SIMULCAST - History and Basics

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Basic Concepts

Definition

Simulcast is the simultaneous operation of two or more transmitters with overlapping coverage on the same frequency.

Simulcast is controlled interference.
Typical Simulcast Coverage

- TX1
  - Non-overlap
  - Overlap #1
- TX2
  - Overlap #1
  - Non-overlap
- TX3
  - Non-overlap
  - Overlap #2
Overlap Areas are Critical Areas

! Overlap areas are those where the RF levels are within 10-15 dB of each other.

! Acceptable size of overlap area depends primarily on maximum audio frequency being transmitted.

! Overlap effects are less pronounced in areas with high multipath and at higher frequencies.
Receiver audio is the sum of the signals being received.
Overlap Areas are Critical Areas

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Overlap Areas are Critical Areas

! Simulcast audio will never sound as good as nonsimulcast in the overlap areas.

! Overlap areas outside main coverage areas may have significant distortion.

! Overlap areas are where we have to control the interference.
Controlled Interference Means:

- Controlled RF Frequency
- Controlled deviation
- Controlled audio phase

These three parameters must be controlled if simulcast is to work.
Remember FATS

F - Frequency
A - Amplitude
T - Timing
S - Signal Strength
RF Frequency/Phase

- Relative frequency between transmitters, not absolute frequency, is important.
- Less than 1 Hz difference between transmitters recommended.
- Ability to provide small offsets in relative frequency may be important but use carefully.
RF Frequency/Phase

Methods

- High Stability Crystal Oscillators - VHF only
- WWVB/GPS Locked XTAL - VHF and UHF
- GPS/Rubidium Locked XTAL - VHF, UHF, 800 MHz, and 900 MHz
RF Frequency/Phase

- Frequency or phase changes can cause rolling fade in overlap area
- VCO phase instability could cause problems
Deviations must be controlled

- Deviation causes rapid frequency/phase changes
- Distortion is caused by different deviations in receiver
- Recovered audio from each transmitter must be within .2 dB
- Cannot be set by service monitor
- Set by using monitor receiver
Amplitude/Deviation Control

- Low Drift Audio Transport Methods (Good)
  - Special analog MW mux
  - Digital channel banks
  - Special digital signal processing
  - RF links

- High Drift Audio Transport Methods (Bad)
  - Analog phone lines
  - Telco T1's
  - Voice over IP
Amplitude/Deviation Control

- Audio frequency response must be matched
  - Each transport route should have the same elements
  - Same type/vintage base stations should be used
- Audio levels held to within .2 dB or better
- Cannot adjust deviation with service monitor
Audio phase difference must not exceed 30 degrees.
Audio phase difference will be audio frequency dependent.
Audio Timing/Phase Control

- Audio phase must be stable
- Audio phase should be adjustable 1000-1500 microseconds
- Methods
  - Passive delay lines (ugh!)
  - Analog active delay lines
  - Digital delay lines
  - Digital signal processing
  - Time marked delay
- Phase is adjusted for the overlap area
- Transport method must keep constant phase
Signal Strength

- Control your overlaps.
- Less is better.
- Think lower elevation not higher.
- Coverage control using lower power and directional antennas.
RF Speed = 5.4 usec/mile
TX1 transit time 600 us + 54 us = 654 us
TX2 transit time 400 us + 81 us = 481 us
Overlap zone time difference = 27 us
30^N @ 1000 Hz = 83 us allowed
Digital data requires less delay difference
3600 bps = 11-13 miles
9600 bps = 6-9 miles
Maintenance Issues

* Individual components cannot be adjusted by themselves
* Standard test equipment cannot be used to make final adjustments
* Any maintenance action in the audio path requires system adjustments
* All measurements are made relative to other transmitters
Maintenance Issues

Typical test setup

- Monitor Receiver
- Scope
- Analog Voltmeter
- Audio
- TX1
- TX2
- AUDIO
- LEVEL ADJ.
- LEVEL ADJ.
- DELAY
- DELAY
- Audio Source
- Scope Sync
- Audio sweep and gated pulse generator
Maintenance Issues

SCOPE DISPLAY

Audio Burst

DELAY TIME

Audio Burst

TX AUDIO

RCV AUDIO

TRACE 1

TRACE 2
Maintenance Issues

! Make sure monitor receiver is not receiving any interference (Watch scope display!)

! Make sure everything is operating in the linear mode (no clipping!)

! Avoid temptation to “tweak” with adjustments

! No “Hoot N’ Holler” adjustments
Maintenance Issues - Digital Paging

ANT. → Monitor Receiver

TX1 → CHANNEL 1

CHANNEL 2 → Scope

Trigger Input → Square Wave Gen.

TX2 → LEVEL ADJ.

LEVEL ADJ. → DELAY

DELAY → Zetron Model 33
Maintenance Issues - Digital Paging

Input to Model 33

RCV AUDIO

SCOPE DISPLAY

Square Wave Burst

DELAY TIME

Square Wave Burst

TRACE 1

TRACE 2
Maintenance Issues

- Use the Convex 806A TIMS
  - Provides standard TIMS measurements
  - Provides delay measurements
  - Allows measurements to be computer controlled.
  - Download measurement information into Convex equalizer cards
  - Some difficulty getting over the air delay measurements
Narrowband Operation

- Main difference between wideband and narrowband FM
  - Narrow IF filters don’t deal with impulse noise as well (multipath holes)
  - Capture effect less pronounced (big affect)
  - Signal-to-noise ratio and audio recovery
- Frequency stability requirements the same.
- Deviation control is more critical.
- Overlap area control more critical
- Digital will help because audio distortion is reduced digital to analog conversion process
- Digital may be worse because coverage holes may develop in overlap areas
Why Simulcast?

- The right technology for modern times.
- Spectrally efficient.
- Provides excellent coverage
- Few alternatives
Equipment vendors and approaches

Motorola
- DSMII cards using a Premisys channel bank (now Zone)
- GPS timing control
- Bulk delay control
- Manual amplitude adjustment
- 4 audio paths per card

MA-COM Harris
- Delay card delays whole T1 or whole channel bank
- GPS timing control
- Bulk delay control
- Manual amplitude adjustment
- 24 circuits/48 if using ADPCM
- Marketed by Harris Intraplex for FM broadcast use
Equipment vendors and approaches

! Tait
  - Automated computer control
  - Audio delay adjustment
  - Audio level adjustment
  - Audio equalization
  - Can use either digital or analog mux

! Convex
  - Computer interface
  - Manual adjustments
  - Audio line equalization
    - Phase
    - Amplitude

! Allen Avionics
  - Manual LC type bulk delay modules
Who is ADCOMM Engineering Company?

! Communications consulting engineering company.
! Systems integration engineering is our speciality.
! We were doing simulcast when simulcast wasn’t cool!
! Non-vendor specific. We don’t sell hardware—only engineering.
! We are a “hands on” engineering company with lots of field experience.
! Clients include: Public safety, utilities, local government, federal government, and private industry.