5 Digital Performance Test Procedures

This section details the digital performance test procedures.

5.1 Objective Performance with AWGN

Objectives

1. Quantify the performance of the IBOC system under varied AWGN channel conditions.
2. Identify the Carrier Power to Noise Density ratio (Cd/No) that corresponds to a 10% Block Error Rate (BLER), for use in the subjective tests of section 5.2.

Methodology

This test series will utilize the test platform to simulate various AWGN channel conditions. In each of these AWGN channel conditions, the performance of a hybrid IBOC signal will be characterized. This characterization will include information on the Block Error Rate (BLER) and "Mode" of the IBOC signal.

The channel conditions will be chosen such that they represent critical transition regions in IBOC operation. For example, as the level of AWGN in the channel is increased, IBOC is expected to eventually transition from a digital mode of operation to a "blend" mode of operation. Once in blend mode, the IBOC receiver will rely on the analog portion of the signal for audio recovery. It is expected that the IBOC receiver will recover error free audio in more benign channel conditions. Therefore, it is only necessary to perform tests near this critical transition point, where IBOC blends to analog. (The NRSC has traditionally referred to this region as the "point of blend").

It has been empirically determined that these "blend events" often occur when the IBOC BLER is between 2% and 10%, depending on the distribution of errors. Using this rule of thumb, the test engineer shall coarsely determine the level of channel impairment that results in a 10% IBOC BLER. Once this impairment level has been coarsely determined, precision tests will be executed at additional points above and below this 10% BLER point. At each of these additional test points, BLER and mode measurements will be repeated three times. Each of these BLER and mode measurements will be taken over the specified amount of time.

Once a sufficient amount of data is collected, a plot of BLER vs. Cd/No and Mode vs. Cd/No shall be generated. This plot will illustrate the error rates and mode of the IBOC signal in the "blend to analog" transition region.

Using this plot of BLER and Mode vs. Cd/No, the test engineer will determine which level of impairment most closely corresponds to an IBOC BLER of 10% (some interpolation may be necessary). This data will be recorded for use in subsequent subjective tests.

Test Conditions

Table 5-1 lists the channel conditions included in this series of tests. These conditions were chosen by the NRSC DAB Subcommittee. Note that the primary test variable is indicated by the caption 'Variable'. The following information may also be helpful in understanding the construction of this table:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the # column.
2. The *Desired* column indicates the mode and power level of the desired signal. The mode is indicated as either: *Analog* or *Hybrid*. The power is indicated as: *Strong (-47dBm), Moderate (-62dBm),* or *Weak (-77dBm).*
3. The *AWGN* column indicates the power level of the AWGN signal
4. The *Msmt Interval(sec)* column indicates the time period for each BLER measurement. The number 60, for example, would indicate that the IBOC system shall be evaluated for errors and mode over a 60 second time period.
5. The *# BLER Msmts* column indicates how many times the BLER and mode measurements will be repeated.
6. The *Step Size(dB)* column specifies the incremental step size that shall be used when increasing the level of impairment. For example, a 1.0dB step size would indicate that the impairment level will be increased in 1.0dB steps, as appropriate BLER/Mode measurements are performed at each step. (Note that this corresponds to horizontal resolution on a BLER vs. Cd/No plot.)

Table 5-1 Objective Performance with AWGN

#	Desired	AWGN	Msmt Interval (sec)	# BLER Msmts	Step Size (dB)
5001	Hybrid: Moderate	Variable	60	3	0.5dB

Procedure

1) Table 5-1 shall be used as a guide for setting up each channel condition.
2) Establish the signal strength, frequency, and mode of the desired signal as indicated in the test grid. For a complete definition of the desired hybrid signal, refer to 2.1.7. The procedures for measuring hybrid power may be found in 3.1.2.
3) Modulate the desired channel with Clipped Pink Noise (section 2.2.1)
4) Apply AWGN at a low power level. Refer to section 2.1.17 for a definition of AWGN noise, and 3.1.5 for the procedures of AWGN noise power measurement.
5) Increase the AWGN power level in coarse increments until a BLER of approximately 10% is observed.
6) Perform high resolution BLER and mode measurements at a sufficient number of impairment levels above and below the 10% BLER point. Use step sizes and measurement intervals as specified in Table 5-1. (Note that BLER measurements may not be possible in cases where the system has transitioned completely to analog mode).

Presentation of Data

Convert the AWGN impairment levels found in the above procedure to Cd/No units. Plot BLER vs. Cd/No and Mode vs. Cd/No on a common graph. At each Cd/No ratio, *all three* BLER and mode measurements shall be reported - there shall be *no* averaging of the data.

5.2 Subjective Performance with AWGN

Objectives

1. Generate audio recordings that represent *IBOC* performance in channel conditions with AWGN impairments that are 2dB "before" the IBOC 10% BLER point.

2. Format these audio recordings for further subjective evaluation and listening tests in an off-line environment.

Methodology

This test series shall utilize the test platform to simulate AWGN channel conditions. Under each of these conditions, the audio output of the IBOC receiver will be recorded.

The channel conditions for these recordings will be chosen such that they represent points that are 2dB "before" the critical transition regions in IBOC operation. These transition regions will have been precisely identified in the objective tests of the previous section (5.1). For example, if the previous test section identifies a 10% BLER at a 50dB Cd/No, then these subjective recordings will be made at a 52dB Cd/No.

Test Conditions

Table 5-2 lists the channel conditions included in this series of tests. These conditions were chosen by the NRSC DAB Subcommittee. The following information may also be helpful in understanding the construction of this table:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the # column.
2. The *Desired* column indicates the mode and power level of the desired signal. The mode is indicated as either: *Analog* or *Hybrid*. The power is indicated as: *Strong (-47dBm), Moderate (-62dBm),* or *Weak (-77dBm).*
3. The *AWGN* column indicates the power level of the AWGN signal. This power level is indicated in relative terms, as described in the methodology section. The "10% BLER" point shown in the table will be determined by the objective test results of the previous section.
4. The *RX* column indicates the receiver that will be used.
5. The *Audio Cut* column indicates the audio selection that will be played and recorded.

Table 5-2 Subjective Performance with AWGN

#	Desired	AWGN	RX	Audio Cut
5101	Hybrid: Moderate	10%BLER – 2dB	IBOC	Bach
5102	Hybrid: Moderate	10%BLER – 2dB	IBOC	Prince
5103	Hybrid: Moderate	10%BLER – 2dB	IBOC	Brokaw

Procedure

1) The IBOC receiver shall be used for this test series.
2) Table 5-2 shall be used as a guide for setting up each channel condition. Each row of the test table shall be executed individually.
3) Establish the signal strength, frequency, and mode of the desired signal as indicated in the test grid. For a complete definition of the desired hybrid signal, refer to 2.1.7. The procedures for measuring hybrid power in the presence of multipath may be found in 3.1.3.
4) Apply AWGN at the power level indicated in the test table. Refer to section 2.1.17 for a definition of AWGN noise, and 3.1.5 for the procedures of AWGN noise power measurement.

5) Set the audio dynamic range processing of the desired channel to a preset which corresponds to the audio cut indicated in the test grid. Refer to Appendix B for a list of presets that should be used with each audio cut.
6) Set up the appropriate multipath simulation on the desired channel. Refer to Appendix D for complete details of each multipath profile. Wait 30 seconds for the multipath simulation to settle into its normal operating mode.
7) Begin recording the output of the IBOC receiver to digital audio tape according to 3.3.1.
8) Play the appropriate audio cut on the desired channel, as indicated in the test grid. Loop this audio cut twice.
9) Perform the audio transfer, editing, leveling and renaming process described in 3.3.2 and 3.3.3.

