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December 4, 2001

Ms. Magalie R. Salas
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, D.C. 20554

Re: MM Docket No. 99-325

Dear Ms. Salas:

iBiquity Digital Corporation ("iBiquity") hereby submits for filing in the above proceeding reports on recent tests conducted on iBiquity's FM In-Band On-Channel Digital Audio Broadcasting system. These test reports were submitted previously to the National Radio Systems Committee ("NRSC") and served as the basis for the NRSC's recent endorsement of iBiquity's technology. It is iBiquity's understanding that the National Association of Broadcasters and the Consumer Electronics Association are filing with the Commission an official copy of the NRSC's analysis of iBiquity's test results and endorsement of the iBiquity system. iBiquity is submitting the actual test results to complete the public record.

These reports contain the results of tests iBiquity conducted pursuant to NRSC test procedures for IBOC DAB. One report details the results of tests conducted to assess the performance of the digital system and the potential impact of the system on main channel analog FM operations. The second report details the results of tests designed to assess the digital system's impact on analog SCA operations in the FM band. As is noted in the NRSC's evaluation, these tests demonstrate that iBiquity's FM system is a significant enhancement over analog FM audio and that the iBiquity system can be implemented without harmful interference to existing analog FM operations.

iBiquity encourages the FCC to promptly seek public comment on these test results and the NRSC's findings in order to advance the Commission's evaluation of this technology. The test results presented in this report and the NRSC evaluation and endorsement demonstrate that IBOC DAB technology is ready for introduction in the marketplace. iBiquity encourages the Commission to refresh the record in this proceeding and to authorize the deployment of iBiquity's IBOC system for digital audio broadcasting.

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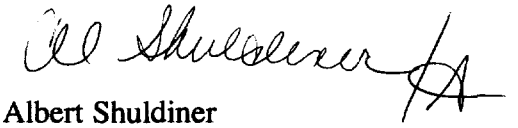
Any questions concerning this matter should be directed to the undersigned.

Sincerely,



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Report to the
National Radio Systems Committee

Supplemental Report on IBOC Compatibility With Analog and Digital FM SCA Operations

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October 19, 2001

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This supplemental report analyzes the impact of IBOC DAB on existing analog and digital FM SCA operations. This report should be reviewed in conjunction with iBiquity Digital Corporation's ("iBiquity") August 2001 report to the NRSC on main channel FM laboratory and field testing. The following results demonstrate that, overall, the introduction of IBOC will have no harmful impact on analog SCA operations for either the host station or adjacent channel stations. In addition, the test results indicate the introduction of IBOC will have no impact on digital SCA operations.

I. Tests and Procedures

All SCA tests were conducted pursuant to the NRSC's test procedures for laboratory and field testing. Moreover, all the tests used facilities and procedures identical to those detailed in iBiquity's August 2001 report. All SCA laboratory objective tests were conducted at the ATTC. Field tests were conducted by iBiquity in the presence of NRSC observers. Sound samples from both the lab and the field were subjectively evaluated at Dynastat. This report contains an analysis of the test results. Following the report are a series of appendices containing the ATTC's report on laboratory tests, the results of the subjective evaluations conducted at Dynastat and maps detailing the locations of the field tests.

Table 1 below lists the receivers used in the SCA compatibility tests:

Receiver	Model No.	Serial No.	Test Conducted
CozmoCom	---	0073696	92 kHz Analog SCA
Compol	SCA-BL	Sample 1001	92 kHz Analog SCA
Sectra	DRB-3000	340002576	76 kHz Digital SCA
McMartin	TR-E5/55M	286834	67 kHz Analog SCA
Norver	---	A0012461	67 kHz Analog SCA
Audemat	RDS Analyzer	---	57 kHz Analog SCA

