Phase I Study Report for the

NRSC AFAB FMTG FM Multiplex Task Group on Compatibility of

Single Sideband Stereo FM Transmissions

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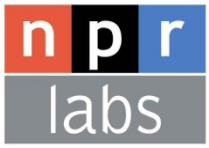

COMPATIBILITY OF SINGLE SIDEBAND STEREO FM TRANSMISSIONS

ABSTRACT

This report presents the results of research and testing of Single Sideband Stereo for FM Transmission. The objective of this study was to determine the compatibility in frequency-modulation sound broadcasting using Single Sideband Suppressed-Carrier Stereo (SSBSC) in comparison with the current Double Sideband Suppressed-Carrier Stereo (DSBSC) method. Specifically, this phase of testing was intended to determine the radio-frequency protection ratios in frequency-modulation sound broadcasting using Single Sideband Suppressed-Carrier Stereo in comparison with the current Double Sideband Suppressed-Carrier Stereo method. (RF protection ratios determine the minimum value of desired-to-interfering signal ratio to produce a target audio signal to noise ratio, by means of objective measurement with a meter intended to represent the ear's sensitivity to low level audio noise and interference.) The transmission standards applied conformed to the U.S. FM broadcast system defined in 47 CFR Part 73. The testing procedures were based on pertinent ITU recommendations for RF protection ratio measurements.

INTRODUCTION

This study was designed to determine the radio-frequency protection ratios in frequency-modulation sound broadcasting using Single Sideband Suppressed-Carrier Stereo, and compare it to ratios determined in the same manner using the current Double Sideband Suppressed-Carrier Stereo method. The RF protection ratio is the minimum value of desired-to-interfering signal ratio at which a target audio signal to noise ratio is achieved. In these tests the audio SNR is measured objectively with a standard psophometer, a meter intended to represent the ear's sensitivity to low level audio noise and interference.

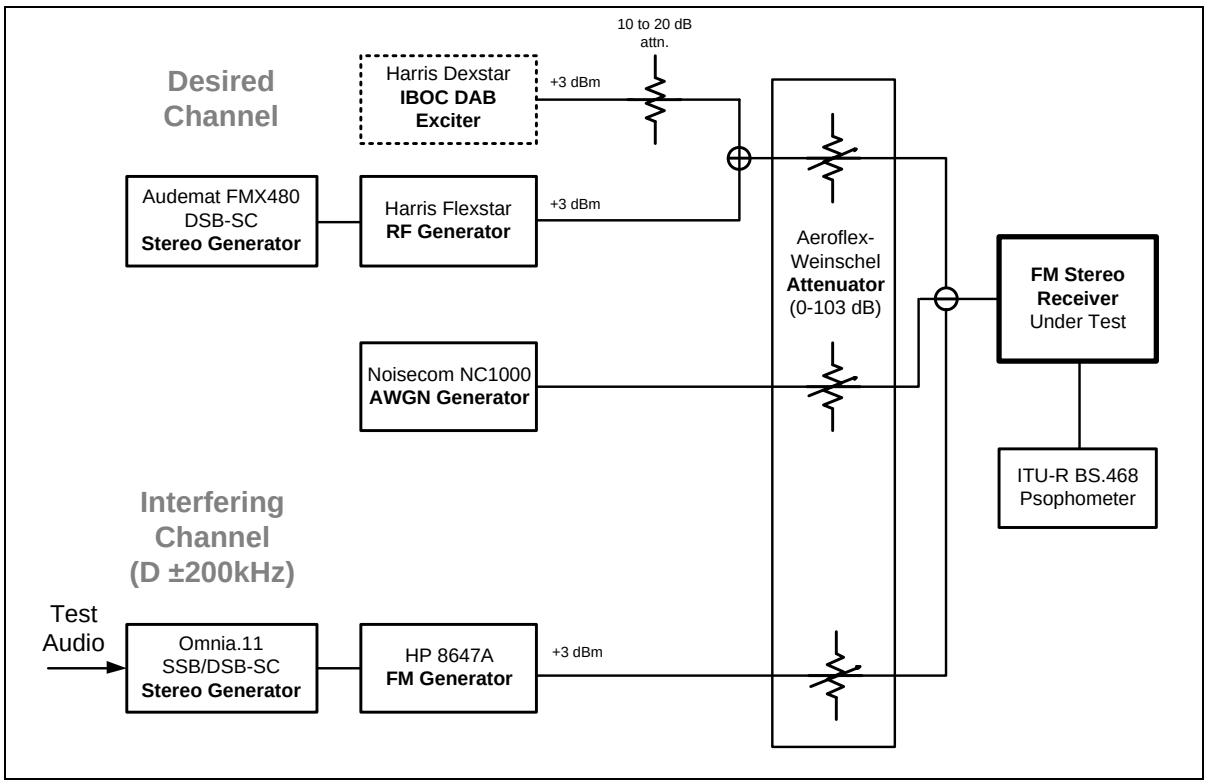

Figure 1 - Diagram of RF test bed used for D/U ratio measurements

Tests were performed with interfering signals for both co-channel and first-adjacent channel (±200kHz relative to the desired carrier). A diagram of the RF test bed is shown above and a summary of the test procedure is included as Table 2.

The Desired Channel was operated with symmetrical IBOC sidebands in the P1 mode at -14dBc, which is the FCC's "blanket increase" level at which any station may operate, and is also approximately mid-way between the maximum injection allowable (-10 dBc) and the original implementation level (-20 dBc). Experiment with other digital injection levels showed that

IBOC injection with the P1 mode had a minimal effect of the results. In part this is because the noise degradation criteria for testing the impact of compatibility with co- and first-adjacent interference from DSBSC and SSBSC was capped at a weighted quasi-peak audio SNR of -40 dB, which is a slightly lower noise level than was observed with the majority of stereo FM receivers from host IBOC noise.[1] If a very low-noise criteria (e.g., -50 dB WQPSNR) was used for these tests the effect of IBOC host noise would exceed that threshold for many receivers, rendering interference from the undesired stereo FM signal immeasurable. (In the P3 multicast mode, IBOC host noise could exceed -40 dB WQPSNR with some stereo receivers.)

