



Appendix B – IBOC laboratory test procedures – FM band

 CEA Consumer Electronics Association 2049 Wilson Boulevard Falls Church, VA 22041-3834 (703) 692-7500 1-800-475-7881	NATIONAL RADIO SYSTEMS COMMITTEE	 NAB National Association of Broadcasters 1275 K Street, NW Washington, D.C. 20004-3928 (202) 429-6300 FAX (202) 775-4001
DAB Subcommittee Evaluation of the iBiquity Digital Corporation IBOC System Part 1 – FM IBOC		

**IBOC LABORATORY TEST PROCEDURES – FM BAND
OVERALL COMMENTS**

1. The test laboratory (ATTC) will provide a detailed certification of the test bed.
2. Appendix A is a list of the test results (resulting from these procedures) which must be included in the laboratory test record to be provided to the NRSC at the conclusion of testing. Note that this list is not meant to suggest the format in which those results are to be presented in that record, but is simply an enumeration of those results.
3. IBOC receiver point-of-blend is established by the “mode” signal which is supplied by the receiver. IBOC receiver block error rate (BLER) is also observable.
4. Unless otherwise specified, the audio selections to be used as source material for desired and interfering channels are specified in the NRSC audio test list, and, the source audio for analog reference recordings will be the same as that used for the corresponding IBOC digital audio recordings.
5. The following three RF composite signal levels are used in the FM laboratory tests:

DESIGNATION	DESCRIPTION	LEVEL (DBM)
M	Moderate	-62
S	Strong	-47
W	Weak	-77

6. Digital recordings of analog and IBOC digital audio indicated by these procedures are for archival and/or subjective evaluation purposes. All such recordings will be made in the following format: uncompressed linear 16-bit digital audio sampled at 44.1 kHz, and will be suitable for transfer to CD to facilitate further analysis.
7. Multipath scenarios used in these tests will be the same scenarios used in the EIA DAR laboratory tests conducted in 1995, utilizing nine desired signal paths (rays) and six undesired paths, as specified in Appendix E of the August 11, 1995 report (“VHF Rayleigh 9-path simulation”).
8. The detailed procedure for RF noise measurements will be supplied. See Appendix S of the EIA DAR Laboratory Tests Report, August 11, 1995.
9. For tests involving use of the multipath simulator, the RF level will be characterized according to the procedure described in the ATTC report “The Measurement of Power as applied to IBOC DAB signals in the Presence of Multipath for the FM-band,” Document #00-02 November 16, 2000.
10. Unless otherwise specified, IBOC transmitters will be used to generate undesired signals in co- and adjacent-channel interference tests.

**IBOC LABORATORY TEST PROCEDURES – FM BAND
OVERALL COMMENTS (continued)**

11. Unless otherwise specified, analog audio (as opposed to IBOC digital audio) signal power meas. will be made using the weighted quasi-peak (“WQP,” CCIR weighting filter) measurement technique. Analog audio noise measurements will in addition use a 19 kHz lowpass pilot filter.
12. The host FM to digital power ratio used in the digital performance tests will also be used for the analog compatibility tests.
13. The following four subcarrier configurations are used in the FM laboratory analog compatibility tests (see test groups F, J):

Description	Center frequency (kHz)	INJECTION LEVEL			
		Config. #1	Config. #2	Config. #3	Config. #4
*Main channel audio	N/A	80%	85%	85%	80%
Stereo pilot	19.0	10%	10%	10%	10%
RDS digital subcarrier	57.0	3%	10%	-	-
“High speed” digital subcarrier (HSSC)	76.0	-	-	10%	-
**Analog audio subcarrier – FM modulated, ± 5 kHz peak deviation, 150 μ sec pre-emphasis	67.0	8.5%	-	-	10%
**Analog audio subcarrier – FM modulated, ± 5 kHz peak deviation, 150 μ sec pre-emphasis	92.0	8.5%	-	-	10%
TOTAL subcarrier injection		20%	10%	10%	20%
TOTAL injection (main channel and subcarriers)		110%	105%	105%	110%

* Main channel audio modulated with audio cuts from NRSC Audio Test List for subjective evaluations or 1 kHz tone for S/N measurements

**Analog subcarriers modulated with USASI noise except for subjective evaluations (TBD audio) or S/N measurements (400 Hz tone). When the same audio cuts are used for 67 and 92 kHz subcarriers, they will be offset in time by TBD sec (to de-correlate).