Table 1 – SCA Test Receivers

In accordance with the NRSC test procedures, all six receivers were tested in the lab for both host and adjacent channel compatibility. The objective results from those tests are presented in Appendix SCA-A. The subjective evaluation results from those tests are presented in Appendix SCA-C. In addition, the analog SCA receivers were tested in the field for host compatibility, and sound samples from those tests were subjectively evaluated. The results of that subjective evaluation are also presented in Appendix SCA-C. The objective field results are detailed in Appendix SCA-D. Appendix SCA-B contains a series of maps which depict the test locations from the field. Table 2 below details the station at which each SCA receiver was tested in the field:

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Receiver	Type of Test	Test Station
CozmoCom	92 kHz Analog	WD2XAB
Compol	92 kHz Analog	WPOC
Sectra	76 kHz Digital	WD2XAB
McMartin	67 kHz Analog	WD2XAB
Norver	67 kHz Analog	WPOC
Audemat	57 kHz Analog	WPOC

Table 2 – SCA Field Test Stations

II. Test Results

The laboratory and field test results demonstrate the introduction of IBOC will not harmfully impact existing SCA operations. For the majority of SCA receivers, the tests show no impact in any test environment. In some cases, laboratory tests indicate a theoretical impact from IBOC. However, field tests under these conditions, show that in the real world, the poor audio quality of most analog SCA receivers will mask any impact from the introduction of IBOC.

The SCA tests were conducted in three environments: (i) lab tests without noise; (ii) lab tests with 30,000K noise; and (iii) field tests. The field tests confirm that the laboratory tests without noise are not representative of real world SCA operations. Moreover, the field tests indicate existing SCAs operate in a complicated analog environment that frequently is quite harmful to SCA transmissions. It is difficult to capture in the laboratory the complicated interference environment that confronts SCAs. Moreover, the laboratory tests did not take into account multiple interferers that most SCAs confront. Therefore, iBiquity believes the importance of field tests, as described in the August 2001 report, is even greater for purposes of analyzing SCA compatibility than for main channel operations.

It also is important to note iBiquity found significant disparities between the analog operations of the receivers in the laboratory and the field. These disparities involve analog operations and were unrelated to the introduction of IBOC. For example, the host compatibility results show that in the lab, before the introduction of IBOC, the Compol greatly outperformed the CozmoCom. For the 67 kHz receivers, the Norver outperformed the McMartin. However, in the field, both the Norver and the Compol failed due to analog interference, much of which was host-to-SCA cross talk produced in the receivers themselves. This disparity indicates that the analog operations of SCA receivers are much more sensitive to channel conditions or interference than are regular FM receivers. Moreover, iBiquity believes the SCA receivers were highly dependent on host modulation parameters. As a result, the SCA receivers frequently reached the point of failure even without the introduction of IBOC. These inconsistent results indicate that SCA receivers simply may have performed differently at different times during the testing program, thereby creating a distorted picture of their performance capabilities. iBiquity believes the disparities

between SCA performance in the lab and field are quite important to consider when interpreting test results.

A. Host Compatibility

1. 57 kHz RDS Analog SCA

Both the laboratory and field tests confirmed the introduction of IBOC has no impact on 57 kHz SCA operations. The laboratory tests showed the received block error rate was zero both without and with IBOC. The lab results are summarized below in Table 3.