The Interfering Channel operated in standard analog-only mode, to avoid the effect of IBOC sideband interference on adjacent-channel tests. The values of protection ratio apply to interference from a single source. Additive White Gaussian Noise was inserted at a level of 30,000 degrees Kelvin to represent signal interference and manmade RF noise intercepted by consumer receivers. Measurements were conducted at RF signal powers of -60 dBm and -40 dBm, representing moderately-weak and moderately-strong receive signal conditions. The effect of SSBSC and DSBSC RF protection ratio (D/U) was determined for a received audio signal-to-noise ratio, based on procedures in Recommendation ITU-R BS.641 ("Objective two-signal method of measurement for transmission standards using a maximum frequency deviation of 75 kHz and a pre-emphasis of 50 μs"). This procedure specifies the use of weighted quasi-peak audio SNR with a psophometer defined by Rec. BS.468. This measurement, often referred to as a "weighted quasi-peak audio signal-to-noise ratio" (WQPSNR) has been shown to provide a good correlation to listener's perception of reception quality in the presence of low levels of noise and interference.[2]

Measurements were conducted at near the center of the FM band, on 97.3 MHz and 97.7 MHz for the lower and upper adjacent channels, respectively, and 97.5 MHz for cochannel tests. The same output levels were used for the desired and undesired RF generators, so that the D/U ratios are determined from the difference in the attenuator settings required to produce the target WQPSNR.

Seven consumer analog FM receivers were selected for testing, shown in Table 1, providing a variety of receiver types and RF performance. All of the receivers have conventional DSBSC stereo decoders. While the group is a limited cross-section of radios, the test is focused more on

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[1] "Report to the CPB and FCC on the Advanced IBOC Coverage and Compatibility Study", John Kean, NPR Labs, Nov. 24 2009, pp. 43-49.

[2] "Consumer Ratings of Impaired Audio at Various Signal/Noise Ratios", E. Sheffield, J. Kean, D. Schwab, NAB Engineering Conference Proceedings, 2008.

the effect on RF protection ratio of SSBSC versus DSBSC, rather than receiver performance. As discussed further below, the results show similarities that suggest that additional receivers would not significantly alter the outcome of the study. All receivers were measured with direct connection to their antennal input. This ensured that the signal power delivered to each receiver was substantially the same.

Table 1 - Receivers used in measurements

After-Market Car Radio	Kenwood KDC-3025 	Kenwood EZ-500 
OEM Car Radio	2002 Ford Mustang 	
Desktop Radio	Panasonic SA-PM19 	Bose Wave 
Home Stereo Receiver	Sony STR-DE-197 	
Hi-Performance Tuner	Denon TU-680NAB 	

TEST RESULTS

The effect of SSBSC and DSBSC stereo FM interference on RF protection ratio (D/U) is reported for the seven receivers in Tables 1 through 7. These tables present the raw data from the tests for the following four conditions:

RF Level	Audio WQPSNR Criteria
-40 dBm	30 dB
	40 dB
-60 dBm	30 dB
	40 dB

The D/U ratios are reported for seven modulating tests:

Stereo Modulation Type	Audio Signal	Description
DSBSC	*L+R DSB*	Stereo left and right (equal, in-phase) modulation, stereo pilot and no L-R subcarrier
	L DSB	Left-only encoded channel of a normal DSB-SC modulated signal (Right input has no audio)
	R DSB	Right-only encoded channel of a normal DSB-SC modulated signal (Left input has no audio)
	L-R DSB	DSB-SC signal with only stereo pilot and encoded L-R (left and right equal, opposite phase) DSB-SC signal (no L+R baseband component is produced)
SSBSC	*L-R DSB*	SSB-SC signal with only stereo pilot and encoded L-R (left and right equal, opposite phase) SSB-SC signal (no L+R baseband component)
	L DSB	Left encoded channel of a normal SSB-SC modulated signal (Right input has no audio)
	R DSB	Right encoded channel of a normal SSB-SC modulated signal (Left input has no audio)

Note that *L+R DSB* (L=R) is not repeated for SSBSC: no L-R subchannel signal is generated in either case, making this the same signal for SSBSC and DSBSC.

The "D/U ratios" in the tables are the RF ratio, in dB, of the 97.5 MHz desired FM stereo carrier to an undesired FM stereo carrier (listed in frequency from left to right) at 97.3 MHz (lower first adjacent channel), 97.5 MHz (cochannel) and 97.7 MHz (upper first adjacent channel). The ratio is determined from the nearest RF attenuator setting ("attn. (dB)") at which the specified Audio WQPSNR criterion is met. For example, setting the RF attenuator for the desired to 40 dB produces a desired RF level of -40 dBm, while an undesired RF attenuator setting of 50 dB

would produce an undesired signal level 10 dB lower, at -50 dBm. This combination results in a desired-to-undesired (D/U) ratio of 10 dB, such as:

-40 dBm [desired] – (-50 dBm) [undesired] = 10 dB [D/U].

The four columns to the right of the receiver test tables reduce the data for comparison to the *L+R DSB* modulation for each test condition. *L+R DSB* is the reference modulation ("ref") against which all the other modulations (*L DSB, R DSB, L-R DSB, L-R SSB, L SSB,* and *R DSB*) are compared. Thus, the entries on the six rows below *L+R DSB* show the *change* in D/U ratio for each test condition relative to *L+R DSB* ("ref"), such as:

-14 dB [*L+R DSB D/U*] – (-12 dB) [*L DSB*] = -2 dB [*L D/U rel. L+R DSB*].