Presentation of Data

The test results shall consist of digital audio recordings. Each audio cut will be recorded twice. However, the first cut will be discarded, as it is intended to allow the processor sufficient settling time. The remaining audio cut shall be considered the final test result.

5.3 Objective Performance with AWGN & Multipath

Objectives

1. Quantify the performance of the IBOC system under varied AWGN and multipath channel conditions.
2. Identify the Carrier Power to Noise Density ratio (Cd/No) that corresponds to a 10% Block Error Rate (BLER), for use in the subjective tests of section 5.4.

Methodology

This test series will utilize the test platform to simulate various AWGN and multipath channel conditions. In each of these AWGN/multipath channel conditions, the performance of a hybrid IBOC signal will be characterized. This characterization will include information on the Block Error Rate (BLER) and "Mode" of the IBOC signal.

The channel conditions will be chosen such that they represent critical transition regions in IBOC operation. For example, as the level of AWGN in the channel is increased, IBOC is expected to eventually transition from a digital mode of operation to a "blend" mode of operation. Once in blend mode, the IBOC receiver will rely on the analog portion of the signal for audio recovery. It is expected that the IBOC receiver will recover error free audio in more benign channel conditions. Therefore, it is only necessary to perform tests near this critical transition point, where IBOC blends to analog. (The NRSC has traditionally referred to this region as the "point of blend").

It has been empirically determined that these "blend events" often occur when the IBOC BLER is between 2% and 10%, depending on the distribution of errors. Using this rule of thumb, the test engineer shall coarsely determine the level of channel impairment that results in a 10% IBOC BLER. Once this impairment level has been coarsely determined, precision tests will be executed at additional points above and below this 10% BLER point. At each of these additional test points, BLER and mode measurements will be repeated three times. Each of these BLER and mode measurements will be taken over the specified amount of time.

Once a sufficient amount of data is collected, a plot of BLER vs. Cd/No and Mode vs. Cd/No shall be generated. This plot will illustrate the error rates and mode of the IBOC signal in the "blend to analog" transition region.

Using this plot of BLER and Mode vs. Cd/No, the test engineer will determine which level of impairment most closely corresponds to an IBOC BLER of 10% (some interpolation may be necessary). This data will be recorded for use in subsequent subjective tests.

Test Conditions

Table 5-3 lists the channel conditions included in this series of tests. These conditions were chosen by the NRSC DAB Subcommittee. Note that the primary test variable is indicated by the caption 'Variable'. The following information may also be helpful in understanding the construction of this table:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the #column.
2. The *Desired* column indicates the mode and power level of the desired signal. The mode is indicated as either: *Analog* or *Hybrid.* The power is indicated as: *Strong (-47dBm), Moderate (-62dBm),* or *Weak (-77dBm).*
3. The *AWGN* column indicates the power level of the AWGN signal
4. The *Multipath* column indicates the multipath profile applied to the channel. (see Appendix D)
5. The *Msmt Interval(sec)* column indicates the time period for each BLER measurement. The number 60, for example, would indicate that the IBOC system shall be evaluated for errors and mode over a 60 second time period.
6. The *# BLER Msmts* column indicates how many times the BLER and mode measurements will be repeated.
7. The *Step Size(dB)* column specifies the incremental step size that shall be used when increasing the level of impairment. For example, a 1.0dB step size would indicate that the impairment level will be increased in 1.0dB steps, as appropriate BLER/Mode measurements are performed at each step. (Note that this corresponds to horizontal resolution on a BLER vs. Cd/No plot.)

Table 5-3 Objective Performance with AWGN and Multipath

#	Desired	AWGN	Multipath	Msmt Interval (sec)	# BLER Msmts	Step Size (dB)
5201	Hybrid: Moderate	Variable	US	180	3	1.0
5209	Hybrid: Moderate	Variable	UF	60	3	2.0
5217	Hybrid: Moderate	Variable	TO	60	3	2.0
5225	Hybrid: Moderate	Variable	RF	60	3	2.0

Procedure

1) Table 5-3 shall be used as a guide for setting up each channel condition.
2) Establish the signal strength, frequency, and mode of the desired signal as indicated in the test grid. For a complete definition of the desired hybrid signal, refer to 2.1.7. The procedures for measuring hybrid power may be found in 3.1.2.
3) Modulate the desired channel with Clipped Pink Noise (section 2.2.1)

4) Apply AWGN at a low power level. Refer to section 2.1.17 for a definition of AWGN noise, and 3.1.5 for the procedures of AWGN noise power measurement.
5) Increase the AWGN power level in coarse increments until a BLER of approximately 10% is observed.
6) Perform high resolution BLER and mode measurements at a sufficient number of impairment levels above and below the 10% BLER point. Use step sizes and measurement intervals as specified in Table 5-3. (Note that BLER measurements may not be possible in cases where the system has transitioned completely to analog mode).

Presentation of Data

Convert the AWGN impairment levels found in the above procedure to Cd/No units. Plot BLER vs. Cd/No and Mode vs. Cd/No on a common graph. At each Cd/No ratio, *all three* BLER and mode measurements shall be reported - there shall be *no* averaging of the data.

5.4 Subjective Performance with AWGN & Multipath

Objectives

1. Generate audio recordings that represent *IBOC* performance in AWGN/multipath channel conditions with impairment levels that are 8dB "before" the IBOC 10% BLER point.
2. Generate audio recordings that represent *analog FM* performance in identical channel conditions.
3. Format these audio recordings for further subjective evaluation and listening tests in an off-line environment.

Methodology

This test series shall utilize the test platform to simulate AWGN and multipath channel conditions. Under each of these conditions, the audio output of the IBOC receiver and selected analog receivers will be recorded.

The channel conditions for these recordings will be chosen such that they represent points that are 8dB "before" the critical transition regions in IBOC operation. These transition regions will have been precisely identified in the objective tests of the previous section (5.3). For example, if the previous test section identifies a 10% BLER at a 50dB Cd/No, then these subjective recordings will be made at a 58dB Cd/No.

Test Conditions

Table 5-4 lists the channel conditions included in this series of tests. These conditions were chosen by the NRSC DAB Subcommittee. The following information may also be helpful in understanding the construction of this table:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the # column.
2. The *Desired* column indicates the mode and power level of the desired signal. The mode is indicated as either: *Analog* or *Hybrid*. The power is indicated as: *Strong (-47dBm), Moderate (-62dBm),* or *Weak (-77dBm).*
3. The *AWGN* column indicates the power level of the AWGN signal. This power level is indicated in relative terms, as described in the methodology section. The "10% BLER"

point shown in the table will be determined by the objective test results of the previous section.

4. The *Multipath* column indicates the multipath profile applied to the desired signal. (see Appendix D for details on each profile)
5. The *RX* column indicates the IBOC and analog receivers that will be used for the recordings.
6. The *Audio Cut* column indicates the audio selection played on the desired channel.