14. Unless otherwise indicated, interfering signals will not utilize any subcarriers other than the stereo pilot and L-R signal.
15. For tests involving multipath fading, point-of-blend will be determined utilizing the procedure described in the memo from G. Nease (iBiquity) to Andy Laird (TPWG chairman), dated November 28, 2000, and entitled “Method for the Determination of Point-of-Blend in Multipath Conditions.”
16. NRSC analog test receivers specified on pg. 16 will undergo the following characterization tests: [list TBD]
17. [definition of clipped pink noise to be added here]

IBOC LABORATORY TEST PROCEDURES – FM BAND CALIBRATION					
Test Group	Test & Impairment	TEST DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results Data to be Recorded
		Note: 1. One impairment audio cut will be selected from the NRSC Audio Test List for point of blend tests for calibration.			
A Calibration	1 Power	1. IBOC analog and digital average power will be measured separately (as needed). 2. The digital-only average and peak power will be measured at least once.	NA	Objective	Analog average power level Digital average and peak power levels
	2 Spectrum (each test day or as needed)	1. A spectrum analyzer plot of the system RF spectrum will be taken for each test day (or as needed). 2. The spectrum analyzer settings will be: RES BW 1 kHz, VBW 30 Hz, and sweep span of 500 kHz.	M	Objective	Spectrum plot
	3 Point of blend (as needed)	1. Gaussian noise will be added to the signal in 0.20 dB steps until point of blend is detected (using mode signal), or block error equivalent to point of blend is observed.	M	Objective	Noise level, BLER at point of blend
	4 Analog host proof-of-performance	1. During the analog compatibility tests, a proof of performance test will be conducted on the analog host portion of the IBOC system. A high quality demodulator will be used for this test.	Varying	Objective	Frequency response, L&R separation, audio SNR, and audio THD
	5 Monitor calibration (as needed)	1. The analog modulation monitors will be calibrated. Bessel null is the recommended method for calibration. Settings for the Belar Wizard modulation monitor will be: Hold 1.0 sec; Peak Mod 100.5%; Infinite off; Blank off; Resolution 0.1%; Time Mode past; Pk Weight 9 cyc; ppm duration 100 ms; ppm threshold 10.	NA	Objective	Calibration results
	6 Test bed calibration (prior to test)	1. All of the critical components in the test bed, including the multipath simulator, attenuators, combiners, filters, generators, and measuring instruments, will be certified by the testing laboratory prior to tests.	NA	Objective	Calibration results

<p align="center">IBOC LABORATORY TEST PROCEDURES – FM BAND DIGITAL PERFORMANCE</p>					
Test Group	Test & Impairment	TEST DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results Data to be Recorded
		<p>Notes:</p> <ol style="list-style-type: none"> For urban slow multipath tests, the desired multipath audio selections will be repeated as required to complete a full fading cycle on the MP simulator. The audio will be restarted for each test. The analog reference recordings specified in step B.2.5 will be made with the IBOC digital sidebands removed from the desired signals. 			
B AWGN	1 Linear channel	<ol style="list-style-type: none"> The level of AWGN corresponding to system point of blend will be established. The desired impairment audio segments will be recorded with the AWGN set at a level 2 dB below (i.e. before) the point of blend. The BLER will be recorded with the AWGN set at a level 4 dB below (i.e. before) the point of blend, then with the AWGN level increased in 1 dB steps until at the point of blend, then at 2 dB and 4 dB above (i.e. after) the point of blend. 	M	Objective	Cd/No, BLER for each measurement point (with point of blend identified)
				Subjective	Subjective impairment rating for recording made in step 2
	2 Multipath fading channel	<ol style="list-style-type: none"> This test will be conducted four times, each with a different Rayleigh multipath scenario. The multipath scenarios will be those specified on the “general comments” page of this procedure. Each cut will be recorded for subjective assessment. For each multipath scenario, the level of AWGN corresponding to system point of blend will be established. The desired impairment audio segments will be recorded with the AWGN set at a level 8 dB below (i.e. before) the point of blend. The BLER will be recorded with the AWGN set at a level 8 dB below (i.e. before) the point of blend, then with the AWGN level increased in 2 dB steps until 6 dB above (i.e. after) the point of blend. An analog reference recording will be made using NRSC analog test receivers #1 and #2 (automobile receivers) for each multipath scenario, at the measurement point of step 3. 	M	Objective	Cd/No, BLER for each measurement point (with point of blend identified)
				Subjective	Subjective impairment rating for each multipath scenario and audio cut, for IBOC digital and analog reference recordings made in steps 2 and 5

