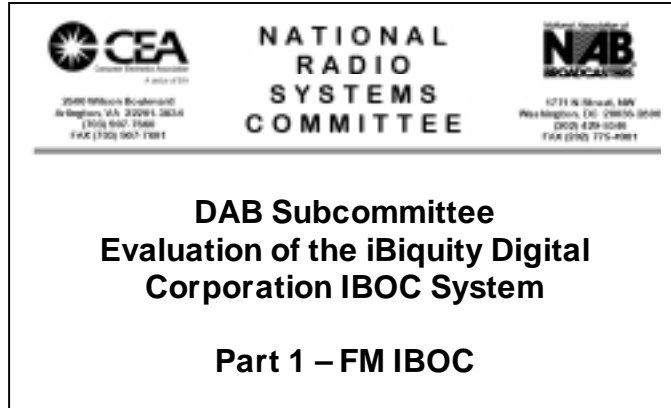


# Appendix D – NRSC analog receiver characterization



The NRSC's FM IBOC compatibility and analog reference tests used four consumer FM stereo receiver models. These receivers were selected because their RF performance characteristics represent receivers used for FM stereo broadcast reception in the U.S. The table lists the receiver make, type, and IBOC test facility. The same model of each manufacture's receiver was used.

<b>FM Receivers Used in the IBOC Laboratory and Field Tests</b>				
<b>Reference number</b>	<b>Make</b>	<b>Type</b>	<b>Test</b>	<b>Characterization test size</b>
01	Delphi	Auto	Field west	Full
02	Delphi	Auto	ATTC laboratory	Full
03	Delphi	Auto	Field east	Short Form
05	Technics	Hi-fi	ATTC laboratory	Full
06	Technics	Hi-fi	Field compatibility	Full
10	Sony	Portable/Table	ATTC laboratory	Full
11	Sony	Portable/Table	Field compatibility	Short Form
17	Pioneer	Auto	Field west	Full
18	Pioneer	Auto	ATTC laboratory	Full
19	Pioneer	Auto	Field East	Short Form

Prior to the start of IBOC laboratory and field-testing an independent test laboratory characterized each receiver for RF sensitivity, RF selectivity, stereo separation, image rejection, IM, and sensitivity to narrow band noise. Over eighteen receivers were characterized of which the ten listed in the above table were used for the IBOC compatibility tests and digital performance tests.

The independent test laboratory conducted seventeen-characterization tests on seven of the ten receivers. Because of time restraints a limited number of characterization tests were conducted on the three remaining receivers. The short form receiver characterization tests consisted of distortion, RF level/SN, stereo separation, 1<sup>st</sup> adjacent selectivity, 2<sup>nd</sup> adjacent selectivity, IM, and narrowband noise sensitivity.

The following is a list of the characterization tests - those tests included in short form testing are noted (SF):

- 1) Local oscillator frequency
- 2) (SF) Distortion at standard output level
- 3) RF input overload
- 4) AM rejection
- 5) Image rejection
- 6) (SF) Curve tests – plots of RF level vs. signal-to-noise (mono, stereo); RF level vs. stereo separation
- 7) Capture ratio
- 8) Selectivity – 1st adjacent (for 30dB RMS S/N)
- 9) Selectivity – 2nd adjacent (for 30dB RMS S/N)
- 10) (SF) Selectivity – 1st adjacent (for 50dB RMS S/N)
- 11) (SF) Selectivity – 2nd adjacent (for 50dB RMS S/N)
- 12) Selectivity – 3rd adjacent (for 50dB RMS S/N)
- 13) 10.7 MHz rejection (not done)
- 14) 10.7 MHz intermodulation
- 15) Local oscillator interference
- 16) (SF) Intermodulation
- 17) (SF) Narrowband noise sensitivity

Included below are summary tables of the receiver characterization data collected for all ten receivers used for the NRSC lab and field IBOC compatibility and performance tests. The tables list the receiver make, test results, and the test facility (lab or field). The tables allow for the direct comparison of receiver basic performance parameters. Each table does not show all the parameters tested. Complete listings of all the test data are in the detailed receiver test reports.<sup>1</sup>

Attachment 1 to this Appendix includes block diagrams of each test mode; in Attachment 2, an example of a full receiver characterization report is given, for one of the Delphi receivers tested.