Table 5-4 Subjective Performance with AWGN and Multipath

#	Desired	AWGN	Multi path	RX	Audio Cut
5251	Hybrid: Moderate	10%BLER – 8dB	US	IBOC	Saito
5252	Analog: Moderate	10%BLER – 8dB	US	2 Auto	Saito
5253	Hybrid: Moderate	10%BLER – 8dB	US	IBOC	Clapton
5254	Analog: Moderate	10%BLER – 8dB	US	2 Auto	Clapton
5255	Hybrid: Moderate	10%BLER – 8dB	US	IBOC	Woman
5256	Analog: Moderate	10%BLER – 8dB	US	2 Auto	Woman
5257	Hybrid: Moderate	10%BLER – 8dB	UF	IBOC	1812
5258	Analog: Moderate	10%BLER – 8dB	UF	2 Auto	1812
5259	Hybrid: Moderate	10%BLER – 8dB	UF	IBOC	Cole
5260	Analog: Moderate	10%BLER – 8dB	UF	2 Auto	Cole
5261	Hybrid: Moderate	10%BLER – 8dB	UF	IBOC	Man
5262	Analog: Moderate	10%BLER – 8dB	UF	2 Auto	Man
5263	Hybrid: Moderate	10%BLER – 8dB	TO	IBOC	Persian
5264	Analog: Moderate	10%BLER – 8dB	TO	2 Auto	Persian
5265	Hybrid: Moderate	10%BLER – 8dB	TO	IBOC	Crowded
5266	Analog: Moderate	10%BLER – 8dB	TO	2 Auto	Crowded
5267	Hybrid: Moderate	10%BLER – 8dB	TO	IBOC	Brokaw
5268	Analog: Moderate	10%BLER – 8dB	TO	2 Auto	Brokaw
5269	Hybrid: Moderate	10%BLER – 8dB	RF	IBOC	Messiah
5270	Analog: Moderate	10%BLER – 8dB	RF	2 Auto	Messiah
5271	Hybrid: Moderate	10%BLER – 8dB	RF	IBOC	Fagen
5272	Analog: Moderate	10%BLER – 8dB	RF	2 Auto	Fagen
5273	Hybrid: Moderate	10%BLER – 8dB	RF	IBOC	Woman
5274	Analog: Moderate	10%BLER – 8dB	RF	2 Auto	Woman

Procedure

1) The IBOC receiver and the two analog automobile receivers will be used for this test series (see Appendix A).
2) Table 5-4 shall be used as a guide for setting up each channel condition. Each row of the test table shall be executed individually.
3) Establish the signal strength, frequency, and mode of the desired signal as indicated in the test grid. For a complete definition of the desired analog and desired hybrid signals, refer to 2.1.1 and 2.1.7, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
4) Apply AWGN at the power level indicated in the test table. Refer to section 2.1.17 for a definition of AWGN noise, and 3.1.5 for the procedures of AWGN noise power measurement.
5) Set the audio dynamic range processing of the desired channel to a preset which corresponds to the audio cut indicated in the test grid. Refer to Appendix B for a list of presets that should be used with each audio cut.

6) Set up the appropriate multipath simulation on the desired channel. Refer to Appendix D for complete details of each multipath profile. Wait 30 seconds for the multipath simulation to settle into its normal operating mode.
7) Begin recording the output of the IBOC or analog receiver to digital audio tape according to 3.3.1.
8) Play the appropriate audio cut on the desired channel, as indicated in the test grid. Loop this audio cut repeatedly for a total of 90 seconds (e.g. a 15 second cut would be looped 6 times).
9) Perform the audio transfer, editing, leveling and renaming process described in 3.3.2 and 3.3.3.

Presentation of Data

The test results shall consist of digital audio recordings. Each audio cut will be recorded a number of times within the 90 second recording window.

5.5 Objective Performance with Impulse Noise

Objectives

1. Quantify the performance of the IBOC system under varied impulse noise conditions.
2. Identify the Average FM to Peak Impulse Noise Power Ratio (Avg-to-Peak) that corresponds to a 10% Block Error Rate (BLER), for use in the subjective tests of section 5.6.

Methodology

This test series will utilize the test platform to simulate various impulse noise conditions. In each of these impulse noise channel conditions, the performance of a hybrid IBOC signal will be characterized. This characterization will include information on the Block Error Rate (BLER) and "Mode" of the IBOC signal.

Impulse noise conditions will be simulated using an RF pulse. The RF pulse shall be generated by "gating" a CW type signal on and off. The gate signal shall have an "on time" duration of 5us, thereby generating an RF pulse that also has a width of 5us. The RF pulse will have a center frequency of 97.3MHz. Various repetition rates will be used between 120 and 2000Hz. In some cases, a pseudo-random repetition rate will be used. This pseudo-random repetition rate will be accomplished through the use of an arbitrary waveform generator (AWG). The AWG will produce a pseudo-random gate signal, resulting in an RF pulse with a pseudo-random repetition rate. Figure 5-1 shows the characteristics of this pseudo-random gate signal.

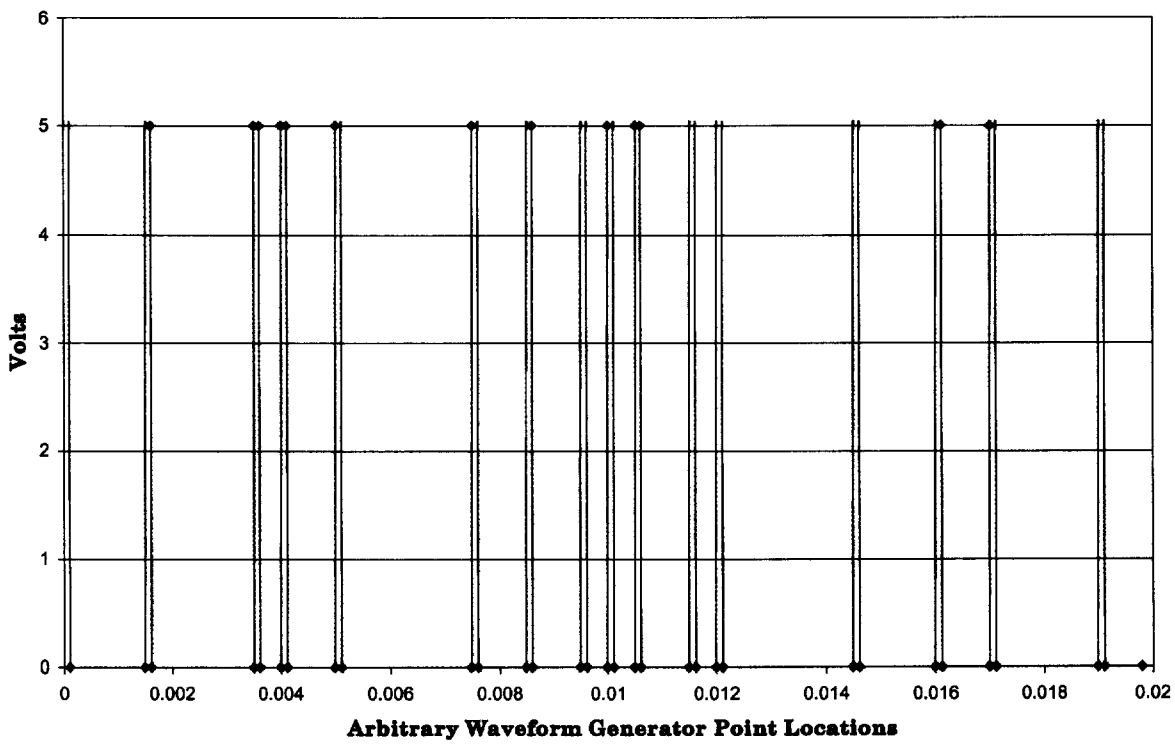
The impulse noise impairment levels will be chosen such that they represent the transition regions in IBOC operation. For example, as the level of impulse noise in the channel is increased, IBOC is expected to eventually transition from a digital mode of operation to a "blend" mode of operation. Once in blend mode, the IBOC receiver will rely on the analog portion of the signal for audio recovery. It is expected that the IBOC receiver will recover error free audio in more benign channel conditions. Therefore, it is only necessary to perform tests near this critical transition point, where IBOC blends to analog. (The NRSC has traditionally referred to this region as the "point of blend").