<p align="center">IBOC LABORATORY TEST PROCEDURES – FM BAND DIGITAL PERFORMANCE</p>							
Test Group	Test & Impairment	TEST DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results Data to be Recorded		
		<p>Notes:</p> <ol style="list-style-type: none"> Desired audio cut used for these tests will be the desired impairment audio classical music selection; undesired audio cut will be the first adjacent impairment audio. Each test will last no more than 30 seconds. The audio will be restarted for each test. The analog reference recordings specified in each step will be made with the IBOC digital sidebands removed from the desired and undesired signals. For test C.1, only those sets of recordings corresponding to pulse frequencies of 120 Hz, and those closest to 500 Hz and 1500 Hz, will be subjectively evaluated. 					
C IBOC with special impairments	1 Impulse noise	<ol style="list-style-type: none"> An RF pulse generator capable of RF pulses with a rise and decay time of at least 3 to 4 nanoseconds will be used for this test. The pulse generator output will be combined with the hybrid IBOC RF signal, and the RF pulse peak power level will be 30 dB above that of the unmodulated analog carrier. IBOC digital audio will be recorded for one minute each, for six pulse rates between 100 Hz to 2000 Hz. 120 Hz pulse rate will be included in all the tests. The center frequency of the RF pulse should be the center frequency of the desired channel. For each measurement point, the mode signal status will be recorded. Steps 2 and 3 will be repeated using a random pulse repetition frequency (PRF) impulse noise source. Steps 2-4 will be repeated using a single lower first adjacent undesired signal. The D/U ratio will be set for +6 dB. An analog reference recording will be made using NRSC analog test receivers #1 and #2 (automobile receivers) for each impulse noise scenario described in steps 2-5. 	M	Objective	Mode signal status for each measurement point		
				Subjective	Subjective impairment rating for each pulse rate, amplitude and interference scenario for IBOC digital and analog reference recordings		
	2 Airplane flutter (Doppler)				M	Objective	Mode signal status for each measurement point
						Subjective	Subjective impairment rating for each airplane flutter scenario for IBOC digital and analog reference recordings

<p align="center">IBOC LABORATORY TEST PROCEDURES – FM BAND DIGITAL PERFORMANCE</p>						
Test Group	Test and Impairment	TEST DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results & Data to be Recorded	
		<p>Notes:</p> <ol style="list-style-type: none"> All interferers are to be hybrid IBOC signals – refer to NRSC Audio Test List for information on interferer modulation. The analog reference recordings specified in each step will be made with the IBOC digital sidebands removed from the desired and undesired signals. For tests D.2 and D.3, analog reference recordings will be made with all relevant permutations of upper/lower adjacent channel interference. The analog reference recordings specified in each step will be made with the IBOC digital sidebands removed from the desired and undesired signals. 				
<p>D IBOC → IBOC</p>	<p>1 Co-channel</p>	<ol style="list-style-type: none"> The co-channel D/U corresponding to system point of blend will be established. The desired impairment audio segments will be recorded with the co-channel D/U set at a level 2 dB below (i.e. before) the point of blend. For each measurement point, the mode signal status will be recorded. The BLER will be recorded with the co-channel D/U set at a level 2 dB below (i.e. before) the point of blend, then with the co-channel level increased in 1 dB steps until 1 dB above (i.e. after) the point of blend. An analog reference recording will be made using NRSC analog test receivers #2 and #3 for the measurement point of step 2. 	<p>M</p>	<p>Objective</p>	<p>Co-channel D/U, BLER, mode signal for each measurement point</p>	
				<p>Subjective</p>	<p>Subjective impairment rating for IBOC digital and analog reference recordings made in steps 2, 4</p>	
	<p>2 Single and dual 1st adjacent</p>		<ol style="list-style-type: none"> Using a lower 1st adjacent channel interferer, the D/U corresponding to system point of blend will be established. The desired impairment audio segments will be recorded with the lower 1st adj. chan. D/U set at a level 2 dB below (i.e. before) the point of blend. For each measurement point, the mode signal status will be recorded. The BLER will be recorded with the lower 1st adj. chan D/U set at a level 2 dB below (i.e. before) the point of blend, then with the 1st adj. chan. level increased in 1 dB steps until 1 dB above (i.e. after) the point of blend. Steps 1-3 will be repeated with the addition of an upper 1st adj. chan. interferer at 6 dB D/U. An analog reference recording will be made using all 4 NRSC analog test receivers for the measurement point 2 dB below (i.e. before) the point of blend. 	<p>M</p>	<p>Objective</p>	<p>1st adj. channel D/U, BLER, mode signal status for each measurement point</p>
					<p>Subjective</p>	<p>Subjective impairment rating for IBOC digital and analog reference recordings made in steps 2, 4, and 5</p>