To illustrate the calculations, the Panasonic SA-PM19 receiver listed in Table 3 has an L+R DSB lower-adjacent channel D/U of -14 dB (undesired is 14 dB stronger than the desired signal), but a *L DSB* D/U of -12 dB, which is 2 dB weaker to cause the same degradation. The upper sideband test was -2 dB in both tests, so the difference was 0 dB. The average of the two adjacent channel tests was -1 dB.[3]

In the above example, note that this result is a negative number for the change in L: because the required level of the interfering signal became less negative, the interfering signal under test had decreased in comparison to the reference condition. For adjacent channel tests, all of which produce negative D/U ratios in dB, a negative difference indicates greater receiver sensitivity to the interference.

Before charting the results, some additional processing is performed. The Lower ("*L*") and Upper ("*U*") adjacent channel data is averaged together for each modulation condition in the "*L&U*" column. The change in cochannel ("*CoChan*") D/U ratio is also compared to the *L+R DSB* condition for each test. Some logic is applied to the cells in the four right columns so that a lack of *L+R DSB* data will prevent a D/U ratio calculation, resulting in a "*" entry. (Although the RF attenuators have a 100 dB range, there were some interference conditions that exceeded the attenuator's setting range.) If only one first-adjacent measurement ("*L*" or "*U*") is present, the single data appears in the averaged ("*L&U*") cell. However, if both *L* and *U* are unavailable a "*" entry appears in *L&U*.

For the charts, below, the results from all receivers are averaged together within a common condition of signal power and modulation under test. Based on the negative polarity of all of the adjacent-channel tests, all other stereo modulation conditions result in a decrease in the required D/U ratio, which is represented as a positive change in relation to the L+R DSB reference. The

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[3] The asymmetry shown in these tests is common for many FM receivers using analog intermediate-frequency amplifiers, whose filters may vary in center frequency slightly above or below 10.7 MHz. Tests of this type are very sensitive to this asymmetry, although the effect on reception is relatively small. Averaging the upper and lower adjacent channels help to cancel out these variations in asymmetry.

left and right audio measurements are the same RF condition and have been averaged together for greater precision in the charts.

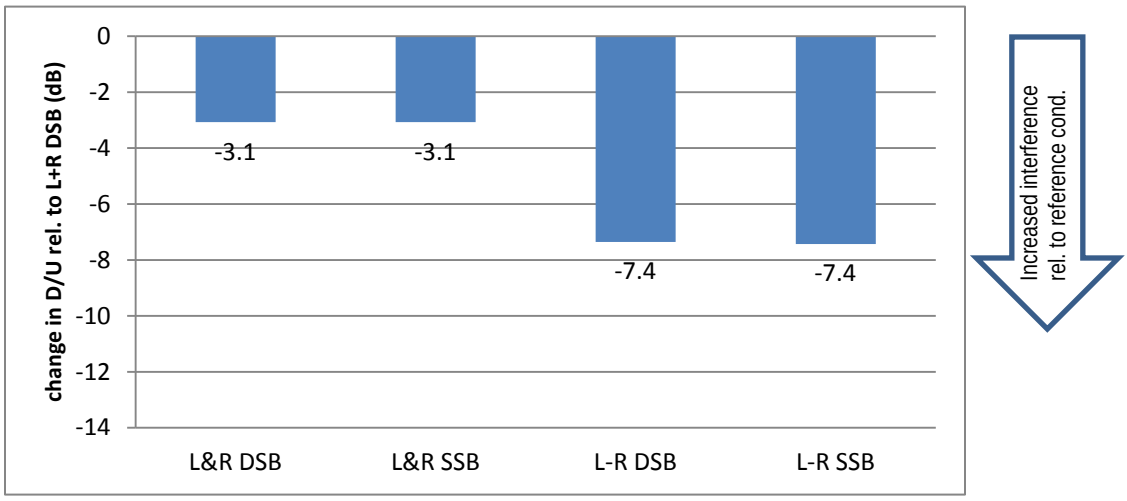

Figure 2 – Change in adjacent-channel ratios for 40 dB WQPSNR at -40 dBm

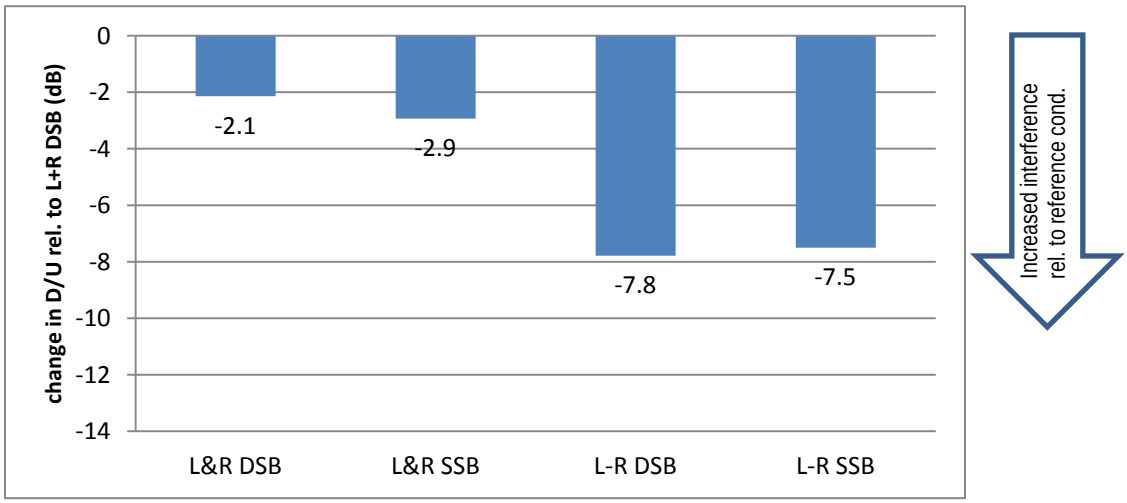

Figure 3 – Change in adjacent-channel ratios for 40 dB WQPSNR at -60 dBm

Figure 2 shows that at -40 dBm, a relatively strong received signal and a moderately quiet WQPSNR of 40 dB, the effect of SSB conditions was identical to the DSB counterparts. The actual values are listed below each of the graph bars.