### **1) Local oscillator frequency**

$$94.1 + 10.7 = 104.8 \text{ MHz}$$

<b>Receiver</b>	<b>LO Frequency MHz</b>	<b>Deviation MHz</b>	<b>Test</b>
01 Delphi	104.801	+0.001	Field west
02 Delphi	104.801	+0.001	ATTC laboratory
03 Delphi	Short Form	-	Field east
05 Technics	104.750	-0.050	ATTC laboratory
06 Technics	104.748	-0.052	Field compatibility
10 Sony	104.801	+0.001	ATTC laboratory
11 Sony	Short Form	-	Field compatibility
17 Pioneer	104.799	-0.001	Field west
18 Pioneer	104.798	-0.002	ATTC laboratory
19 Pioneer	Short Form	-	Field East

<sup>1</sup> To be published by the NRSC.

**2) (SF) Distortion at standard output level**

1 kHz tone 75 kHz deviation, mono; test setup 2

Receiver	THD % Left	THD % Right	Test
01 Delphi	0.43	0.43	Field west
02 Delphi	0.48	0.35	ATTC laboratory
03 Delphi	0.40	0.40	Field east
05 Technics	0.15	0.18	ATTC laboratory
06 Technics	0.17	0.17	Field compatibility
10 Sony	0.28	0.28	ATTC laboratory
11 Sony	0.32	0.27	Field compatibility
17 Pioneer	0.38	0.39	Field west
18 Pioneer	0.36	0.38	ATTC laboratory
19 Pioneer	0.32	0.33	Field East

**3) RF input overload**

1 kHz tone, 75 kHz dev, mono; increase RF level until 5% THD at radio output, and record RF level; test setup 1

Receiver	RF level in dBm at 5% THD	Test
01 Delphi	22	Field west
02 Delphi	22	ATTC laboratory
03 Delphi	SF	Field east
05 Technics	22	ATTC laboratory
06 Technics	22	Field compatibility
10 Sony	20.2	ATTC laboratory
11 Sony	SF	Field compatibility
17 Pioneer	22	Field west
18 Pioneer	22	ATTC laboratory
19 Pioneer	SF	Field east

**4) AM rejection**

1 kHz tone 75 kHz deviation, mono; set radio audio to std. ref. level and record THD; set modulation mode to FM (75 kHz), AM (30%), record THD; test setup 2

Receiver	THD difference in dB	Test
01 Delphi	-0.10	Field west
02 Delphi	0.00	ATTC laboratory
03 Delphi	SF	Field east
05 Technics	-0.83	ATTC laboratory
06 Technics	-3.00	Field compatibility
10 Sony	0.00	ATTC laboratory
11 Sony	SF	Field compatibility
17 Pioneer	0.00	Field west
18 Pioneer	0.00	ATTC laboratory
19 Pioneer	SF	Field east

**5) Image rejection**

Set radio audio to std. ref. level; decrease RF level until S/N ratio = 30dB, record RF level 1; tune RF gen to desired freq. +/- 2X freq.; adjust RF level until S/N ratio= 30dB, record RF level 2; test setup 2

Receiver	Image Rejection in dB	Test
01 Delphi	-48	Field west
02 Delphi	-49	ATTC laboratory
03 Delphi	SF	Field east
05 Technics	-53	ATTC laboratory
06 Technics	-52	Field compatibility
10 Sony	-22	ATTC laboratory
11 Sony	SF	Field compatibility
17 Pioneer	-44	Field west
18 Pioneer	-44	ATTC laboratory
19 Pioneer	SF	Field east

**6) (SF) RF level vs. S/N, separation**

S/N WQP; signal, noise vs. RF level mono; signal, noise vs. RF level stereo; stereo separation vs. RF level; test setup 2

Receiver	Mono WQP S/N at -55dBm / -90dBm	Stereo WQP S/N at -55 dBm / -90 dBm	Separation at -55 dBm / -90 dBm
01 Delphi	64/45	56/45	29/0
02 Delphi	64/45	56/45	29/.5
03 Delphi	63/46	55/46	31/0
05 Technics	64/49	58/29	36/26
06 Technics	64/50	58/28	28/23
10 Sony	55/43	51/23	40/22
11 Sony	56/45	51/24	39/24
17 Pioneer	58/44	53/44	33/0
18 Pioneer	59/46	54/46	34/0
19 Pioneer	60/42	53/43	36/0