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**IBOC LABORATORY TEST PROCEDURES – FM BAND
DIGITAL PERFORMANCE**

Test Group	Test and Impairment	TEST DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results & Data to be Recorded
D IBOC → IBOC	3 Single and dual 2nd adjacent, and simultaneous single 2nd and single 1st adjacent	<p>Notes:</p> <ol style="list-style-type: none"> All interferers are to be hybrid IBOC signals – refer to NRSC Audio Test List for information on interferer modulation. The analog reference recordings specified in each step will be made with the IBOC digital sidebands removed from the desired and undesired signals. For tests D.2 and D.3, analog reference recordings will be made with all relevant permutations of upper/lower adjacent channel interference. The analog reference recordings specified in each step will be made with the IBOC digital sidebands removed from the desired and undesired signals. <ol style="list-style-type: none"> Using a lower 2nd adjacent channel interferer, the D/U corresponding to system point of blend will be established. The desired impairment audio segments will be recorded with the lower 2nd adj. chan. D/U set at a level 2 dB below (i.e. before) the point of blend. For each measurement point, the mode signal status will be recorded. The BLER will be recorded with the lower 1st adj. chan D/U set at a level 2 dB below (i.e. before) the point of blend, then with the 1st adj. chan. level increased in 1 dB steps until 1 dB above (i.e. after) the point of blend. Steps 1-3 will be repeated with the addition of an upper 1st adj. chan. interferer at 6 dB D/U. Simultaneous upper and lower 2nd adj. chan. tests will be conducted using the D/U setting in step 2 for the lower interferer and with the upper interferer fixed at -20 dB D/U. An analog reference recording will be made using NRSC analog test receivers #3 and #4 (non-automobile receivers) for the measurement point 2 dB below (i.e. before) the point of blend. 	M	Objective Subjective	2nd adj. channel D/U, BLER, mode signal status for each measurement point Subjective impairment rating for IBOC digital and analog reference recordings made in steps 2, 4, 5, and 6

<p align="center">IBOC LABORATORY TEST PROCEDURES – FM BAND DIGITAL PERFORMANCE</p>						
Test Group	Test and Impairment	TEST DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results & Data to be Recorded	
		<p>Notes:</p> <ol style="list-style-type: none"> Each undesired channel will be modulated with the multipath interference selection. When there are two undesired channels, the audio cuts and multipath conditions will be time shifted with respect to one another by TBD ms (for audio) and TBD ms (for multipath). The audio in each channel (both desired and undesired) shall be synchronized in time with respect to its respective multipath simulator. For tests E.2 and E.3, analog reference recordings will be made with all relevant permutations of upper/lower adjacent channel interference. The analog reference recordings specified in each step will be made using NRSC analog test receivers #1 and #2 (automobile receivers), and with the IBOC digital sidebands removed from the desired and undesired signals. 				
<p>E IBOC → IBOC with multipath</p>	<p>1 Co-channel</p>	<p>1. Test D.1 will be repeated using the four multipath scenarios, except that the desired impairment audio segments will be recorded with the co-channel D/U set at a level 8 dB below (i.e. before) the point of blend (instead of 2 dB).</p>	<p>M</p>	<p>Objective</p>	<p>Co-channel D/U, BLER, mode signal status for each measurement point</p>	
				<p>Subjective</p>	<p>Subjective impairment rating for IBOC digital and analog reference recordings made in steps 2, 4</p>	
	<p>2 Single and dual 1st adjacent</p>	<p>1. Test D.2 will be repeated using the four multipath scenarios, except that the desired impairment audio segments will be recorded with the 1st adjacent channel D/U set at a level 8 dB below (i.e. before) the point of blend (instead of 2 dB).</p>	<p>M</p>	<p>Objective</p>	<p>1st adj. chan. D/U, BLER, mode signal status for each measurement point</p>	
				<p>Subjective</p>	<p>Subjective impairment rating for IBOC digital and analog reference recordings made in steps 2, 4, and 5</p>	
	<p>3 Single and dual 2nd adjacent, and simultaneous single 2nd and single 1st adjacent</p>		<p>1. Test D.3 will be repeated using the four multipath scenarios, except that the desired impairment audio segments will be recorded with the 2nd adjacent channel D/U set at a level 8 dB below (i.e. before) the point of blend (instead of 2 dB). If the D/U level at a measurement point is greater than -20 dB, no multipath will be used on the undesired signal for that measurement.</p>	<p>M</p>	<p>Objective</p>	<p>2nd adj. chan. D/U, BLER, mode signal status for each measurement point</p>
					<p>Subjective</p>	<p>Subjective impairment rating for IBOC digital and analog reference recordings made in steps 2, 4, 5, and 6</p>