It has been empirically determined that these "blend events" often occur when the IBOC BLER is between 2% and 10%, depending on the distribution of errors. Using this rule of thumb, the test engineer shall coarsely determine the level of channel impairment that results in a 10% IBOC BLER. Once this impairment level has been coarsely determined, precision tests will be executed at additional points above and below this 10% BLER point. At each of these additional test points, BLER and mode measurements will be repeated three times. Each of these BLER and mode measurements will be taken over the specified amount of time.

Once a sufficient amount of data is collected, a plot of BLER vs. Avg-to-Peak Power and Mode vs. Avg-to-Peak Power shall be generated. This plot will illustrate the error rates and mode of the IBOC signal in the "blend to analog" transition region.

Using this plot of BLER and Mode vs. Avg-to-Peak Power, the test engineer will determine which level of impairment most closely corresponds to an IBOC BLER of 10% (some interpolation may be necessary). This data will be recorded for use in subsequent subjective tests.

Figure 5-1 Characteristics of Pseudo-Random Gate Signal



Test Conditions

Table 5-5 lists the channel conditions included in this series of tests. These conditions were chosen by the NRSC DAB Subcommittee. Note that the primary test variable is indicated by the caption 'Variable'. The following information may also be helpful in understanding the construction of this table:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the # column.
2. The *Desired* column indicates the mode and power level of the desired signal. The mode is indicated as either: *Analog* or *Hybrid*. The power is indicated as: *Strong (-47dBm), Moderate (-62dBm),* or *Weak (-77dBm).*
3. The *Impulse Noise Peak Power* indicates the peak power of the gated RF pulse.
4. The *Impulse Rep Rate* column indicates the repetition rate of the gated RF pulse.
5. The *Msmt Interval(sec)* column indicates the time period for each BLER measurement. The number 60, for example, would indicate that the IBOC system shall be evaluated for errors and mode over a 60 second time period.
6. The *# BLER Msmts* column indicates how many times the BLER and mode measurements will be repeated.
7. The *Step Size(dB)* column specifies the incremental step size that shall be used when increasing the level of impairment. For example, a 1.0dB step size would indicate that the impairment level will be increased in 1.0dB steps, as appropriate BLER/Mode measurements are performed at each step.

Table 5-5 Objective Performance with Impulse Noise

#	Desired	Upper 1st adj.	Impulse Noise Peak Power (dBm)	Impulse Rep Rate (Hz)	Msmt Interval (sec)	# BLER Msmts	Step Size (dB)
5501	Hybrid: Moderate		Variable	120	60	3	1.0
5502	Hybrid: Moderate	Hybrid: +6dB	Variable	120	60	3	1.0
5503	Hybrid: Moderate		Variable	330	60	3	1.0
5504	Hybrid: Moderate	Hybrid: +6dB	Variable	330	60	3	1.0
5505	Hybrid: Moderate		Variable	510	60	3	1.0
5506	Hybrid: Moderate	Hybrid: +6dB	Variable	510	60	3	1.0
5507	Hybrid: Moderate		Variable	1200	60	3	1.0
5508	Hybrid: Moderate	Hybrid: +6dB	Variable	1200	60	3	1.0
5509	Hybrid: Moderate		Variable	1800	60	3	1.0
5510	Hybrid: Moderate	Hybrid: +6dB	Variable	1800	60	3	1.0
5511	Hybrid: Moderate		Variable	2000	60	3	1.0
5512	Hybrid: Moderate	Hybrid: +6dB	Variable	2000	60	3	1.0
5513	Hybrid: Moderate		Variable	Pseudo-Random	60	3	1.0
5514	Hybrid: Moderate	Hybrid: +6dB	Variable	Pseudo-Random	60	3	1.0

Procedure

1) The IBOC receiver shall be used for this test series.
2) Table 5-5 shall be used as a guide for setting up each channel condition. Each row of the test table shall be executed individually.
3) Establish the signal strength, frequency, and mode of the desired signal as indicated in the test grid. For a complete definition of the desired hybrid signal, refer to 2.1.7. The procedures for measuring hybrid power may be found in 3.1.2.
4) Establish the signal strength, frequency, and mode of any adjacent channel undesired signal(s) as indicated in the test grid. For a complete definition of undesired analog and undesired hybrid signals, refer to 2.1.14 and 2.1.16, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
5) Modulate the desired channel with Clipped Pink Noise (section 2.2.1)
6) Set the Average FM to Peak Impulse Noise power ratio to a low level.
7) Increase the impulse noise peak power in coarse increments until a BLER of approximately 10% is observed.

8) Perform high resolution BLER and mode measurements at a sufficient number of impairment levels above and below the 10% BLER point. Use step sizes and measurement intervals as specified in Table 5-5. (Note that BLER measurements may not be possible in cases where the system has transitioned completely to analog mode).

Presentation of Data

Plot BLER vs. Avg-to-Peak and Mode vs. Avg-to-Peak on a common graph.

5.6 Subjective Performance with Impulse Noise

Objectives

1. Generate audio recordings that represent *IBOC* performance in impulse noise channel conditions with impairment levels that are 2dB "before" the IBOC 10% BLER point.
2. Generate audio recordings that represent *analog FM* performance in identical channel conditions.
3. Format these audio recordings for further subjective evaluation and listening tests in an off-line environment.

Methodology

This test series shall utilize the test platform to simulate impulse noise impairments. Under each of these conditions, the audio output of the IBOC receiver and selected analog receivers will be recorded.

The channel conditions for these recordings will be chosen such that they represent points that are 2dB "before" the critical transition regions in IBOC operation. These transition regions will have been precisely identified in the objective tests of the previous section (5.3). For example, if the previous test section identifies a 10% BLER at a -20dB Avg-to-Peak Ratio, then these subjective recordings will be made at a -18dB Avg-to-Peak Ratio.

Test Conditions

Table 5-6 lists the channel conditions included in this series of tests. These conditions were chosen by the NRSC DAB Subcommittee. Note that the primary test variable is indicated by the caption 'Variable'. The following information may also be helpful in understanding the construction of this table:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the # column.
2. The *Desired* column indicates the mode and power level of the desired signal. The mode is indicated as either: *Analog* or *Hybrid*. The power is indicated as: *Strong (-47dBm), Moderate (-62dBm),* or *Weak (-77dBm).*
3. The *Impulse Noise Peak Power* indicates the peak power of the gated RF pulse. This power level is indicated in relative terms. The "10% BLER" point shown in the table will be determined by the objective test results of the previous section.
4. The *Rep Rate* column indicates the repetition rate of the gated RF pulse.
5. The *RX* column indicates the IBOC and analog receivers that will be used for the recordings.
6. The *Audio Cut* column indicates the audio selection to be played on the desired channel.

