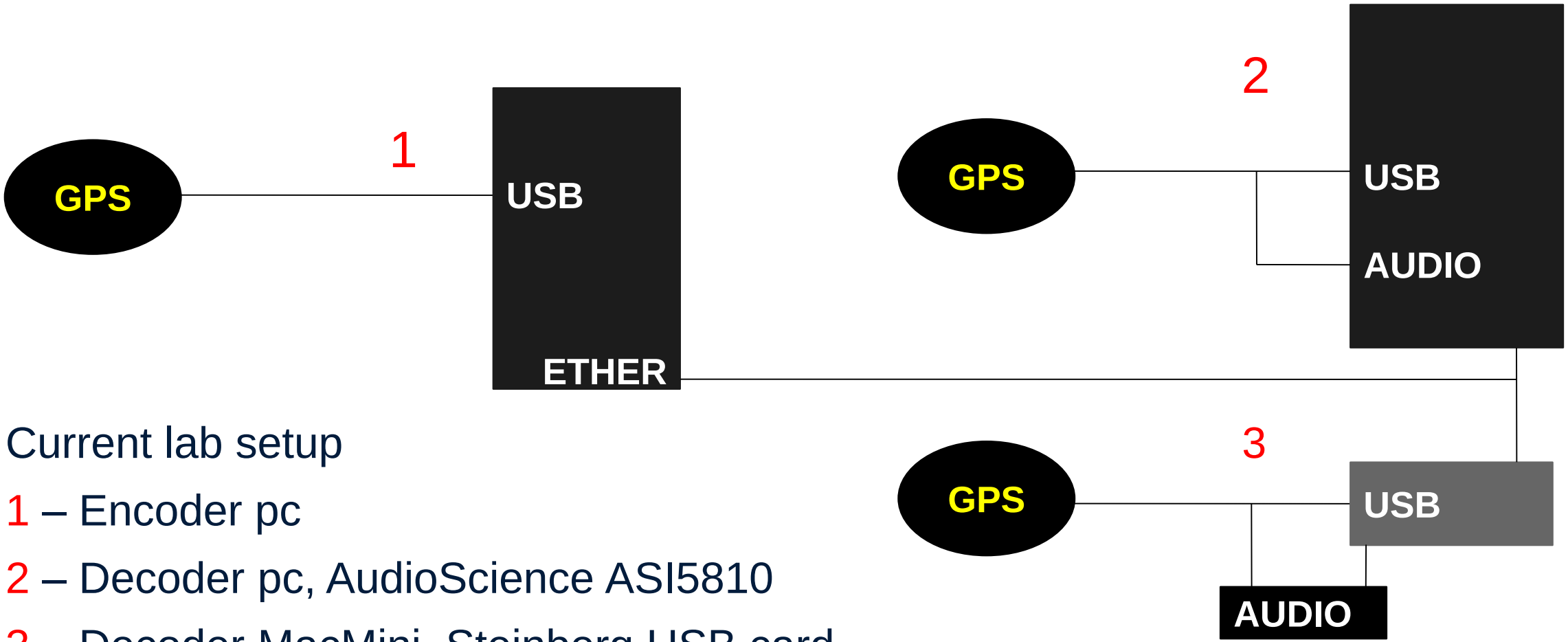
NMEA via USB / RS232

- Standardized format
- Time in seconds
- > 5 ms jitter

PPS pulses

- Perfect timing

µMPX: Streaming features: SFN



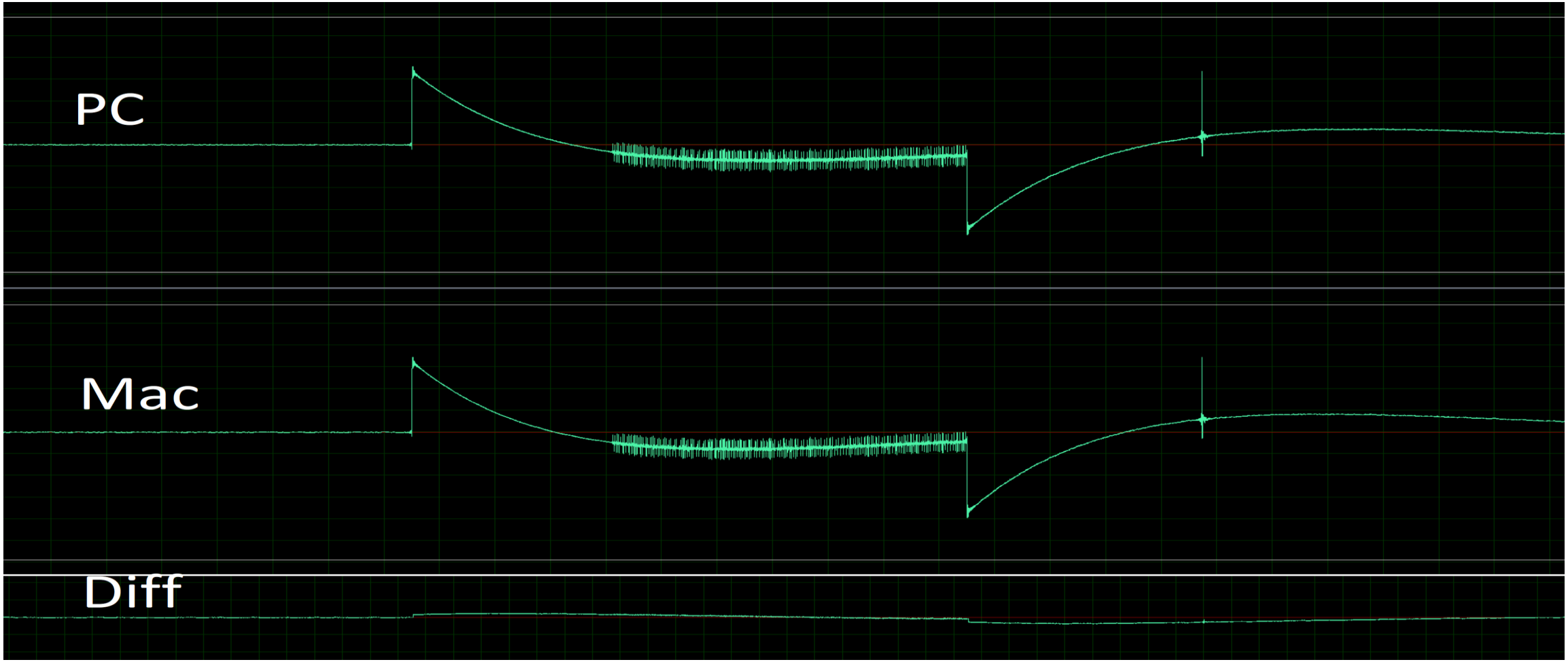
Current lab setup

1 – Encoder pc

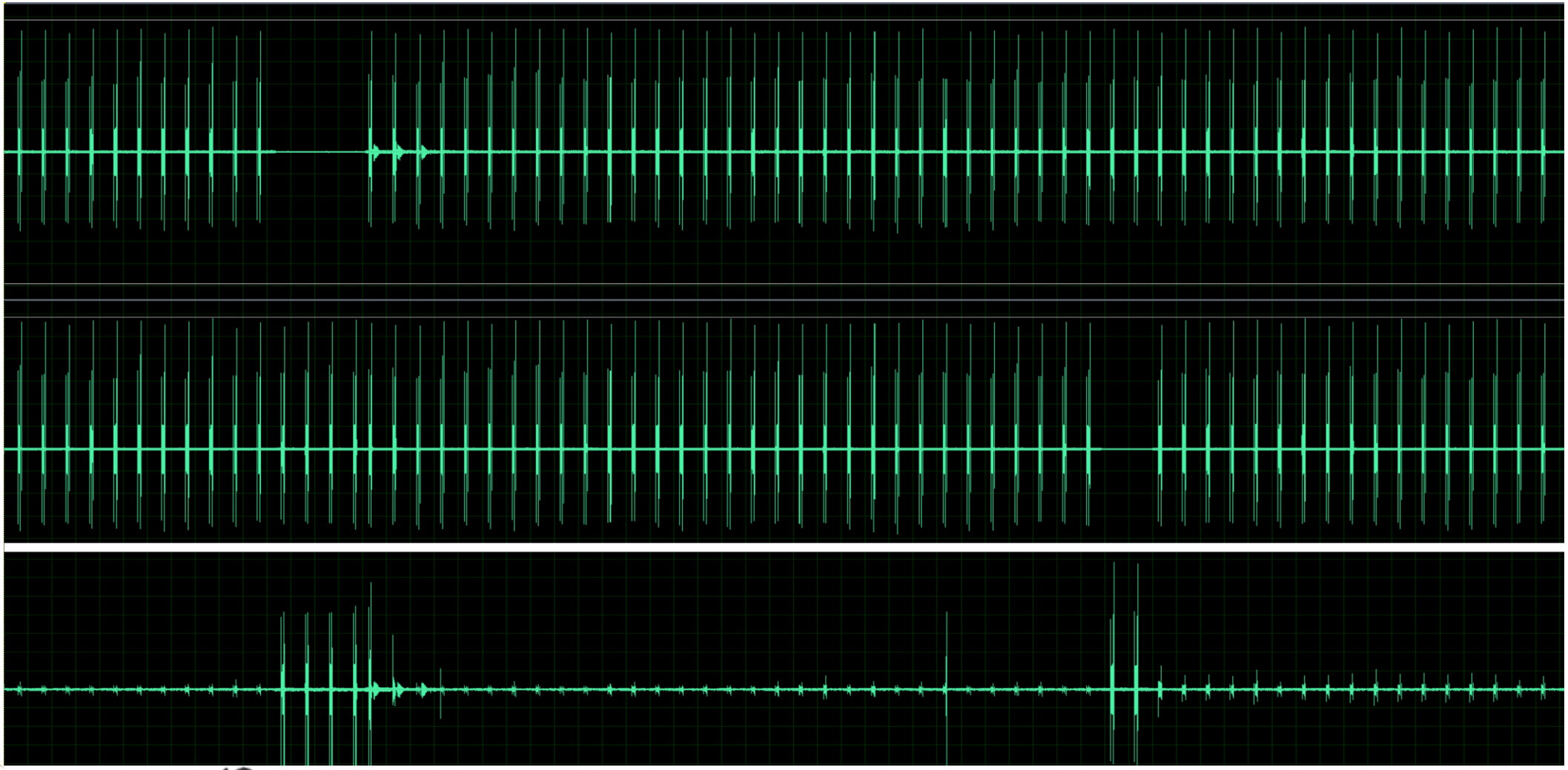
2 – Decoder pc, AudioScience ASI5810

3 – Decoder MacMini, Steinberg USB card

µMPX: Streaming features: SFN: Results



µMPX: Streaming features: SFN: Results



µMPX: Availability

- Stand alone Encoder and Decoder applications
- Omnia SST Built-In encoder cap
- Omnia 9 Encoder integration in next release, first hardware processor to integrate, others to follow

In Development:

- Dedicated Hardware implementations to follow in stages
- SFN support possible with controlled clocking

Thank You

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