IBOC LABORATORY TEST PROCEDURES – FM BAND ANALOG COMPATIBILITY (w/adjacent channel IBOC)					
Test Group	Test & Impairment	DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results Data to be Recorded
		Notes: 1. These tests will compare hybrid IBOC-to-analog with analog-to-analog interference. The desired signal XMTR will be non-IBOC, and the undesired signal XMTR will be hybrid IBOC with the IBOC digital sidebands alternately turned on and off (see below). 2. The test will be conducted with no background RF noise and with RF AWGN equivalent to 30,000K. 3. The undesired analog will be modulated with the interference selection. 4. All NRSC analog test receivers will be used, however, subjective evaluations will only be made for the worst performing interferer (i.e. upper or lower) for each radio UNLESS the performance difference (as determined objectively) between interference cases is > 5 dB.			
F IBOC → Analog (main channel audio) (interference to an analog receiver with no other impairments)	1 Single 1st adjacent	1. The desired signal will be modulated with 1 kHz tone and pilot (no other subcarriers). 2. Using a lower 1st-adjacent channel IBOC interferer, with the IBOC digital sidebands turned on, the desired main channel analog WQP S/N ratio will be measured for D/U settings of 16 dB, 6 dB, -4 dB, -14 dB, and -24 dB. 3. Step 2 will be repeated with the IBOC digital sidebands turned off. 4. Steps 2 and 3 will be repeated using an upper 1st-adjacent channel IBOC interferer.	M (W for -14, -24 dB D/U cases)	Objective	Analog S/N ratio at specified D/Us with IBOC digital sidebands on and off (main channel audio)
	2 Single 2nd adjacent	1. The desired signal will be modulated with 1 kHz tone and pilot (no other subcarriers). 2. Using a lower 2nd-adjacent channel IBOC interferer, with the IBOC digital sidebands turned on, the desired analog WQP S/N ratio will be measured for D/U settings of -20, -25, -30, -35, and -40 dB. 3. Step 2 will be repeated with the IBOC digital sidebands turned off. 4. Steps 2 and 3 will be repeated using an upper 2nd-adjacent channel IBOC interferer.			
	3 Single 1st adjacent	1. The desired signal will be modulated with the desired impairment audio selections (no other subcarriers). 2. Using a lower 1st-adjacent channel IBOC interferer, with the IBOC digital sidebands turned on, audio recordings of the desired signal main channel audio will be made for D/U settings of 16 dB, 6 dB, and -4 dB. 3. Step 2 will be repeated with the IBOC digital sidebands turned off. 4. Steps 2 and 3 will be repeated using an upper 1st-adjacent channel IBOC interferer.	M	Subjective	Subjective impairment rating for each D/U setting for desired main channel analog audio signals with undesired IBOC digital sidebands on and off (for worst performing interferer for each radio only)
	4 Single 2nd adjacent	1. Same as test F.3, using 2nd adjacent instead of 1st adjacent channel interferers, at D/U settings of -20 dB and -40 dB.			