ATTC #	Desired	RDS Inj	AWGN	Main Ch. Audio	BLER (%)
2201	RDS: Analog: Strong	3.00%	None	CPN	0.00 ± 0.00
2202	RDS: Hybrid: Strong	3.00%	None	CPN	0.00 ± 0.00
2203	RDS: Analog: Moderate	3.00%	None	CPN	0.00 ± 0.00
2204	RDS: Hybrid: Moderate	3.00%	None	CPN	0.00 ± 0.00
2205	RDS: Analog: Strong	3.00%	30,000K	CPN	0.00 ± 0.00
2206	RDS: Hybrid: Strong	3.00%	30,000K	CPN	0.00 ± 0.00
2207	RDS: Analog: Moderate	3.00%	30,000K	CPN	0.00 ± 0.00
2208	RDS: Hybrid: Moderate	3.00%	30,000K	CPN	0.00 ± 0.00
2209	RDS: Analog: Strong	3.00%	None	None	0.00 ± 0.00
2210	RDS: Hybrid: Strong	3.00%	None	None	0.00 ± 0.00
2211	RDS: Analog: Moderate	3.00%	None	None	0.00 ± 0.00
2212	RDS: Hybrid: Moderate	3.00%	None	None	0.00 ± 0.00
2213	RDS: Analog: Strong	3.00%	30,000K	None	0.00 ± 0.00
2214	RDS: Hybrid: Strong	3.00%	30,000K	None	0.00 ± 0.00
2215	RDS: Analog: Moderate	3.00%	30,000K	None	0.00 ± 0.00
2216	RDS: Hybrid: Moderate	3.00%	30,000K	None	0.00 ± 0.00
2217	RDS: Analog: Strong	10.00%	None	CPN	0.00 ± 0.00
2218	RDS: Hybrid: Strong	10.00%	None	CPN	0.00 ± 0.00
2219	RDS: Analog: Moderate	10.00%	None	CPN	0.00 ± 0.00
2220	RDS: Hybrid: Moderate	10.00%	None	CPN	0.00 ± 0.00
2221	RDS: Analog: Strong	10.00%	30,000K	CPN	0.00 ± 0.00
2222	RDS: Hybrid: Strong	10.00%	30,000K	CPN	0.00 ± 0.00
2223	RDS: Analog: Moderate	10.00%	30,000K	CPN	0.00 ± 0.00
2224	RDS: Hybrid: Moderate	10.00%	30,000K	CPN	0.00 ± 0.00
2225	RDS: Analog: Strong	10.00%	None	None	0.00 ± 0.00
2226	RDS: Hybrid: Strong	10.00%	None	None	0.00 ± 0.00
2227	RDS: Analog: Moderate	10.00%	None	None	0.00 ± 0.00
2228	RDS: Hybrid: Moderate	10.00%	None	None	0.00 ± 0.00
2229	RDS: Analog: Strong	10.00%	30,000K	None	0.00 ± 0.00
2230	RDS: Hybrid: Strong	10.00%	30,000K	None	0.00 ± 0.00
2231	RDS: Analog: Moderate	10.00%	30,000K	None	0.00 ± 0.00
2232	RDS: Hybrid: Moderate	10.00%	30,000K	None	0.00 ± 0.00

Table 3 – IBOC Interference into Host 57 kHz RDS SCA
(extracted from ATTC Report)

The objective data from the field tests also demonstrated no meaningful change in the block error rate with the introduction of IBOC. Compatibility data taken over a range of analog-only, baseline performance points show the introduction of IBOC has no impact at very good, moderate or poor signal conditions. Figure 1 below illustrates the field test results for the 57 kHz RDS SCA receiver.