Table 5-6 Subjective Performance with Impulse Noise

#	Desired	Upper 1st adj.	Impulse Noise Peak Power	Rep Rate (Hz)	RX	Audio Cut
5601	Hybrid: Moderate		10%BLER - 2dB	120	IBOC	Stravinsky
5602	Analog: Moderate		10%BLER - 2dB	120	2 Auto	Stravinsky
5603	Hybrid: Moderate	Hybrid: +6dB	10%BLER - 2dB	120	IBOC	Ibert
5604	Analog: Moderate	Analog: +6dB	10%BLER - 2dB	120	2 Auto	Ibert
5605	Hybrid: Moderate		10%BLER - 2dB	330	IBOC	Debussy
5606	Analog: Moderate		10%BLER - 2dB	330	2 Auto	Debussy
5607	Hybrid: Moderate	Hybrid: +6dB	10%BLER - 2dB	330	IBOC	Carmen
5608	Analog: Moderate	Analog: +6dB	10%BLER - 2dB	330	2 Auto	Carmen
5609	Hybrid: Moderate		10%BLER - 2dB	510	IBOC	Messiah
5610	Analog: Moderate		10%BLER - 2dB	510	2 Auto	Messiah
5611	Hybrid: Moderate	Hybrid: +6dB	10%BLER - 2dB	510	IBOC	1812
5612	Analog: Moderate	Analog: +6dB	10%BLER - 2dB	510	2 Auto	1812
5613	Hybrid: Moderate		10%BLER - 2dB	1200	IBOC	Ibert
5614	Analog: Moderate		10%BLER - 2dB	1200	2 Auto	Ibert
5615	Hybrid: Moderate	Hybrid: +6dB	10%BLER - 2dB	1200	IBOC	Bach
5616	Analog: Moderate	Analog: +6dB	10%BLER - 2dB	1200	2 Auto	Bach
5617	Hybrid: Moderate		10%BLER - 2dB	1800	IBOC	Stravinsky
5618	Analog: Moderate		10%BLER - 2dB	1800	2 Auto	Stravinsky
5619	Hybrid: Moderate	Hybrid: +6dB	10%BLER - 2dB	1800	IBOC	Ibert
5620	Analog: Moderate	Analog: +6dB	10%BLER - 2dB	1800	2 Auto	Ibert
5621	Hybrid: Moderate		10%BLER - 2dB	2000	IBOC	Debussy
5622	Analog: Moderate		10%BLER - 2dB	2000	2 Auto	Debussy
5623	Hybrid: Moderate	Hybrid: +6dB	10%BLER - 2dB	2000	IBOC	Carmen
5624	Analog: Moderate	Analog: +6dB	10%BLER - 2dB	2000	2 Auto	Carmen
5625	Hybrid: Moderate		10%BLER - 2dB	Pseudo-Random	IBOC	Messiah
5626	Analog: Moderate		10%BLER - 2dB	Pseudo-Random	2 Auto	Messiah
5627	Hybrid: Moderate	Hybrid: +6dB	10%BLER - 2dB	Pseudo-Random	IBOC	Bach
5628	Analog: Moderate	Analog: +6dB	10%BLER - 2dB	Pseudo-Random	2 Auto	Bach

Procedure

1) The IBOC receiver and the two analog automobile receivers will be used for this test series (see Appendix A).
2) Table 5-6 shall be used as a guide for setting up each channel condition. Each row of the test table shall be executed individually.
3) Establish the signal strength, frequency, and mode of the desired signal as indicated in the test grid. For a complete definition of the desired analog and desired hybrid signals, refer to 2.1.1 and 2.1.7, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
4) Establish the signal strength, frequency, and mode of the undesired signal (if applicable) as indicated in the test grid. For a complete definition of the undesired analog and undesired hybrid signals, refer to 2.1.14 and 2.1.16, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
5) Apply impulse noise at the power level and repetition rate indicated in the test table.
6) Set the audio dynamic range processing of the desired channel to a preset which corresponds to the audio cut indicated in the test grid. Refer to Appendix B for a list of presets that should be used with each audio cut.
7) Begin recording the output of the IBOC or analog receiver to digital audio tape according to 3.3.1.
8) Play the appropriate audio cut on the desired channel, as indicated in the test grid. Loop this audio cut twice.

9) Perform the audio transfer, editing, leveling and renaming process described in 3.3.2 and 3.3.3.

Presentation of Data

The test results shall consist of digital audio recordings. Each audio cut will be recorded twice. However, the first cut will be discarded, as it is intended to allow the processor sufficient settling time. The remaining audio cut shall be considered the final test result.

5.7 Objective Performance with Airplane Flutter

Objectives

Quantify the performance of IBOC under "airplane flutter" channel conditions. Record the mode and BLER of IBOC under several different types of airplane flutter conditions.

Methodology

This test series will utilize the test platform to simulate various types of airplane flutter channel conditions. In each of these conditions, the performance of a hybrid IBOC signal will be characterized. This characterization will include information on the Block Error Rate (BLER) and "Mode" of the IBOC signal.

The specific channel conditions have been chosen according to the requirements of the NRSC. In each of these conditions, BLER and mode measurements will be repeated three times. Each of these BLER and mode measurements will be taken over the specified amount of time.

Test Conditions

Table 5-7 lists the channel conditions included in this series of tests. These conditions were chosen by the NRSC DAB Subcommittee. The following information may also be helpful in understanding the construction of this table:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the # column.
2. The *Desired* column indicates the mode and power level of the desired signal. The mode is indicated as either: *Analog* or *Hybrid*. The power is indicated as: *Strong (-47dBm), Moderate (-62dBm),* or *Weak (-77dBm).*
3. The *Multipath Type* column indicates the type of airplane flutter applied to the channel (see Appendix D for profile details)
4. The *Msmt Interval(sec)* column indicates the time period for each BLER measurement. The number 60, for example, would indicate that the IBOC system shall be evaluated for errors and mode over a 60 second time period.
5. The *# BLER Msmts* column indicates how many times the BLER and mode measurements will be repeated.

Table 5-7 Objective Performance with Airplane Flutter

#	Lower 1st adj.	Desired	Multipath Type	Msmt Interval (sec)	# BLER Msmts
5651		Hybrid: Moderate	Air400	180	1
5652	Hybrid: +6dB	Hybrid: Moderate	Air400	180	1
5653		Hybrid: Moderate	Air200	180	1
5654	Hybrid: +6dB	Hybrid: Moderate	Air200	180	1
5655		Hybrid: Moderate	Air100	180	1
5656	Hybrid: +6dB	Hybrid: Moderate	Air100	180	1

Procedure

1) Table 5-7 shall be used as a guide for setting up each channel condition.
2) Establish the signal strength, frequency, and mode of the desired signal as indicated in the test grid. For a complete definition of the desired analog and desired hybrid signals, refer to 2.1.1 and 2.1.7, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
3) Establish the signal strength, frequency, and mode of the undesired signal (if applicable) as indicated in the test grid. For a complete definition of the undesired analog and undesired hybrid signals, refer to 2.1.14 and 2.1.16, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
4) Modulate the desired channel with Clipped Pink Noise (section 2.2.1)
5) Perform BLER and mode measurements on the IBOC signal.

Presentation of Data

The BLER and mode of the IBOC signal shall be reported for each channel condition.

5.8 Subjective Performance with Airplane Flutter

Objectives

1. Generate audio recordings that represent *IBOC* performance in airplane flutter conditions.
2. Generate audio recordings that represent *analog FM* performance in identical channel conditions.
3. Format these audio recordings for further subjective evaluation and listening tests in an off-line environment.

Methodology

This test series shall utilize the test platform to simulate airplane flutter conditions. Under each of type of airplane flutter condition, the audio output of the IBOC receiver and selected analog receivers will be recorded. These channel conditions have been chosen in accordance with the NRSC requirements.

Test Conditions

Table 5-8 lists the channel conditions included in this series of tests. These conditions were chosen by the NRSC DAB Subcommittee. The following information may also be helpful in understanding the construction of this table:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the # column.

2. The *Desired* column indicates the mode and power level of the desired signal. The mode is indicated as either: *Analog* or *Hybrid*. The power is indicated as: *Strong (-47dBm), Moderate (-62dBm),* or *Weak (-77dBm).*
3. The *Lower 1st* columns indicates the presence or absence of a lower first adjacent signal.
4. The *Multipath* column indicates the multipath (airplane flutter) profile applied to the desired signal (see Appendix D for details on each profile).
5. The *RX* column indicates the IBOC and analog receivers that will be used for the recordings.
6. The *Audio Cut* column indicates the audio selection played on the desired channel.