IBOC LABORATORY TEST PROCEDURES – FM BAND ANALOG COMPATIBILITY (w/adjacent channel IBOC)					
Test Group	Test & Impairment	DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results Data to be Recorded
		Notes: 1. These tests will compare hybrid IBOC-to-analog with analog-to-analog interference for FM subcarriers. The desired signal XMTR will be non-IBOC, and the undesired signal XMTR will be hybrid IBOC with the IBOC digital sidebands alternately turned on and off (see below). 2. The test will be conducted with no background RF noise and with RF AWGN equivalent to 30,000K. 3. The undesired analog will be modulated with the interference selection. 4. All NRSC analog subcarrier test receivers will be used, however, subj. evaluations will only be made for the worst performing interferer (i.e. upper or lower) for each radio UNLESS the performance difference (as determined objectively) between interference cases is > 5 dB.			
F/SC IBOC → Analog (FM subcarriers) (interference to an analog receiver with no other impairments)	1 Single 1st adjacent – analog subcarriers	1. The desired signal will be modulated with CPN, and subcarrier config. #4. 2. Using a lower 1st-adj. chan. IBOC interferer, with the IBOC digital sidebands turned on, the 67 kHz, 92 kHz subcarrier audio WQP S/N ratio will be meas. for D/U settings of 16 dB, 6 dB. 3. Step 2 will be repeated with the IBOC digital sidebands turned off. 4. Steps 2 and 3 will be repeated using an upper 1st-adjacent channel IBOC interferer.	M	Objective	Analog S/N ratio at specified D/Us with IBOC digital sidebands on and off (67 kHz subcarrier audio, 92 kHz subcarrier audio)
	2 Single 2nd adjacent – analog subcarriers	1. The desired signal will be modulated with CPN, and subcarrier configuration #4 (67 kHz and 92 kHz analog). 2. Using a lower 2nd-adjacent channel IBOC interferer, with the IBOC digital sidebands turned on, the 67 kHz and 92 kHz subcarrier audio WQP S/N ratio will be measured for D/U settings of 0, -10 dB, -20 dB, and -30 dB. 3. Step 2 will be repeated with the IBOC digital sidebands turned off. 4. Steps 2 and 3 will be repeated using an upper 2nd-adjacent channel IBOC interferer.			
	3 Single 1st adjacent – digital subcarriers	1. The desired signal will be mod. with CPN, and subcarrier config. #2 (RDS). 2. Using a lower 1st-adjacent channel IBOC interferer, with the IBOC digital sidebands turned on, the subcarrier error rate will be measured for D/U settings of 26 dB, 16 dB and 6 dB. 3. Step 2 will be repeated with the IBOC digital sidebands turned off. 4. Steps 2 and 3 will be repeated using an upper 1st-adjacent channel IBOC interferer. 5. Steps 2-4 will be repeated using subcarrier configuration #3 (HSSC).	M	Objective	Digital subcarrier error rate at specified D/Us with IBOC digital sidebands on and off (RDS, HSSC)

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IBOC LABORATORY TEST PROCEDURES – FM BAND ANALOG COMPATIBILITY (w/adjacent channel IBOC)					
Test Group	Test & Impairment	DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results Data to be Recorded
		<p>Notes:</p> <ol style="list-style-type: none"> These tests will compare hybrid IBOC-to-analog with analog-to-analog interference for FM subcarriers. The desired signal XMTR will be non-IBOC, and the undesired signal XMTR will be hybrid IBOC with the IBOC digital sidebands alternately turned on and off (see below). The test will be conducted with no background RF noise and with RF AWGN equivalent to 30,000K. The undesired analog will be modulated with the interference selection. All NRSC analog subcarrier test receivers will be used, however, subj. evaluations will only be made for the worst performing interferer (i.e. upper or lower) for each radio UNLESS the performance difference (as determined objectively) between interference cases is > 5 dB. 			
F/SC IBOC → Analog (FM subcarriers) (interference to an analog receiver with no other impairments)	4 Single 2nd adjacent – digital subcarriers	<ol style="list-style-type: none"> The desired signal will be mod. with CPN, and subcarrier config. #2 (RDS). Using a lower 2nd-adjacent channel IBOC interferer, with the IBOC digital sidebands turned on, the subcarrier error rate will be meas. for D/U settings of 0 dB, -10 dB, -20 dB, and -30 dB. Step 2 will be repeated with the IBOC digital sidebands turned off. Steps 2 and 3 will be repeated using an upper 2nd-adjacent channel IBOC interferer. Steps 2-4 will be repeated using subcarrier configuration #3 (HSSC). 	M	Objective	Digital subcarrier error rate at specified D/Us with IBOC digital sidebands on and off (RDS, HSSC)
	5 Single 1st adjacent – analog subcarriers	<ol style="list-style-type: none"> The desired signal will be modulated with TBD audio (from audio cut list), and subcarrier configuration #4 (67 kHz and 92 kHz analog). Using a lower 1st-adjacent channel IBOC interferer, with the IBOC digital sidebands turned on, audio recordings of the 67 kHz and 92 kHz subcarrier audio will be made for D/U settings of 16 dB, and 6 dB. Step 2 will be repeated with the IBOC digital sidebands turned off. Steps 2 and 3 will be repeated using an upper 1st-adjacent channel IBOC interferer. 	M	Subjective	Subjective impairment rating for each D/U setting for 67 kHz and 92 kHz subcarrier analog audio signals with undesired IBOC digital sidebands on and off (for worst performing interferer for each radio only)
	6 Single 2nd adjacent – analog subcarriers	<ol style="list-style-type: none"> The desired signal will be modulated with TBD audio (from audio cut list), and subcarrier configuration #4 (67 kHz and 92 kHz analog). Using a lower 2nd-adjacent channel IBOC interferer, with the IBOC digital sidebands turned on, audio recordings of the 67 kHz and 92 kHz subcarrier audio will be made for D/U settings of -10 dB and -30 dB. Step 2 will be repeated with the IBOC digital sidebands turned off. Steps 2 and 3 will be repeated using an upper 2nd-adjacent channel IBOC interferer. 			