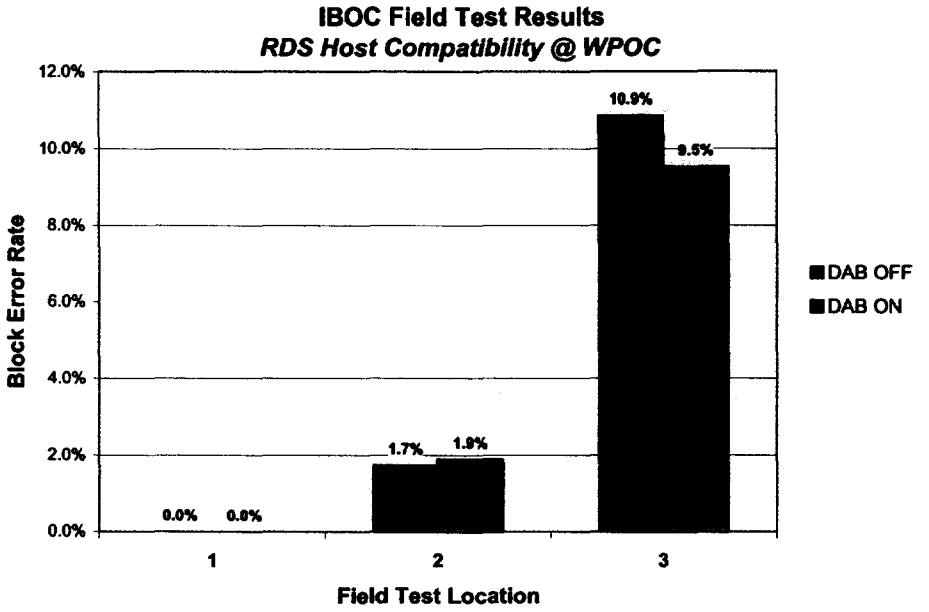

Figure 1 – Host Compatibility Field Test Results for 57 kHz SCA

2. 67 kHz Analog SCA

The 67 kHz analog SCA tests were conducted using both the McMartin and the Norver receivers. This was the first example of a significant disparity between laboratory and field tests. In the lab, the Norver outperformed the McMartin. Although there is some question as to whether consumers would listen to the receivers even before the introduction of IBOC, assuming this were the case, the objective lab results do indicate a potential impact from the introduction of IBOC for the Norver receiver. These objective lab results are supported by the subjective evaluation of sound samples from the lab, as detailed in Table 3. The field tests indicate, however, that the Norver receiver failed due to host analog cross talk before the introduction of IBOC. The subjective evaluation scores from the field tests fell to 1.5 through 1.9. Therefore, if the receiver is already failing without IBOC, it follows that the introduction of IBOC will not raise a host compatibility issue for the Norver receiver. The McMartin receiver exhibited an insignificant change in performance due to the introduction of IBOC in both the lab and the field. The subjective evaluation results on these receivers are summarized in Table 3 below:

Receiver	LABORATORY								FIELD					
	NO NOISE				30,000K Noise				LOCA-TION 1		LOCA-TION 2		LOCA-TION 3	
	FEMALE		MALE		FEMALE		MALE							
	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
McMartin	3.3	3.0	3.7	3.3	3.0	2.8	3.0	2.9	4.3	4.2	3.8	3.6	4.5	4.4
Norver	4.0	2.9	3.7	2.6	3.0	2.5	2.9	2.3	1.5	1.6	1.6	1.7	1.9	1.6

Table 3 – Lab and Field Subjective Results for 67 kHz Host Compatibility

3. 76 kHz Digital SCA

Both the laboratory and field tests confirm the introduction of IBOC has no impact on 76 kHz digital SCA operations. The laboratory tests show the Block Error Rate was zero both without and with IBOC. Table 4 below summarizes these test results.

ATTC #	Desired	AWGN	Main Ch.	BLER Before Correction (%)	BLER After Correction (%)
2401	DARC: Analog: Strong	None	CPN	0.00 ± 0.00	0.00 ± 0.00
2402	DARC: Hybrid: Strong	None	CPN	0.00 ± 0.00	0.00 ± 0.00
2403	DARC: Analog: Moderate	None	CPN	0.00 ± 0.00	0.00 ± 0.00
2404	DARC: Hybrid: Moderate	None	CPN	0.00 ± 0.00	0.00 ± 0.00
2405	DARC: Analog: Strong	30,000K	CPN	0.00 ± 0.00	0.00 ± 0.00
2406	DARC: Hybrid: Strong	30,000K	CPN	0.00 ± 0.00	0.00 ± 0.00
2407	DARC: Analog: Moderate	30,000K	CPN	0.00 ± 0.00	0.00 ± 0.00
2408	DARC: Hybrid: Moderate	30,000K	CPN	0.00 ± 0.00	0.00 ± 0.00
2409	DARC: Analog: Strong	None	None	0.00 ± 0.00	0.00 ± 0.00
2410	DARC: Hybrid: Strong	None	None	0.00 ± 0.00	0.00 ± 0.00
2411	DARC: Analog: Moderate	None	None	0.00 ± 0.00	0.00 ± 0.00
2412	DARC: Hybrid: Moderate	None	None	0.00 ± 0.00	0.00 ± 0.00
2413	DARC: Analog: Strong	30,000K	None	0.00 ± 0.00	0.00 ± 0.00
2414	DARC: Hybrid: Strong	30,000K	None	0.01 ± 0.03	0.00 ± 0.00
2415	DARC: Analog: Moderate	30,000K	None	0.00 ± 0.00	0.00 ± 0.00
2416	DARC: Hybrid: Moderate	30,000K	None	0.00 ± 0.00	0.00 ± 0.00

