iBiquity Digital Corporation does not make any warranty or representation whatsoever as to the sufficiency or accuracy of information contained in this document. It is further acknowledged that there can be no assurance that this document will not change, perhaps substantially, in the future. Accordingly, iBiquity Digital Corporation assumes no responsibility arising from any present use or misuse of this document.
Copyright © 2010 iBiquity Digital Corporation.
All rights reserved.
The contents of this publication may not be reproduced in any media without the express written permission of iBiquity Digital Corporation.

TRADEMARKS
All other trademarks, whether claimed or registered, are the exclusive property of their respective owners.
Table of Contents

Contents

1 SCOPE ..............................................................................................................................................................1
2 EXECUTIVE SUMMARY ..................................................................................................................................1
3 TRANSMITTER LOCATIONS ..........................................................................................................................2
4 TRIAL TEST RUNS AND SELECTION OF TEST AREAS ............................................................................3
5 TIME ALIGNMENT ...........................................................................................................................................5
6 PERFORMANCE AFTER TIME ALIGNMENT ...............................................................................................7
7 DIGITAL-ONLY BOOSTER COMPATIBILITY WITH MAIN HOST ANALOG SIGNAL .......................................9

List of Figures

Figure 3-1: Map of the Baltimore, Maryland Metropolitan Area ..................................................................................2
Figure 4-1: Main Transmitter Only ...............................................................................................................................3
Figure 4-2: Booster Transmitter Only ...........................................................................................................................3
Figure 4-3: Main and Booster – Actual Test Runs on the Synchronized System (Non-time Aligned) .........................4
Figure 4-4: Main and Booster – Predicted Ideal Performance .......................................................................................4
Figure 5-1: 20 microsecond Misalignment / 3.7 miles Delay Spread and Exgine Delay Adjustment Window ............5
Figure 6-1: Main and Booster – HD Radio Signal Coverage after Time Alignment .....................................................7
Figure 6-2: HD Radio Signal Coverage before Time Alignment ..................................................................................8
Figure 6-3: HD Radio Signal Coverage after Time Alignment .....................................................................................8
1 Scope

This document describes the results (to date) of interim field testing the iBiquity implementation of Single Frequency Network (SFN) technology on the following local experimental stations:

WD2XAB
WD2XAB-FM1

2 Executive Summary

In accordance with the previously submitted HD Radio Single Frequency Network Broadcast Test Plan, iBiquity Digital Corporation constructed two local Baltimore SFN test stations:

Main Site (Station)
Booster Site (Station)

The test program examined both digital performance and digital compatibility with the host analog signal.

The performance tests characterized digital coverage of the main station, as well as extensions of digital coverage with the addition of the digital booster.

The analog compatibility tests examined the potential interference from IBOC sidebands on the host analog signal near the booster site. Digital compatibility was characterized principally in the area of signal overlap, where signals from the Main and Booster transmitter were of similar field intensity. Non-aligned waveforms in this area have the potential to cause the carriers from both transmitters to null in a period equal to the inverse of the time alignment differential.

The results of these early tests have been very encouraging.

iBiquity’s synchronized SFN Booster technology has the potential to not only extend an FM station’s HD Radio signal coverage to the protected contour, but also fill areas of compromised signal, well within the station’s coverage area.
3 Transmitter Locations

The map of the Baltimore, Maryland metropolitan area shown in Figure 3-1 shows the Main transmitter site (WD2XAB) in the lower left and the Booster transmitter site (WD2XAB-FM1) in the upper right.

![Map of the Baltimore, Maryland Metropolitan Area](image)

*Figure 3-1: Map of the Baltimore, Maryland Metropolitan Area*
4 Trial Test Runs and Selection of Test Areas

ComStudy propagation prediction software was used to identify areas of potential overlap of the two signals. Areas in white were predicted to receive the HD Radio signal. Separate test runs (green and yellow dots) by the iBiquity test van on the Main transmitter (Figure 4-1) and Booster transmitter (Figure 4-2) refined the individual areas of coverage. A green dot indicates the measured HD Radio signal reception.

Figure 4-1: Main Transmitter Only

Figure 4-2: Booster Transmitter Only
The map shown in Figure 4-3 was the record for the actual first test runs on the synchronized (but non-time aligned) system; the map shown in Figure 4-4 was the prediction for the ideal performance from the individual test runs. For comparison purposes, the circled area (Harford Road) fared much better in the prediction than in the actual tests because of signal timing misalignment. Section 6 characterizes coverage improvements after the signals were time aligned in this overlap region.

Figure 4-3: Main and Booster – Actual Test Runs on the Synchronized System (Non-time Aligned)

Figure 4-4: Main and Booster – Predicted Ideal Performance
The iBiquity test van was driven to Harford Road which was an area located in the center of signal overlap. The spectrum nullled out at intervals of 49 kHz, as shown in the plot in Figure 5-1.

![Graph](image)

**Figure 5-1: 20 microsecond Misalignment / 3.7 miles Delay Spread and Exgine Delay Adjustment Window**

This corresponds to a delay spread of 20 microseconds. Since light travels one mile in 5.37 microseconds, this means that the overlap point is 3.7 miles closer to the Booster transmitter site than the Main transmitter site.

A delay offset of 20 microseconds was added to the Booster’s transmission to cause the signals to align at the point of reception. Spectra were obtained at a number of locations on Harford Road showing the alignment at the points of overlap (see the next page).

Further testing in Boston should characterize reception performance at multiple locations with various delays.

It should be noted that the HD Radio transmission system uses time and frequency diversity to improve signal robustness and the receiver’s equalizer tracks the carrier amplitude variations. The effect of the nulls on the digital signal has far less impact than the “multipath-like” interference that results in analog FM.
HD Radio™ Single Frequency Network Interim Field Test Results - WD2XAB

Harford Road Spectrum (After Time Alignment)

M1: -106.45 dBm @ 93.315 MHz
M2 - M1: -0.92 dB, 0.044 MHz

M1: -100.28 dBm @ 93.296 MHz
M2 - M1: -4.07 dB, 0.058 MHz

Measured Signal Overlap Locations
6 Performance After Time Alignment

Following the alignment procedure, test runs were repeated and improved performance was indicated in the overlap areas as shown in Figure 6-1, Figure 6-2, and Figure 6-3.

Figure 6-1: Main and Booster – HD Radio Signal Coverage after Time Alignment
Figure 6-2: HD Radio Signal Coverage before Time Alignment

Figure 6-3: HD Radio Signal Coverage after Time Alignment
7 Digital-Only Booster Compatibility with Main Host Analog Signal

iBiquity will soon characterize the effect of a digital-only Booster transmitter’s IBOC carriers on the Main transmitter’s host analog signal. High levels of digital energy may impact reception on this weak signal close to the Booster site.

It may be possible to mitigate this localized interference by injecting a low-level, synchronized, modulated, analog carrier into the Booster’s signal. The interference potential will then be re-evaluated on typical OEM receivers, aftermarket analog automotive receivers, and tabletop receivers.