Table 5-8 Subjective Performance with Airplane Flutter

#	Lower 1st adj.	Desired	Multipath Type	RX	Audio Cut
5701		Hybrid: Moderate	Airplane 400	IBOC	Debussy
5702		Analog: Moderate	Airplane 400	1 Hi-Fi, 1 Portable	Debussy
5703	Hybrid: +6dB	Hybrid: Moderate	Airplane 400	IBOC	Carmen
5704	Analog: +6dB	Analog: Moderate	Airplane 400	1 Hi-Fi, 1 Portable	Carmen
5705		Hybrid: Moderate	Airplane 200	IBOC	1812
5706		Analog: Moderate	Airplane 200	1 Hi-Fi, 1 Portable	1812
5707	Hybrid: +6dB	Hybrid: Moderate	Airplane 200	IBOC	Bach
5708	Analog: +6dB	Analog: Moderate	Airplane 200	1 Hi-Fi, 1 Portable	Bach
5709		Hybrid: Moderate	Airplane 100	IBOC	Messiah
5710		Analog: Moderate	Airplane 100	1 Hi-Fi, 1 Portable	Messiah
5711	Hybrid: +6dB	Hybrid: Moderate	Airplane 100	IBOC	Stravinsky
5712	Analog: +6dB	Analog: Moderate	Airplane 100	1 Hi-Fi, 1 Portable	Stravinsky

Procedure

1) The IBOC receiver and two analog receivers will be used for this test series (see Appendix A).
2) Table 5-8 shall be used as a guide for setting up each channel condition. Each row of the test table shall be executed individually.
3) Establish the signal strength, frequency, and mode of the desired signal as indicated in the test grid. For a complete definition of the desired analog and desired hybrid signals, refer to 2.1.1 and 2.1.7, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
4) Establish the signal strength, frequency, and mode of the undesired signal (if applicable) as indicated in the test grid. For a complete definition of the undesired analog and undesired hybrid signals, refer to 2.1.14 and 2.1.16, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
5) Set the audio dynamic range processing of the desired channel to a preset which corresponds to the audio cut indicated in the test grid. Refer to Appendix B for a list of presets that should be used with each audio cut.
6) Set up the appropriate multipath simulation on the desired channel. Refer to Appendix D for complete details of each multipath profile. Wait 30 seconds for the multipath simulation to settle into its normal operating mode.
7) Begin recording the output of the IBOC or analog receiver to digital audio tape according to 3.3.1.
8) Play the appropriate audio cut on the desired channel, as indicated in the test grid. Loop this audio cut twice.

9) Perform the audio transfer, editing, leveling and renaming process described in 3.3.2 and 3.3.3.

Presentation of Data

The test results shall consist of digital audio recordings. Each audio cut will be recorded twice. However, the first cut will be discarded, as it is intended to allow the processor sufficient settling time. The remaining audio cut shall be considered the final test result.

5.9 Objective Performance with Interferers

Objectives

1. Quantify the performance of the IBOC system under various adjacent and co-channel interference scenarios.
2. Identify the Desired to Undesired Ratio (D/U) that corresponds to a 10% Block Error Rate (BLER), for use in the subjective tests of section 5.10.

Methodology

This test series will utilize the test platform to simulate various adjacent and co-channel interference scenarios. In each of these interference scenarios, the performance of a hybrid IBOC signal will be characterized. This characterization will include information on the Block Error Rate (BLER) and "Mode" of the IBOC signal.

The channel conditions will be chosen such that they represent critical transition regions in IBOC operation. For example, as the level of adjacent channel interference is increased, IBOC is expected to eventually transition from a digital mode of operation to a "blend" mode of operation. Once in blend mode, the IBOC receiver will rely on the analog portion of the signal for audio recovery. It is expected that the IBOC receiver will recover error free audio in more benign channel conditions. Therefore, it is only necessary to perform tests near this critical transition point, where IBOC blends to analog. (The NRSC has traditionally referred to this region as the "point of blend").

It has been empirically determined that these "blend events" often occur when the IBOC BLER is between 2% and 10%, depending on the distribution of errors. Using this rule of thumb, the test engineer shall coarsely determine the level of adjacent channel interference that results in a 10% IBOC BLER. Once this interference level has been coarsely determined, precision tests will be executed at additional points above and below this 10% BLER point. At each of these additional test points, BLER and mode measurements will be repeated three times. Each of these BLER and mode measurements will be taken over the specified amount of time.

Once a sufficient amount of data is collected, a plot of BLER vs. D/U and Mode vs. D/U shall be generated. This plot will illustrate the error rates and mode of the IBOC signal in the "blend to analog" transition region.

Using this plot of BLER and Mode vs. D/U, the test engineer will determine which level of adjacent or co-channel interference most closely corresponds to an IBOC BLER of 10% (some interpolation may be necessary). This data will be recorded for use in subsequent subjective tests

Test Conditions

Table 5-9 lists the interference scenarios included in this series of tests. These scenarios were chosen by the NRSC DAB Subcommittee. Note that the primary test variable is indicated by the caption 'Variable'. The following information may also be helpful in understanding the construction of this table:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the # column.
2. The *Desired* column indicates the mode and power level of the desired signal. The mode is indicated as either: *Analog* or *Hybrid*. The power is indicated as: *Strong (-47dBm), Moderate (-62dBm),* or *Weak (-77dBm).*
3. The interferer columns indicate the mode and power level of interfering signals. If a fixed number is given (e.g. +6), this number represents the power of the interferer, expressed as a D/U ratio.
4. The *Msmt Interval(sec)* column indicates the time period for each BLER measurement. The number 60, for example, would indicate that the IBOC system shall be evaluated for errors and mode over a 60 second time period.
5. The *# BLER Msmts* column indicates how many times the BLER and mode measurements will be repeated.
6. The *Step Size(dB)* column specifies the incremental step size that shall be used when increasing the level of impairment. For example, a 1.0dB step size would indicate that the impairment level will be increased in 1.0dB steps, as appropriate BLER/Mode measurements are performed at each step. (Note that this corresponds to horizontal resolution on a BLER vs. D/U plot.)

Table 5-9 Objective Performance with Co-Channel/Adjacent Channel Interferers

#	Lower 2nd adj.	Lower 1st adj.	Desired	Upper 1st adj.	Upper 2nd adj	Co-Channel	Msmt Interval (sec)	# BLER Msmts	Step Size (dB)
NRSC D.1									
5301			Hybrid: Moderate			Hybrid: Variable	60	3	1.0
NRSC D.2									
5305		Hybrid: Variable	Hybrid: Moderate				60	3	1.0
5309		Hybrid: Variable	Hybrid: Moderate	Hybrid: +6dB			60	3	1.0
NRSC D.3									
5313	Hybrid: Variable		Hybrid: Moderate				60	3	1.0
5317	Hybrid: Variable		Hybrid: Moderate	Hybrid: +6dB			60	3	1.0
5321	Hybrid: Variable		Hybrid: Moderate		Hybrid: -20dB		60	3	1.0

Procedure

1) The IBOC receiver shall be used for this test series.
2) Table 5-9 shall be used as a guide for setting up each channel condition. Each row of the test table shall be executed individually.