The results in Figure 3 show the adjacent channel effects at the same noise criteria (40 dB WQPSNR), but at a weaker signal power of -60 dB. Taking the left and right channel tests together, the SSB tests averaged less than 1 dB less favorably than the DSB tests. The L-R tests were effectively a tie between DSB and SSB.

- In the next two charts the audio WQPSNR criterion was lowered to 30 dB, where noise begins to be perceptible, but not annoying, with most programming. In Figure 4 and Figure 5 the results at -40 dBm and -60 dBm, respectively, for L&R DSB and L&R SSB are within 0.6 dB, which is not significant. However, the result for L-R SSB in Figure 4 shows a 2 dB

poorer D/U ratio than L-R DSB. It is unclear why this effect was not evident in Figure 2, where the results were equal for both stereo modulation schemes. However, an adjacent channel condition with a desired signal power of -40 dBm is unlikely, as the received field strength would be greater than 70 dBu, making most first adjacent signals weak by comparison. In Figure 5 the impact of L-R SSB is worse than L-R DSB, but by only 0.8 dB, which again is not a significant difference. There is less receiver data for this test, and difference is moderated by the car receivers, probably because the car receivers are partially blended to mono at -60 dBm, which tends to mask differences in the stereo reception.

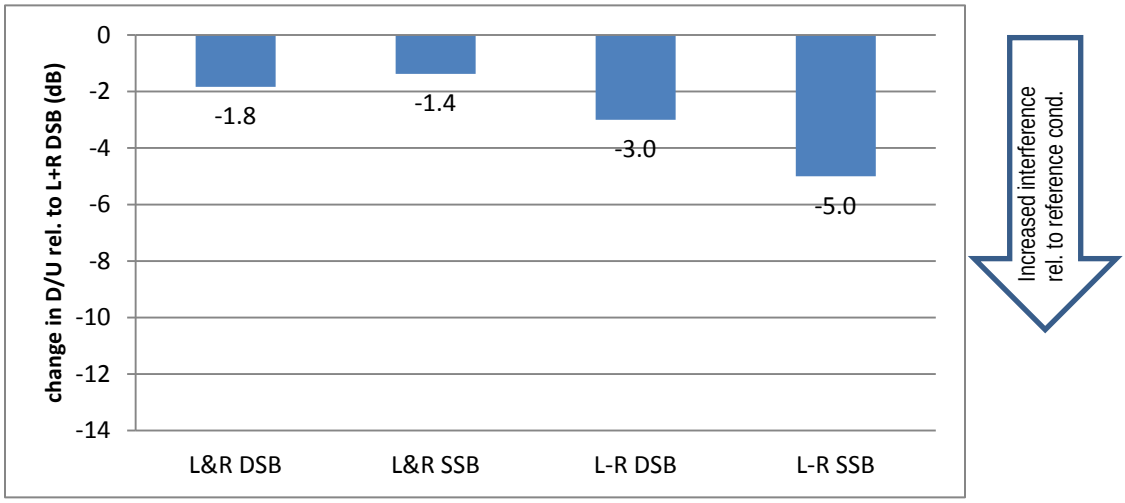

Figure 4 – Change in adjacent-channel ratios for 30 dB WQPSNR at -40 dBm

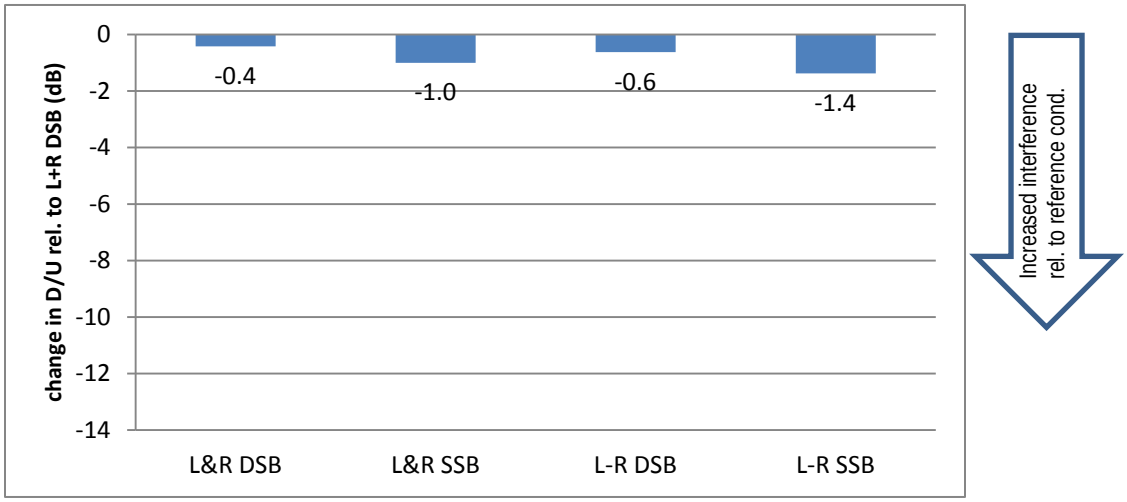

Figure 5 – Change in adjacent-channel ratio for 30 dB WQPSNR at -60 dBm

Figure 6 through Figure 9 show the results with cochannel tests of DSB and SSB. Protection against interference in this case requires a higher desired signal than undesired signal, especially in stereo. This reverses the polarity of the D/U ratio change; however, it is believed to be more appropriate to maintain the same calculation as for adjacent channel tests, such as:

36 dB [*L+R DSB* ref] - 32 dB [*L DSB*] = 4 dB [*CoChan D/U rel. L+R DSB*]

The sign of this result is positive, which is *smaller* in D/U (from 36 to 32 dB) signifying that the receiver is less sensitive to interference than the reference L+R DSB test.