Table 4 – IBOC Interference into Host 76 kHz DARC SCA
(extracted from ATTC report)

Moreover, the field tests demonstrated no meaningful impact on the high speed digital SCA operation over a range of signal conditions. Figures 2 and 3 below illustrate the digital SCA operations with and without IBOC.

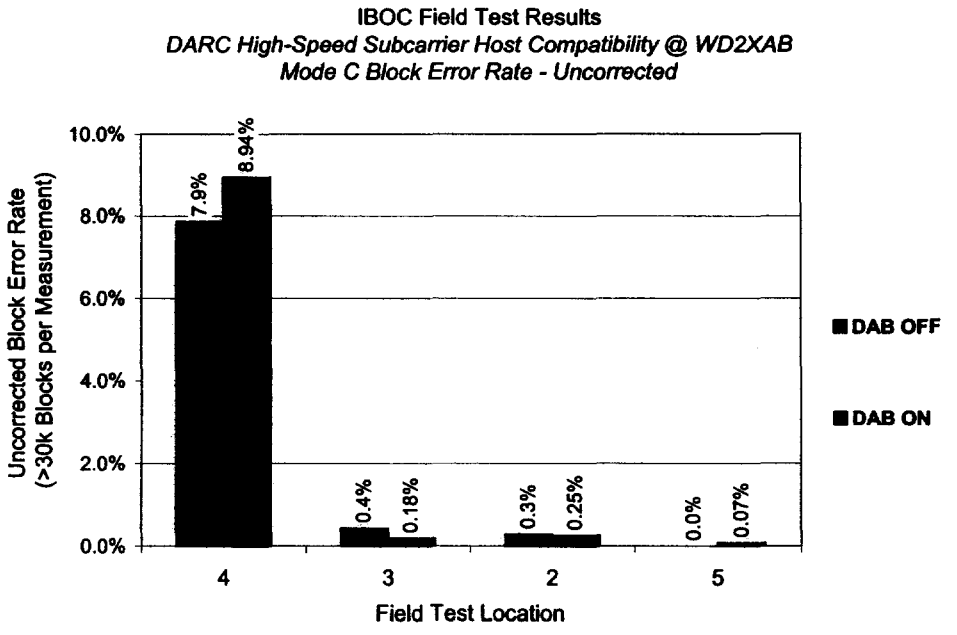

Figure 2 – Host Compatibility Field Test Results for 76 kHz SCA
(before DARC receiver forward error correction)