3) Establish the signal strength, frequency, and mode of the desired signal as indicated in the test grid. For a complete definition of the desired hybrid signal, refer to 2.1.7. The procedures for measuring hybrid power may be found in 3.1.2.
4) Establish the signal strength, frequency, and mode of the undesired signal(s) as indicated in the test grid. For a complete definition of undesired analog and undesired hybrid signals, refer to 2.1.14 and 2.1.16, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
5) Modulate the desired channel with Clipped Pink Noise (section 2.2.1)
6) Modulate the undesired channel(s) with Processed Rock (section 2.2.2)
7) Set the D/U ratio of the *variable* interferer to a low power level.
8) Increase the D/U ratio of the variable interferer in coarse increments until a BLER of approximately 10% is observed.
9) Perform high resolution BLER and mode measurements at a sufficient number of impairment levels above and below the 10% BLER point. Use step sizes and measurement intervals as specified in Table 5-9. (Note that BLER measurements may not be possible in cases where the system has transitioned completely to analog mode).

Presentation of Data

Plot BLER vs. D/U and Mode vs. D/U on a common graph. At each D/U ratio, *all three* BLER and mode measurements shall be reported - there shall be *no* averaging of the data.

5.10 Subjective Performance with Interferers

Objectives

1. Generate audio recordings that represent *IBOC* performance in adjacent and co-channel interference scenarios, with interferer levels that are 2dB "before" the IBOC 10% BLER point.
2. Generate audio recordings that represent *analog FM* performance in identical interference conditions.
3. Format these audio recordings for further subjective evaluation and listening tests in an off-line environment.

Methodology

This test series shall utilize the test platform to simulate adjacent and co-channel interference scenarios. In each of these scenarios, the audio output of the IBOC receiver and selected analog receivers will be recorded.

The channel conditions for these recordings will be chosen such that they represent points that are 2dB "before" the critical transition regions in IBOC operation. These transition regions will have been precisely identified in the objective tests of the previous section (5.9). For example, if the previous test section identifies a 10% BLER at a –30dB D/U, then these subjective recordings will be made at a –28dB D/U.

Test Conditions

Table 5-10 lists the interference scenarios included in this series of tests. These scenarios were chosen by the NRSC DAB Subcommittee. The following information may also be helpful in understanding the construction of this table:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the # column.
2. The *Desired* column indicates the mode and power level of the desired signal. The mode is indicated as either: *Analog* or *Hybrid*. The power is indicated as: *Strong (-47dBm), Moderate (-62dBm),* or *Weak (-77dBm).*
3. The interferer columns indicate the mode and power level of interfering signals. If a fixed number is given (e.g. +6), this number represents the power of the interferer, expressed as a D/U ratio. If the caption "10%BLER-2dB" appears, the interfering signal will be set at a level 2dB prior to the 10%BLER point (as determined by the previous tests of section 5.9)
4. The *RX* column indicates the various IBOC and analog receivers to be used for each test.
5. The *Audio Cut* column indicates the audio selection to be played on the desired channel

Table 5-10 Subjective Performance with Co-Channel/Adjacent Channel Interferers

#	Lower 2nd adj.	Lower 1st adj.	Desired	Upper 1st adj.	Upper 2nd adj	Co-Channel	RX	Audio Cut
				NRSC D.1				
5351			Hybrid: Moderate			Hybrid: 10%BLER-2dB	IBOC	Messiah
5352			Analog: Moderate			Analog: 10%BLER-2dB	1 Auto, 1 Hi-Fi	Messiah
5353			Hybrid: Moderate			Hybrid: 10%BLER-2dB	IBOC	Earth
5354			Analog: Moderate			Analog: 10%BLER-2dB	1 Auto, 1 Hi-Fi	Earth
				NRSC D.2				
5355		Hybrid: 10%BLER-2dB	Hybrid: Moderate				IBOC	Stravinsky
5356		Analog: 10%BLER-2dB	Analog: Moderate				2 Auto, 1 Hi-Fi, 1 Portable	Stravinsky
5357		Hybrid: 10%BLER-2dB	Hybrid: Moderate				IBOC	CSNY
5358		Analog: 10%BLER-2dB	Analog: Moderate				2 Auto, 1 Hi-Fi, 1 Portable	CSNY
5359		Hybrid: 10%BLER-2dB	Hybrid: Moderate	Hybrid: +6dB			IBOC	Saito
5360		Analog: 10%BLER-2dB	Analog: Moderate	Analog: +6dB			2 Auto, 1 Hi-Fi, 1 Portable	Saito
5361		Hybrid: 10%BLER-2dB	Hybrid: Moderate	Hybrid: +6dB			IBOC	Vega
5362		Analog: 10%BLER-2dB	Analog: Moderate	Analog: +6dB			2 Auto, 1 Hi-Fi, 1 Portable	Vega
				NRSC D.3				
5363	Hybrid: 10%BLER–2dB		Hybrid: Moderate				IBOC	Debussy
5364	Analog: 10%BLER–2dB		Analog: Moderate				1 Hi-Fi, 1 Portable	Debussy
5365	Hybrid: 10%BLER–2dB		Hybrid: Moderate				IBOC	Travis
5366	Analog: 10%BLER–2dB		Analog: Moderate				1 Hi-Fi, 1 Portable	Travis

#	Lower 2nd adj.	Lower 1st adj.	Desired	Upper 1st adj.	Upper 2nd adj	Co-Channel	RX	Audio Cut
5367	Hybrid: 10%BLER–2dB		Hybrid: Moderate	Hybrid: +6dB			IBOC	1812
5368	Analog: 10%BLER–2dB		Analog: Moderate	Analog: +6dB			1 Hi-Fi, 1 Portable	1812
5369	Hybrid: 10%BLER–2dB		Hybrid: Moderate	Hybrid: +6dB			IBOC	REO
5370	Analog: 10%BLER–2dB		Analog: Moderate	Analog: +6dB			1 Hi-Fi, 1 Portable	REO
5371	Hybrid: 10%BLER–2dB		Hybrid: Moderate		Hybrid: -20dB		IBOC	Ibert
5372	Analog: 10%BLER–2dB		Analog: Moderate		Analog: -20dB		1 Hi-Fi, 1 Portable	Ibert
5373	Hybrid: 10%BLER–2dB		Hybrid: Moderate		Hybrid: -20dB		IBOC	Grant
5374	Analog: 10%BLER–2dB		Analog: Moderate		Analog: -20dB		1 Hi-Fi, 1 Portable	Grant

Procedure

1) The IBOC receiver and four analog receivers will be used for this test series (see Appendix A).
2) Table 5-10 shall be used as a guide for setting up each channel condition. Each row of the test table shall be executed individually.
3) Establish the signal strength, frequency, and mode of the desired signal as indicated in the test grid. For a complete definition of the desired analog and desired hybrid signals, refer to 2.1.1 and 2.1.7, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
4) Establish the signal strength, frequency, and mode of the undesired signal (if applicable) as indicated in the test grid. For a complete definition of the undesired analog and undesired hybrid signals, refer to 2.1.14 and 2.1.16, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
5) Set the audio dynamic range processing of the desired channel to a preset which corresponds to the audio cut indicated in the test grid. Refer to Appendix B for a list of presets that should be used with each audio cut.
6) Begin recording the output of the IBOC or analog receiver to digital audio tape according to 3.3.1.
7) Play the appropriate audio cut on the desired channel, as indicated in the test grid. Loop this audio cut twice.
8) Perform the audio transfer, editing, leveling and renaming process described in 3.3.2 and 3.3.3.

Presentation of Data

The test results shall consist of digital audio recordings. Each audio cut will be recorded twice. However, the first cut will be discarded, as it is intended to allow the processor sufficient settling time. The remaining audio cut shall be considered the final test result.

5.11 Objective Performance with Interferers and Multipath

Objectives

1. Quantify the performance of the IBOC system under various adjacent and co-channel interference scenarios in multipath impaired channel conditions.

2. Identify the Desired to Undesired Ratio (D/U) that corresponds to a 10% Block Error Rate (BLER), for use in the subjective tests of section 5.12.