The next two charts, Figure 6 and Figure 7, show the effects with 40 dB WQPSNR at -40 dBm and -60 dBm received signal power. Figure 6 shows no difference between *L&R DSB* and *L&R SSB* in left and right tests. The results for the same tests are lower with *L&R SSB* by 0.8 dB at -60 dBm, meaning that SSB requires 0.8 dB more protection than DSB. For the L-R tests, the D/U ratio is approximately 1.4 dB worse for SSB at -40 dBm, and is 2 dB worse in the same L-R test at -60 dBm.

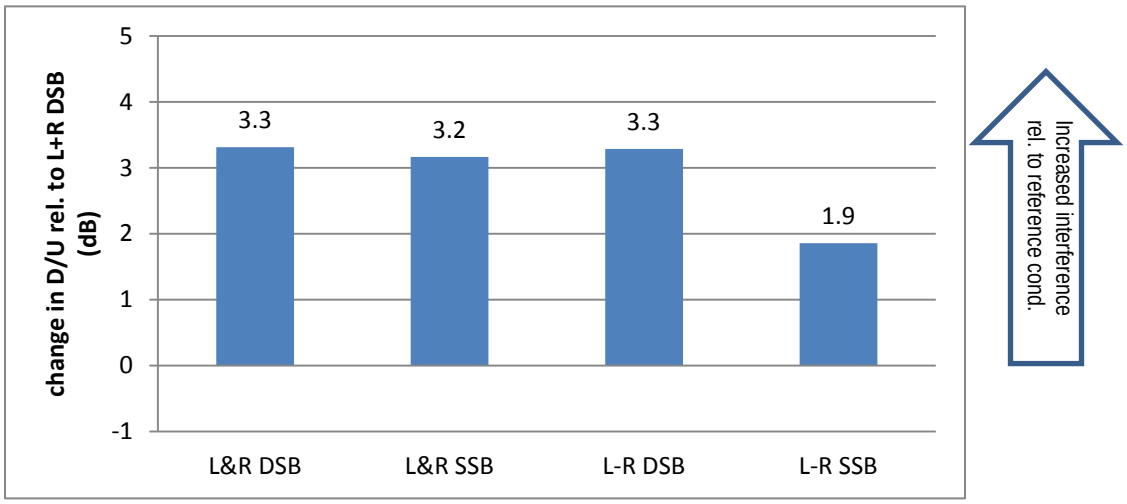

Figure 6 - Cochannel results for 40 dB WQPSNR at -40 dBm

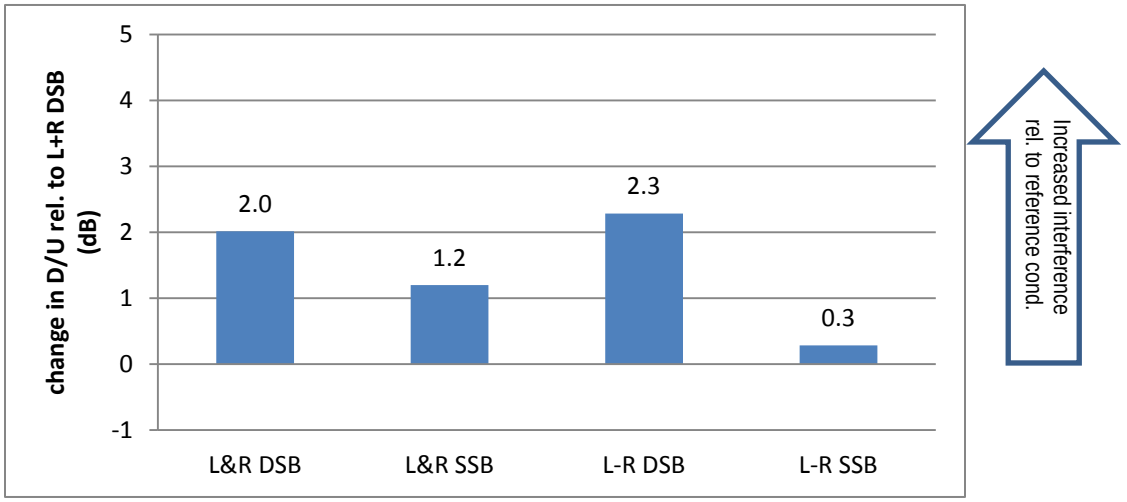

Figure 7 - Cochannel results for 40 dB WQPSNR at -60 dBm

In the tests at 30 dB WQPSNR, the results are slightly worse for SSB. Figure 8 shows that the margin is 2.1 dB worse for *L&R SSB* than *L&R SSB*. In Figure 9, at -60 dBm, the margin for left and right modulation holds at 2.2 dB lower for *L&R SSB*.

For the L-R tests in Figure 8, the SSB interference performance at -40 dBm drops by 3.3 dB relative to DSB. At -60 dBm, in Figure 9, the differences remain 3.2 dB lower with SSB than DSB.