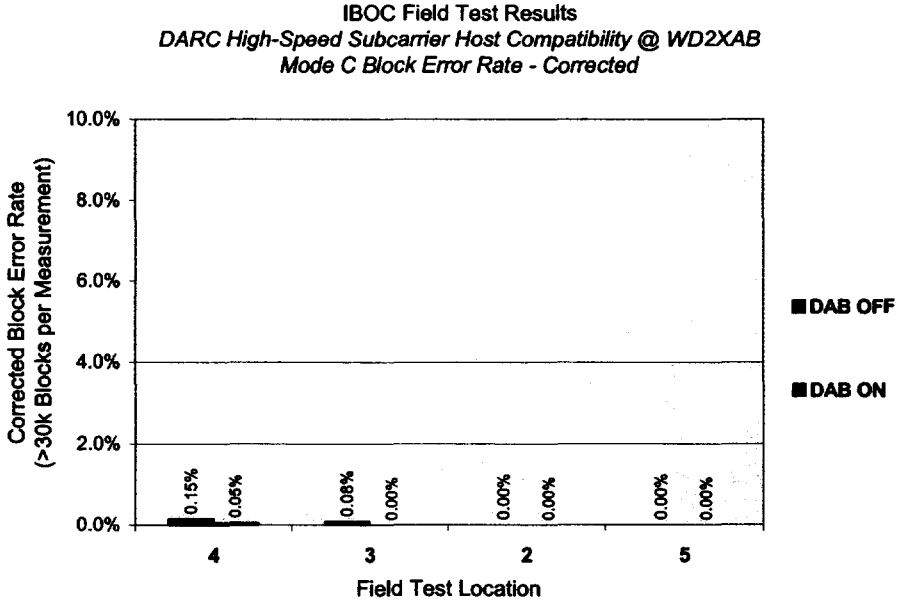

Figure 3 – Host Compatibility Field Test Results for 76 kHz SCA
(after DARC receiver forward error correction)

4. 92 kHz Analog SCA

The 92 kHz analog SCA tests were conducted using both the CozmoCom and the Compol receivers. As was the case with the 67 kHz receivers, the 92 kHz receivers also exhibited different performance in the lab and in the field. In the lab, the Compol outperformed the CozmoCom. Again, there is a threshold question as to whether the signal-to-noise ratios of the analog operations (27.9 dB, 27 dB and 18.5 dB) would be considered listenable. Presupposing this were the case, the objective lab results again indicate a potential impact from the introduction of IBOC. As was the case for the 67 kHz SCA, these objective results were supported by the subjective evaluation of sound samples from the lab. However, as with the Norver receiver, field tests indicated that the Compol receiver failed due to analog interference before the introduction of IBOC. Therefore, the introduction of IBOC would not raise a host compatibility issue for the Compol receiver. The laboratory and field test mean opinion scores confirmed that participants would continue to listen to the CozmoCom even with the introduction of IBOC. The subjective evaluation results on these receivers are summarized in Table 4 below:

Receiver	LABORATORY								FIELD					
	NO NOISE				30,000K				LOCA-TION 1		LOCA-TION 2		LOCA-TION 3	
	FEMALE		MALE		FEMALE		MALE							
	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
CozmoCom	2.1	1.6	2.1	1.6	2.2	1.7	2.1	1.7	4.2	3.5	3.1	2.8	4.4	2.9
Compol	3.6	1.5	3.6	1.4	2.6	1.5	2.5	1.4	1.4	1.2	1.5	1.2	1.4	1.2

Table 4 – Lab and Field Results for 92 kHz Host Compatibility

B. Adjacent Channel Compatibility

All adjacent channel compatibility tests were conducted with a single first or single second adjacent channel interferer. There were no tests conducted with dual interferers. No field tests of adjacent channel interference were conducted.

1. 57 kHz RDS Analog SCA

The laboratory tests confirm the introduction of IBOC has no impact on adjacent channel 57 kHz SCA operations. The tests were run with a single first adjacent channel interferer operating at +26, +16 and +6 dB D/U ratios. Second adjacent channel compatibility tests were conducted with the interferer at 0, -10, -20 and –30 dB D/U ratios. In all cases, the Block Error Rate was zero both without and with IBOC.[1]

2. 67 kHz Analog SCA

The laboratory tests confirm the compatibility of IBOC with adjacent channel 67 kHz SCA operations. In the case of first adjacent channel interference, tests confirm that the introduction of IBOC did not degrade SCA performance on the first adjacent channel at interference levels of +16 dB D/U. At +6 dB D/U, the objective results indicate there is no impact from the introduction of IBOC. Although subjective evaluation results indicate a potential impact for the McMartin receiver without noise at the +6 dB D/U level, iBiquity believes that the more realistic assessment of this scenario requires the injection of noise. With 30,000K noise, there is no relevant impact to the McMartin receiver from the introduction of IBOC on the first adjacent station.