IBOC LABORATORY TEST PROCEDURES – FM BAND ANALOG COMPATIBILITY (w/adjacent channel IBOC)					
Test Group	Test & Impairment	TEST DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results & Data to be Recorded
		<p>Notes:</p> <ol style="list-style-type: none"> 1. These tests will compare hybrid IBOC-to-analog with analog-to-analog interference. The desired signal transmitter will be non-IBOC, and the undesired signal transmitter will be hybrid IBOC with the IBOC digital sidebands alternately turned on and off (according to the procedures below). 2. Both desired and undesired signals will be subject to multipath fading, using the urban slow and urban fast multipath scenarios. 3. The test will be conducted with no background RF noise and with RF AWGN equivalent to 30,000K. 4. The undesired channel will be modulated with the multipath interference selection. 5. The audio in each channel (both desired and undesired) shall be synchronized in time with respect to its respective multipath simulator. 6. NRSC analog test receivers #1 and #2 (automobile receivers) will be used for this test, however, subjective evaluations will only be made for the worst performing interferer (i.e. upper or lower) for each radio UNLESS the performance difference (as determined objectively) between interference cases is > 5 dB. 			
<p>G</p> <p>IBOC → Analog (main channel audio) with multipath</p> <p>(interference to an analog receiver with multipath on the desired and undesired signals)</p>	<p>1</p> <p>Single 1st Adjacent</p>	<ol style="list-style-type: none"> 1. The desired signal will be modulated with the desired impairment audio selections. 2. Using a lower 1st-adjacent channel IBOC interferer, with the IBOC digital sidebands turned on, audio recordings of the desired signal will be made for the urban slow and urban fast multipath scenarios, for a D/U setting of +6 dB. 3. Step 2 will be repeated with the IBOC digital sidebands turned off. 4. Steps 2 and 3 will be repeated using an upper 1st-adjacent channel IBOC interferer. 	M	Subjective	<p>Subjective impairment rating for desired analog signal with undesired IBOC digital sidebands on and off (for worst performing interferer for each radio only)</p>

IBOC LABORATORY TEST PROCEDURES – FM BAND DIGITAL PERFORMANCE					
Test Group	Test & Impairment	TEST DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results Data to be Recorded
		Notes: 1. The audio will be the classical music selection of the desired impairment audio. 2. Each acquisition recording will last one minute. 3. Each test will be repeated at least five times and the results recorded for further assessment.			
H IBOC acquisition	1 Acquisition with varying signal level	1. Using the strong signal level, the RF input will be disconnected from the receiver (as close to the receiver input connector as possible) for sixty seconds to assure loss of lock. 2. The signal will then be reconnected to the IBOC receiver. 3. The audio start will be synchronized with the signal reconnection. 4. The time to audio output will be measured in seconds using a digital oscilloscope (in storage mode). 5. Steps 1-4 will be repeated with the moderate signal level. 6. Steps 1-5 will be repeated with a +6 dB D/U lower first adjacent interferer.	S & M	Objective	Acquisition time at each noise level and audio recordings based upon laboratory observation (listening)

IBOC LABORATORY TEST PROCEDURES – FM BAND DIGITAL QUALITY					
Test Group	Test & Impairment	TEST DESCRIPTION	Desired Signal Level	Type of Evaluation	Test Results & Data to be Recorded
I IBOC quality	1 Quality transmission test	1. Tests will be conducted using the audio quality selections. 2. Each of the selections will be transmitted through the IBOC system without impairment and recorded for subjective evaluation. 3. For each measurement point, the mode signal status will be recorded.	S	Objective	Mode signal status of system during recording of audio selections
				Subjective	Subjective rating for each audio quality selection