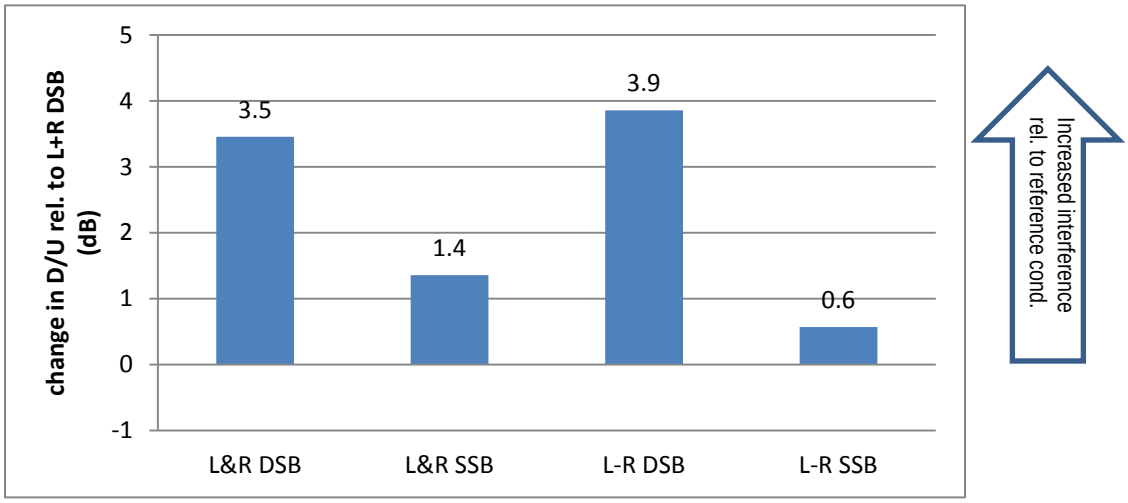

Figure 8 - Cochannel results for 30 dB WQPSNR at -40 dBm

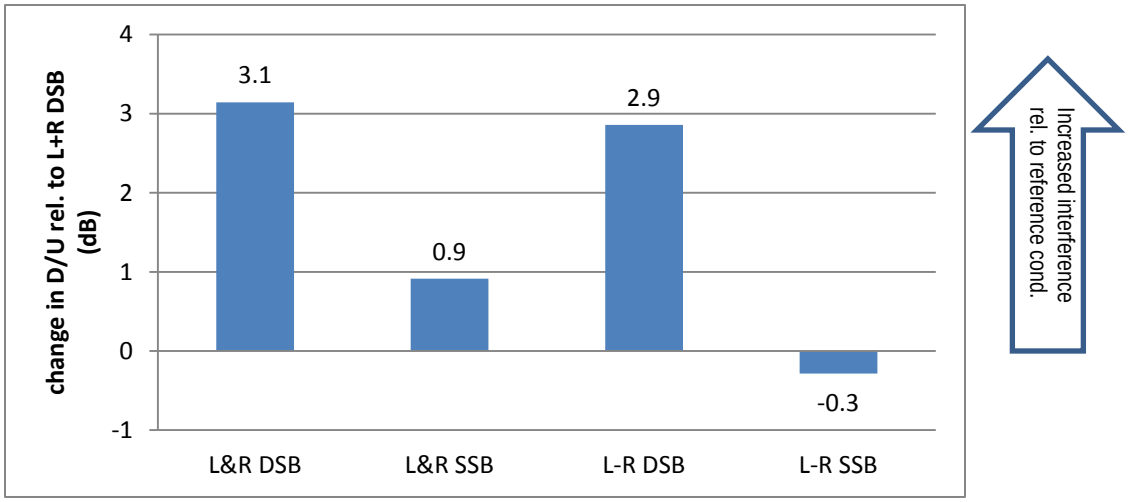

Figure 9 - Cochannel results for 30 dB WQPSNR at -60 dBm

CONCLUSIONS

The results for adjacent channel interference show little difference between SSB and DSB modulation. With cochannel interference there appears to be a tendency for SSB to produce greater interference, particularly in the 30 dB WQPSNR tests. With L-R modulation, all of the SSB results were 1.4 dB to 3.3 dB worse than DSB. It can be argued that L-R is a severe test that does not occur in practice. Overall, then, the differences between SSB and the present DSB stereo are not significant for co- and first-adjacent channel interference conditions.

PROCEDURE FOR RF INTERFERENCE PROTECTION RATIO TESTS

Table 2 - Step-by-step summary of test procedure

Test Procedure	Step #	Description	Notes
Equipment calibrations	1	Perform a daily check of absolute RF levels from the FM and noise generators, as well as modulation and stereo pilot injection (using Belar FMHD-1) for Desired and interfering channel generators.	Note: it has not been determined whether IBOC is needed for these tests, but the generators have been shown with dashed lines in the diagram.
Desired channel RF level	2	Adjust RF attenuator to produce -60dBm (analog FM host) at antenna input of FM stereo receiver under test; note RF attenuator setting	Standard RF receive level, moderately weak condition; RF frequency in mid-FM band (approx. 98 MHz)
AWGN RF level	3	Adjust RF attenuator to produce -100.8dBm (equivalent to 30,000 degree Kelvin at 50 ohms) at antenna input of FM stereo receiver under test	
Desired channel reference audio level setup	4	Set 1kHz tone to produce 100% FM modulation (with stereo pilot at 9%); stereo generator is operated in unprocessed mode; remove 1kHz modulation after psophometer reading	Note psophometer readings on L and R audio channel as Reference for audio SNR levels
Measurement procedure for RF protection ratio	5	Noting reading of psophometer on L (or R) audio channel of receiver, reduce RF attenuator setting until audio SNR is reduced to 40dB; record RF attenuator value and ratio in dB relative to Desired channel	

Carry out measurements according to the following matrix of test conditions
("x" indicates a measurement of the RF ratio of Interfering signal to Desired signal,
"L" and "R" modulation measurements are averaged together)

Interfering Channel: / Modulation:	Co	Lower 1st	Upper 1st
L+R DSB	x	x	x
L DSB	x	x	x
R DSB	x	x	x
L-R DSB	x	x	x
L-R SSB	x	x	x
L SSB	x	x	x
R SSB	x	x	x

Repeat the measurements with an audio SNR target of 30dB

Repeat the measurements with an RF signal level of -40dBm (strong signal)