**7) Capture ratio**

D: -55dBm, 1kHz, 22.5 dev, Mono; U: -120dBm, CW; increase U audio drop 1dB, record RF level; increase U audio drop 30dB, record RF level (RF Lev. 1 – RF Lev. 2)/2; test setup 3

Receiver	Capture Ratio dB	Test
01 Delphi	-2.5	Field west
02 Delphi	-2.0	ATTC laboratory
03 Delphi	SF	Field east
05 Technics	-2.8	ATTC laboratory
06 Technics	-4.1	Field compatibility
10 Sony	1	ATTC laboratory
11 Sony	SF	Field compatibility
17 Pioneer	-4.0	Field west
18 Pioneer	6.5	ATTC laboratory
19 Pioneer	SF	Field east

**8) Selectivity – 1st adjacent 30 dB RMS S/N**

See TP; test setup 3

Receiver	Stereo Upper D/U dB	Stereo Lower D/U dB	Test
01 Delphi	-18	-19	Field west
02 Delphi	-22	-16	ATTC laboratory
03 Delphi	SF	SF	Field east
05 Technics	-11	-3	ATTC laboratory
06 Technics	-3	-4	Field compatibility
10 Sony	2	1	ATTC laboratory
11 Sony	SF	SF	Field compatibility
17 Pioneer	-17	-23	Field west
18 Pioneer	-24	-22	ATTC laboratory
19 Pioneer	SF	SF	Field east

**9) Selectivity – 2nd adjacent 30 dB RMS S/N**

See TP; test setup 3

Receiver	Stereo Upper D/U dB	Stereo Lower D/U dB	Test
01 Delphi	-55	-55	Field west
02 Delphi	-55	-55	ATTC laboratory
03 Delphi	SF	SF	Field east
05 Technics	-55	-55	ATTC laboratory
06 Technics	-55	-55	Field compatibility
10 Sony	-18	-20	ATTC laboratory
11 Sony	SF	SF	Field compatibility
17 Pioneer	-55	-55	Field west
18 Pioneer	-55	-55	ATTC laboratory
19 Pioneer	SF	SF	Field east

Note: A D/U of -55dB is the test bed limit.

**10) (SF) Selectivity – 1st adjacent 50 dB RMS S/N**

See TP; test setup 3

Receiver	Stereo Upper D/U dB	Stereo Lower D/U dB	Test
01 Delphi	-13	-18	Field west
02 Delphi	-18	-14	ATTC laboratory
03 Delphi	-21	-15	Field east
05 Technics	1	10	ATTC laboratory
06 Technics	10	9	Field compatibility
10 Sony	20	21	ATTC laboratory
11 Sony	18	23	Field compatibility
17 Pioneer	-12	-18	Field west
18 Pioneer	-19	-17	ATTC laboratory
19 Pioneer	-23	-11	Field east

**11) (SF) Selectivity – 2nd adjacent 50 dB RMS S/N**

See TP; test setup 3

Receiver	Stereo Upper D/U dB	Stereo Lower D/U dB	Test
01 Delphi	-55	-55	Field west
02 Delphi	-55	-55	ATTC laboratory
03 Delphi	SF	SF	Field east
05 Technics	-48	-45	ATTC laboratory
06 Technics	-43	-43	Field compatibility
10 Sony	-7	-11	ATTC laboratory
11 Sony	-9	-12	Field compatibility
17 Pioneer	-55	-55	Field west
18 Pioneer	-55	-55	ATTC laboratory
19 Pioneer	-55	-55	Field east

Note: A D/U of -55dB is the test bed limit.

**12) Selectivity – 3rd adjacent 50 dB RMS S/N**

See TP; test setup 3

Receiver	Stereo Upper D/U dB	Stereo Lower D/U dB	Test
01 Delphi	-55	-55	Field west
02 Delphi	-55	-55	ATTC laboratory
03 Delphi	SF	SF	Field east
05 Technics	-48	-45	ATTC laboratory
06 Technics	-45	-43	Field compatibility
10 Sony	-26	-22	ATTC laboratory
11 Sony	SF	SF	Field compatibility
17 Pioneer	-55	-55	Field west
18 Pioneer	-55	-55	ATTC laboratory
19 Pioneer	SF	SF	Field east

Note: A D/U of -55dB is the test bed limit.