Methodology

This test series will utilize the test platform to simulate various co and adjacent channel interference scenarios with multipath impairments. In each of these interference scenarios, the performance of a hybrid IBOC signal will be characterized. This characterization will include information on the Block Error Rate (BLER) and "Mode" of the IBOC signal.

The channel conditions will be chosen such that they represent critical transition regions in IBOC operation. For example, as the level of adjacent channel interference is increased, IBOC is expected to eventually transition from a digital mode of operation to a "blend" mode of operation. Once in blend mode, the IBOC receiver will rely on the analog portion of the signal for audio recovery. It is expected that the IBOC receiver will recover error free audio in more benign channel conditions. Therefore, it is only necessary to perform tests near this critical transition point, where IBOC blends to analog. (The NRSC has traditionally referred to this region as the "point of blend").

It has been empirically determined that these "blend events" often occur when the IBOC BLER is between 2% and 10%, depending on the distribution of errors. Using this rule of thumb, the test engineer shall coarsely determine the level of adjacent channel interference that results in a 10% IBOC BLER. Once this interference level has been coarsely determined, precision tests will be executed at additional points above and below this 10% BLER point. At each of these additional test points, BLER and mode measurements will be repeated three times. Each of these BLER and mode measurements will be taken over the specified amount of time.

Once a sufficient amount of data is collected, a plot of BLER vs. D/U and Mode vs. D/U shall be generated. This plot will illustrate the error rates and mode of the IBOC signal in the "blend to analog" transition region.

Using this plot of BLER and Mode vs. D/U, the test engineer will determine which level of adjacent or co-channel interference most closely corresponds to an IBOC BLER of 10% (some interpolation may be necessary). This data will be recorded for use in subsequent subjective tests

Test Conditions

Table 5-11 lists the interference scenarios included in this series of tests. These scenarios were chosen by the NRSC DAB Subcommittee. Note that the primary test variable is indicated by the caption 'Variable'. The following information may also be helpful in understanding the construction of this table:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the #column.
2. The *Desired* column indicates the mode and power level of the desired signal. The mode is indicated as either: *Analog* or *Hybrid*. The power is indicated as: *Strong (-47dBm), Moderate (-62dBm),* or *Weak (-77dBm).*

3. The interferer columns indicate the mode and power level of interfering signals. If a fixed number is given (e.g. +6), this number represents the power of the interferer, expressed as a D/U ratio.
4. The *Multipath* column indicates the type of multipath applied to each signal in the scenario (refer to Appendix D for multipath profile details)
5. The *Msmt Interval(sec)* column indicates the time period for each BLER measurement. The number 60, for example, would indicate that the IBOC system shall be evaluated for errors and mode over a 60 second time period.
6. The *# BLER Msmts* column indicates how many times the BLER and mode measurements will be repeated.
7. The *Step Size(dB)* column specifies the incremental step size that shall be used when increasing the level of impairment. For example, a 1.0dB step size would indicate that the impairment level will be increased in 1.0dB steps, as appropriate BLER/Mode measurements are performed at each step. (Note that this corresponds to horizontal resolution on a BLER vs. D/U plot.)

Table 5-11 Objective Performance with Co-Channel/Adjacent Channel Interferers and Multipath

#	Lower 2nd adj.	Lower 1st adj.	Desired	Upper 1st adj.	Upper 2nd adj	Co-Channel	Multi-path	Msmt Interval (sec)	# BLER Msmt	Step Size (dB)
NRSC Tests E.1										
5401			Hybrid: Moderate			Hybrid: Variable	US	360	3	1
5402			Hybrid: Moderate			Hybrid: Variable	UF	180	3	1
5403			Hybrid: Moderate			Hybrid: Variable	TO	180	3	1
5404			Hybrid: Moderate			Hybrid: Variable	RF	180	3	1
NRSC Tests E.2										
5405		Hybrid: Variable	Hybrid: Moderate				US	360	3	2
5406		Hybrid: Variable	Hybrid: Moderate				UF	180	3	2
5407		Hybrid: Variable	Hybrid: Moderate				TO	180	3	2
5408		Hybrid: Variable	Hybrid: Moderate				RF	180	3	2
5409		Hybrid: Variable	Hybrid: Moderate	Hybrid: +6dB			US	360	3	2
5410		Hybrid: Variable	Hybrid: Moderate	Hybrid: +6dB			UF	180	3	2
5411		Hybrid: Variable	Hybrid: Moderate	Hybrid: +6dB			TO	180	3	2
5412		Hybrid: Variable	Hybrid: Moderate	Hybrid: +6dB			RF	180	3	2
NRSC Tests E.3										
5413	Hybrid: Variable		Hybrid: Moderate				US	360	3	2
5414	Hybrid: Variable		Hybrid: Moderate				UF	180	3	2
5415	Hybrid: Variable		Hybrid: Moderate				TO	180	3	2
5416	Hybrid: Variable		Hybrid: Moderate				RF	180	3	2

#	Lower 2nd adj.	Lower 1st adj.	Desired	Upper 1st adj.	Upper 2nd adj	Co-Channel	Multi-path	Msmt Interval (sec)	# BLER Msmt	Step Size (dB)
5417	Hybrid: Variable		Hybrid: Moderate	Hybrid: +6dB			US	360	3	2
5418	Hybrid: Variable		Hybrid: Moderate	Hybrid: +6dB			UF	180	3	2
5419	Hybrid: Variable		Hybrid: Moderate	Hybrid: +6dB			TO	180	3	2
5420	Hybrid: Variable		Hybrid: Moderate	Hybrid: +6dB			RF	180	3	2
5421	Hybrid: Variable		Hybrid: Moderate		Hybrid: -20dB		US	360	3	2
5422	Hybrid: Variable		Hybrid: Moderate		Hybrid: -20dB		UF	180	3	2
5423	Hybrid: Variable		Hybrid: Moderate		Hybrid: -20dB		TO	180	3	2
5424	Hybrid: Variable		Hybrid: Moderate		Hybrid: -20dB		RF	180	3	2

Procedure

1) The IBOC receiver shall be used for this test series.
2) Table 5-11 shall be used as a guide for setting up each channel condition. Each row of the test table shall be executed individually.
3) Establish the signal strength, frequency, and mode of the desired signal as indicated in the test grid. For a complete definition of the desired hybrid signal, refer to 2.1.7. The procedures for measuring hybrid power may be found in 3.1.2.
4) Establish the signal strength, frequency, and mode of the undesired signal(s) as indicated in the test grid. For a complete definition of undesired analog and undesired hybrid signals, refer to 2.1.14 and 2.1.16, respectively. The procedures for measuring FM power may be found in 3.1.1 and 3.1.2.
5) Set up the appropriate multipath simulation on the desired channel and undesired channels. Note that there are actually three separate simulations to set up, one for each channel. Refer to Appendix D for complete details on each multipath profile. Wait 30 seconds for the multipath simulation to settle into its normal operating mode.
6) Modulate the desired channel with Clipped Pink Noise (section 2.2.1)
7) Modulate the undesired channel(s) with Processed Rock (section 2.2.2)
8) Set the D/U ratio of the *variable* interferer to a low power level.
9) Increase the D/U ratio of the variable interferer in coarse increments until a BLER of approximately 10% is observed.
10) Perform high resolution BLER and mode measurements at a sufficient number of impairment levels above and below the 10% BLER point. Use step sizes and measurement intervals as specified in Table 5-11. (Note that BLER measurements may not be possible in cases where the system has transitioned completely to analog mode).

Presentation of Data

Plot BLER vs. D/U and Mode vs. D/U on a common graph. At each D/U ratio, *all three* BLER and mode measurements shall be reported - there shall be *no* averaging of the data.