IBOC LABORATORY TEST PROCEDURES – FM BAND ANALOG COMPATIBILITY (Host)					
Test Group	Test & Impairment	TEST PROCEDURE	Desired Signal Level	Type of Evaluation	Test Results Data to be Recorded
		Note: 1. The test will be conducted with no background RF noise and with RF AWGN equivalent to 30,000K.			
J IBOC → Host analog	1 IBOC to host analog	1. All 4 NRSC analog test receivers will be used for this test. 2. The host FM transmitter will be set for a total of 75 kHz deviation, modulated with a 1 kHz tone and pilot. 3. With the host IBOC digital sidebands turned on, the host analog WQP S/N ratio, and stereo separation will be measured. 4. Step 3 will be repeated with the host IBOC digital sidebands turned off.	S	Objective	Host analog S/N ratio, stereo separation, with IBOC digital sidebands on and off
	2 IBOC to host analog	1. All 4 NRSC analog test receivers will be used for this test. 2. The host FM transmitter will be set for a total of 75 kHz deviation, modulated with the desired impairment audio selections. 3. With the host IBOC digital sidebands turned on, audio recordings of the host analog the desired signal will be made. 4. Step 3 will be repeated with the host IBOC digital sidebands turned off.	S	Subjective	Subjective impairment rating of host analog audio with IBOC digital sidebands on and off
	3 IBOC to subcarriers – baseband spectral plots	1. The host FM transmitter will be set for a total of 75 kHz deviation, modulated with a 1 kHz tone and pilot. 2. With the host IBOC digital sidebands turned on , the received baseband noise floor (100 Hz to 300 kHz) will be plotted using a wideband precision demodulator. 3. Step 2 will be repeated with the host IBOC digital sidebands turned off. 4. Steps 2 and 3 will be repeated with the 1 kHz program audio tone removed.	S & M	Objective	Baseband noise floor plots for various operating conditions
	4 IBOC to subcarriers – analog subcarrier performance	1. The FM host channel will be modulated with pilot, CPN on main channel audio, and subcarrier configuration #1 (RDS, 67 kHz analog, 92 kHz analog). 2. With the host IBOC digital sidebands turned on, the analog subcarrier S/N ratio will be measured on both 67 kHz and 92 kHz subcarriers. 3. Step 2 will be repeated with the host IBOC digital sidebands turned off. 4. With the host IBOC digital sidebands turned on, and the FM host channel main channel audio modulation changed from CPN to TBD (from audio cut list), audio recordings will be made of both the 67 kHz and 92 kHz subcarriers using TBD audio. 5. Step 4 will be repeated with the host IBOC digital sidebands turned off.	S & M	Objective	Analog subcarrier audio S/N ratio with IBOC digital sidebands on and off
				Subjective	Subjective rating for each audio quality selection

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**IBOC LABORATORY TEST PROCEDURES – FM BAND
ANALOG COMPATIBILITY (Host)**

Test Group	Test & Impairment	TEST PROCEDURE	Desired Signal Level	Type of Evaluation	Test Results Data to be Recorded
<p>Note:</p> <p>1. These tests will be conducted with no background RF noise and with RF AWGN equivalent to 30,000K.</p>					
<p>J</p> <p>IBOC → Host analog</p>	<p>5</p> <p>IBOC to subcarriers – RDS subcarrier performance</p>	<p>1. The FM host channel will be modulated with pilot, CPN on main channel audio, and subcarrier configuration #1 (RDS at 3% injection).</p> <p>2. With the host IBOC digital sidebands turned on, the RDS BLER will be measured. [RDS MEASUREMENT SOFTWARE TBD]</p> <p>3. Step 2 will be repeated with the host IBOC digital sidebands turned off.</p> <p>4. Steps 2 and 3 will be repeated with the 1 kHz program audio tone removed.</p> <p>5. Steps 2-4 will be repeated, substituting subcarrier configuration #1 with subcarrier configuration #2 (RDS at 10% injection).</p>	<p>S & M</p>	<p>Objective</p>	<p>RDS error rate for various operating conditions</p>
	<p>6</p> <p>IBOC to subcarriers – “high speed” digital subcarrier (HSSC) performance</p>	<p>1. The FM host channel will be modulated with pilot, CPN on main channel audio, and subcarrier configuration #3 (HSSC).</p> <p>2. With the host IBOC digital sidebands turned on, the high speed digital subcarrier (HSSC) BLER will be measured.</p> <p>3. Step 2 will be repeated with the host IBOC digital sidebands turned off.</p> <p>4. Steps 2 and 3 will be repeated with the 1 kHz program audio tone removed.</p>	<p>S & M</p>	<p>Objective</p>	<p>HSSC error rate for various operating conditions</p>

NRSC Analog Test Receivers			
Number	Make and Model	Type	Age in Years
1	Delphi Model: 09394139	Auto OEM	New
2	Pioneer Model: KEH-1900	Auto Aftermarket	New
3	Technics Model: SA-EX140	Home HiFi	New
4	Sony Model: CFD-S32	Table Combo	New

NRSC Analog Subcarrier Test Receivers			
Number	Make and Model	Type	Age in Years
5	McMartin	67 kHz	
6	Norver	67 kHz Reading services	
7	CozmoCom	92 kHz	
8	ComPol SCA-BL	92 kHz	