Repeat the measurements with multiple receivers (e.g., OEM and after-market car, shelf system, table radio)

Table 3 - Protection Ratios for Panasonic SA-PM19 After-Market Car Radio

RF Level	40 dB attn. =		-40 dBm							
Left Ch. Out	40 dB WQPSNR						D/U rel.			
Undesired (MHz)	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	26	-14	76	36	38	-2	ref	ref	ref	ref
L DSB	28	-12	72	32	38	-2	-2	0	-1	4
R DSB	*	*	*	*	*	*	*	*	*	*
L-R DSB	33	-7	72	32	40	0	-7	-2	-4.5	4
L-R SSB	33	-7	74	34	40	0	-7	-2	-4.5	2
L SSB	28	-12	72	32	38	-2	-2	0	-1	4
R SSB	*	*	*	*	*	*	*	*	*	*
RF Level	60 dB attn. =		-60 dBm							
Left Ch. Out	40 dB WQPSNR						D/U rel.			
Undesired	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	45	-15	99	39	58	-2	ref	ref	ref	ref
L DSB	48	-12	95	35	57	-3	-3	1	-1	4
R DSB	*	*	*	*	*	*	*	*	*	*
L-R DSB	55	-5	95	35	60	0	-10	-2	-6	4
L-R SSB	54	-6	96	36	60	0	-9	-2	-5.5	3
L SSB	47	-13	96	36	58	-2	-2	0	-1	3
R SSB	*	*	*	*	*	*	*	*	*	*
RF Level	40 dB attn. =		-40 dBm							
Left Ch. Out	30 dB WQPSNR						D/U rel.			
Undesired (MHz)	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	*	*	66	26	*	*	*	*	*	ref
L DSB	25	-15	62	22	*	*	*	*	*	4
R DSB	*	*	*	*	*	*	*	*	*	*
L-R DSB	25	-15	62	22	36	-4	*	*	*	4
L-R SSB	26	-14	65	25	*	*	*	*	*	1
L SSB	*	*	63	23	37	-3	*	*	*	3
R SSB	*	*	*	*	*	*	*	*	*	*
RF Level	60 dB attn. =		-60 dBm							
Left Ch. Out	30 dB WQPSNR						D/U rel.			
Undesired	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	*	*	86	26	57	-3	*	ref	ref	ref
L DSB	*	*	82	22	*	*	*	*	*	4
R DSB	*	*	*	*	*	*	*	*	*	
L-R DSB	44	-16	83	23	55	-5	*	2	2	3
L-R SSB	44	-16	84	24	56	-4	*	1	1	2
L SSB	*	*	82	22	56	-4	*	1	1	4
R SSB	*	*	*	*	*	*	*	*	*	

* Indicates that data was not collected (e.g., range of signal attenuator was exceeded, psophometer could not read)

Table 4 - Protection Ratios for 2002 Ford Mustang OEM Car Radio

RF Level	40 dB attn. =		-40 dBm							
Left Ch. Out	40 dB SNR						D/U rel. L+R DSB			
Undesired (MHz)	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	20	-20	73	33	23	-17	ref	ref	ref	ref
L DSB	25	-15	70	30	30	-10	-5	-7	-6	3
R DSB	*	*	*	*	*	*	*	*	*	*
L-R DSB	30	-10	70	30	35	-5	-10	-12	-11	3
L-R SSB	30	-10	72	32	35	-5	-10	-12	-11	1
L SSB	24	-16	71	31	28	-12	-4	-5	-4.5	2
R SSB	*	*	*	*	*	*	*	*	*	*
RF Level	60	dB attn. =	-60	dBm						
Left Ch. Out	40 dB SNR						D/U rel. L+R DSB			
Undesired	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	39	-21	95	35	42	-18	ref	ref	ref	ref
L DSB	45	-15	90	30	48	-12	-6	-6	-6	5
R DSB	*	*	*	*	*	*	*	*	*	*
L-R DSB	51	-9	90	30	55	-5	-12	-13	-12.5	5
L-R SSB	51	-9	93	33	53	-7	-12	-11	-11.5	2
L SSB	45	-15	90	30	48	-12	-6	-6	-6	5
R SSB	*	*	*	*	*	*	*	*	*	*
RF Level	40	dB attn. =	-40	dBm						
Left Ch. Out	30 dB SNR						D/U rel. L+R DSB			
Undesired (MHz)	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	18	-22	64	24	22	-18	ref	ref	ref	ref
L DSB	18	-22	60	20	21	-19	0	1	0.5	4
R DSB	*	*	*	*	*	*	*	*	*	*
L-R DSB	19	-21	60	20	22	-18	-1	0	-0.5	4
L-R SSB	*	*	62	22	*	*	*	*	*	2
L SSB	19	-21	60	20	22	-18	-1	0	-0.5	4
R SSB	*	*	*	*	*	*	*	*	*	*
RF Level	60	dB attn. =	-60	dBm						
Left Ch. Out	30 dB SNR						D/U rel. L+R DSB			
Undesired	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	38	-22	83	23	41	-19	ref	ref	ref	ref
L DSB	38	-22	79	19	41	-19	0	0	0	4
R DSB	*	*	*	*	*	*	*	*	*	
L-R DSB	40	-20	80	20	40	-20	-2	1	-0.5	3
L-R SSB	39	-21	81	21	42	-18	-1	-1	-1	2
L SSB	38	-22	80	20	41	-19	0	0	0	3
R SSB	*	*	*	*	*	*	*	*	*	

* Indicates that data was not collected (e.g., range of signal attenuator was exceeded, psophometer could not read)