**13) 10.7 MHz rejection (no implications from IBOC)**

**14) 10.7 MHz intermodulation (FCC Taboo)**

D -45 dBm; target S/N 50 dB RMS; see TP

Receiver	10.6 MHz D/U dB	10.7 MHz D/U dB	Test
01 Delphi	-55	-55	Field west
02 Delphi	-55	-55	ATTC laboratory
03 Delphi	SF	SF	Field east
05 Technics	-19	-19	ATTC laboratory
06 Technics	-19	-20	Field compatibility
10 Sony	-4	0	ATTC laboratory
11 Sony	SF	SF	Field compatibility
17 Pioneer	-39	-35	Field west
18 Pioneer	-40	-36	ATTC laboratory
19 Pioneer	SF	SF	Field east

Note: A D/U of -55dB is the test bed limit.

### **15) Local oscillator interference**

U 94.1MHz +10.6MHz or 10.7MHz; D Pilot only -45 dBm; target 50 dB S/N; see TP

Receiver	10.6 MHz D/U dB	10.7 MHz D/U dB	Test
01 Delphi	-55	-55	Field west
02 Delphi	-55	-55	ATTC laboratory
03 Delphi	SF	SF	Field east
05 Technics	-16	-21	ATTC laboratory
06 Technics	-15	-21	Field compatibility
10 Sony	1	6	ATTC laboratory
11 Sony	1	4	Field compatibility
17 Pioneer	-36	-28	Field west
18 Pioneer	-37	-27	ATTC laboratory
19 Pioneer	-38	-30	Field east

Note: A D/U of -55dB is the test bed limit.

### **16) (SF) Intermodulation**

Three tone receiver performance with IM signals at 800kHz and 1600kHz above desired.; see TP

D = -47 dBm:

Receiver	D only S/N WQP dB	-10 dB D/U S/N WQP dB	-20 dB D/U S/N WQP dB	-30 dB D/U S/N WQP dB	Test
01 Delphi	59	58	50	42	Field west
02 Delphi	59	58	51	43	ATTC laboratory
03 Delphi	57	57	52	47	Field east
05 Technics	59	41	13	2	ATTC laboratory
06 Technics	60	47	18	3	Field compatibility
10 Sony	52	10	1	0	ATTC laboratory
11 Sony	52	8	0	0	Field compatibility
17 Pioneer	55	54	52	44	Field west
18 Pioneer	56	55	53	45	ATTC laboratory
19 Pioneer	56	56	54	43	Field east

D = -62 dBm:

Receiver	D only S/N WQP dB	-10 dB D/U S/N WQP dB	-20 dB D/U S/N WQP dB	-30 dB D/U S/N WQP dB	Test
01 Delphi	52	51	49	43	Field west
02 Delphi	52	51	50	44	ATTC laboratory
03 Delphi	48	48	48	47	Field east
05 Technics	56	55	43	14	ATTC laboratory
06 Technics	55	54	46	17	Field compatibility
10 Sony	49	33	3	0	ATTC laboratory
11 Sony	49	30	2	0	Field compatibility
17 Pioneer	49	49	48	44	Field west
18 Pioneer	50	50	50	46	ATTC laboratory
19 Pioneer	49	49	49	47	Field east

**17) (SF) Narrowband noise sensitivity**

D/U at 45dB target S/N; receiver stereo; D -62dBm; see TP

<b>Receiver</b>	<b>-190 kHz D/U dB</b>	<b>-114 kHz D/U dB</b>	<b>Center Channel D/U dB</b>	<b>+114 kHz D/U dB</b>	<b>+190 kHz D/U dB</b>
01 Delphi	-20	-2	24	1	-19
02 Delphi	-20	4	22	3	-13
03 Delphi	-19	1	24	-2	-20
05 Technics	14	37	26	33	2
06 Technics	2	31	20	34	8
10 Sony	36	47	34	48	35
11 Sony	36	47	27	44	30
17 Pioneer	-15	4	27	4	-15
18 Pioneer	-18	2	26	1	-19
19 Pioneer	-16	6	25	-1	-19