The introduction of IBOC on the second adjacent channel had no impact on the operation of the Norver receiver. With 0 and -10 dB D/U ratios of second adjacent channel interference, the introduction of IBOC had no meaningful impact on the SNR of the receiver. The subjective evaluation results confirm no noticeable change in the audio at -10 dB D/U first adjacent channel interference after the introduction of IBOC. At -20 and -30 dB D/U in the lab, the Norver failed before the introduction of IBOC, and subjective tests at -30 dB D/U

[1] See Appendix SCA-A at 16.

confirm this failure. The McMartin receiver showed no impact from IBOC at the 0, -10 or -20 dB D/U interference ratios in the lab. These results were confirmed by the subjective evaluation at the -10 dB D/U interference level. At -30 dB D/U, the introduction of IBOC has the potential to degrade the performance of the SCA. Without field tests, however, it is impossible to determine whether the McMartin would even perform at this level of analog interference.

3. 76 kHz Digital SCA

The laboratory tests confirm the introduction of IBOC had no impact on first adjacent or second adjacent channel 76 kHz SCA operations. In most cases tested, the Block Error Rate was zero both without and with IBOC. In a few cases, the block error rate exceeded zero both without and with IBOC. In those cases, the was an insignificant difference in the BLER with and without IBOC. [2]

4. 92 kHz Analog SCA

The laboratory tests confirm the introduction of IBOC had no impact on first adjacent or second adjacent channel 92 kHz SCA operations. In all tested conditions and with both 92 kHz receivers, analog interference to the SCA operation masked any impact from the introduction of IBOC on adjacent channels.

Both the Compol and the CozmoCom receivers exhibited poor analog-only performance in the lab, even with +16 dB D/U analog first adjacent channel interference. The CozmoCom produced SNRs of 13 to 16 dB. At +6 dB D/U analog first adjacent channel interference, the SNR dropped to 8 dB. The Compol produced SNRs below 6 dB even at +16 dB D/U analog first adjacent interference. The introduction of IBOC had virtually no impact on these already very low SNRs.[3] The subjective evaluations confirmed these results. Before the introduction of IBOC, the CozmoCom scored 1.8 or 1.9. The Compol scored slightly lower. With +6 dB D/U analog first adjacent channel interference, both receivers scored in the 1.3 to 1.1 range. Again, the introduction of IBOC had no real impact on these low subjective evaluation scores.

With second adjacent channel interference, both the CozmoCom and Compol exhibited better performance. With 0 and -10 dB D/U second adjacent channel analog interference, both receivers achieved SNRs of 28 or 29 dB in the absence of noise. In these cases, the introduction of IBOC had no impact. With -30 dB D/U second adjacent channel analog interference, both receivers exhibited failure with SNRs below 10 dB. The subjective evaluations confirmed the CozmoCom and Compol were in failure a majority of the time at that level of second adjacent channel analog interference. With -20 dB D/U analog second adjacent channel analog interference in the lab, both the CozmoCom and the Compol achieved SNRs in the upper 20s without noise. At this level, the lab tests indicate a potential

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[2] See Appendix SCA-A at 18.

[3] See Appendix SCA-A at 12-14.

impact from IBOC. iBiquity believes, however, that it is more appropriate to examine the receivers' performance with noise. At this level of interference with 30,000K noise, the SNR for the Compol drops significantly. iBiquity also believes this test understates the real interference environment. In many, if not most, cases in the real world the SCA will be impacted by first adjacent analog interference at this level of second adjacent channel analog interference. The results of the first adjacent channel interference tests discussed above demonstrate that these receivers fail or have severely degraded performance even with +16 dB D/U of first adjacent channel analog interference. Therefore, iBiquity believes the first adjacent channel analog interference will mask the impact of any potential second adjacent channel digital interference.

III. Conclusion

The laboratory and field tests confirm the introduction of IBOC will have no impact on 57 kHz and 76 kHz SCA operations. In the case of 67 kHz and 92 kHz SCA operations, any potential impact from IBOC will be masked by analog cross talk in the vast majority of cases. As a result, IBOC should not have an impact on SCA listeners.

LIST OF APPENDICES

Appendix SCA-A	ATTC Summary of Test Results
Appendix SCA-B	Field Test Locations
Appendix SCA-C	Subjective Evaluation Results
Appendix SCA-D	Field Test Results