Table 5 - Protection Ratios for Kenwood EZ-500 After-Market Car Radio

RF Level	40	dB attn. =	-40	dBm						
Left Ch. Out	40 dB SNR						D/U rel. L+R DSB			
Undesired (MHz)	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	20	-20	74	34	24	-16	ref	ref	ref	ref
L DSB	24	-16	71	31	26	-14	-4	-2	-3	3
R DSB	24	-16	71	31	26	-14	-4	-2	-3	3
L-R DSB	32	-8	71	31	34	-6	-12	-10	-11	3
L-R SSB	31	-9	73	33	33	-7	-11	-9	-10	1
L SSB	24	-16	71	31	26	-14	-4	-2	-3	3
R SSB	24	-16	71	31	26	-14	-4	-2	-3	3
RF Level	60	dB attn. =	-60	dBm						
Left Ch. Out	40 dB SNR						D/U rel. L+R DSB			
Undesired	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	40	-20	96	36	44	-16	ref	ref	ref	ref
L DSB	44	-16	93	33	46	-14	-4	-2	-3	3
R DSB	44	-16	93	33	46	-14	-4	-2	-3	3
L-R DSB	53	-7	93	33	55	-5	-13	-11	-12	3
L-R SSB	52	-8	97	37	53	-7	-12	-9	-10.5	-1
L SSB	44	-16	94	34	46	-14	-4	-2	-3	2
R SSB	44	-16	94	34	46	-14	-4	-2	-3	2
RF Level	40	dB attn. =	-40	dBm						
Left Ch. Out	30 dB SNR						D/U rel. L+R DSB			
Undesired (MHz)	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	19	-21	65	25	*	*	ref	*	ref	ref
L DSB	21	-19	61	21	25	-15	-2	*	-2	4
R DSB	21	-19	61	21	25	-15	-2	*	-2	4
L-R DSB	23	-17	61	21	*	*	-4	*	-4	4
L-R SSB	24	-16	63	23	*	*	-5	*	-5	2
L SSB	21	-19	61	21	25	-15	-2	*	-2	4
R SSB	21	-19	61	21	25	-15	-2	*	-2	4
RF Level	60	dB attn. =	-60	dBm						
Left Ch. Out	30 dB SNR						D/U rel. L+R DSB			
Undesired	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	38	-22	86	26	*	*	ref	*	ref	ref
L DSB	40	-20	81	21	45	-15	-2	*	-2	5
R DSB	40	-20	81	21	45	-15	-2	*	-2	5
L-R DSB	43	-17	82	22	46	-14	-5	*	-5	4
L-R SSB	43	-17	84	24	*	*	-5	*	-5	2
L SSB	41	-19	81	21	*	*	-3	*	-3	5
R SSB	41	-19	81	21	*	*	-3	*	-3	5

* Indicates that data was not collected (e.g., range of signal attenuator was exceeded, psophometer could not read)

Table 6 - Protection Ratios for Kenwood KDC-3025 After-Market Car Radio

RF Level	40 dB attn. =		-40 dBm							
Left Ch. Out	40 dB SNR						D/U rel. L+R DSB			
Undesired (MHz)	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	22	-18	75	35	21	-19	ref	ref	ref	ref
L DSB	26	-14	71	31	25	-15	-4	-4	-4	4
R DSB	26	-14	72	32	25	-15	-4	-4	-4	3
L-R DSB	32	-8	71	31	34	-6	-10	-13	-11.5	4
L-R SSB	32	-8	73	33	33	-7	-10	-12	-11	2
L SSB	26	-14	72	32	27	-13	-4	-6	-5	3
R SSB	26	-14	72	32	26	-14	-4	-5	-4.5	3
RF Level	60 dB attn. =		-60 dBm							
Left Ch. Out	40 dB SNR						D/U rel. L+R DSB			
Undesired	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	*	*	95	35	44	-16	*	ref	ref	ref
L DSB	46	-14	92	32	46	-14	*	-2	-2	3
R DSB	47	-13	92	32	47	-13	*	-3	-3	3
L-R DSB	52	-8	92	32	53	-7	*	-9	-9	3
L-R SSB	52	-8	94	34	54	-6	*	-10	-10	1
L SSB	46	-14	93	33	48	-12	*	-4	-4	2
R SSB	46	-14	93	33	47	-13	*	-3	-3	2
RF Level	40 dB attn. =		-40 dBm							
Left Ch. Out	30 dB SNR						D/U rel. L+R DSB			
Undesired (MHz)	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	*	*	63	23	*	*	*	*	*	ref
L DSB	*	*	59	19	*	*	*	*	*	4
R DSB	*	*	60	20	*	*	*	*	*	3
L-R DSB	24	-16	59	19	*	*	*	*	*	4
L-R SSB	*	*	61	21	*	*	*	*	*	2
L SSB	*	*	60	20	*	*	*	*	*	3
R SSB	*	*	60	20	*	*	*	*	*	3
RF Level	60 dB attn. =		-60 dBm							
Left Ch. Out	30 dB SNR						D/U rel. L+R DSB			
Undesired	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	*	*	82	22	*	*	*	*	*	ref
L DSB	*	*	79	19	*	*	*	*	*	3
R DSB	*	*	79	19	*	*	*	*	*	3
L-R DSB	*	*	79	19	*	*	*	*	*	3
L-R SSB	*	*	81	21	*	*	*	*	*	1
L SSB	*	*	80	20	*	*	*	*	*	2
R SSB	*	*	80	20	*	*	*	*	*	2

* Indicates that data was not collected (e.g., range of signal attenuator was exceeded, psophometer could not read)

Table 7 - Protection Ratios for Bose Wave Desktop Radio

RF Level	40 dB attn. =		-40 dBm							
Left Ch. Out	40 dB SNR						D/U rel.			
Undesired (MHz)	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	41	1	73	33	37	-3	ref	ref	ref	ref
L DSB	41	1	70	30	35	-5	0	2	1	3
R DSB	41	1	70	30	35	-5	0	2	1	3
L-R DSB	41	1	71	31	36	-4	0	1	0.5	2
L-R SSB	43	3	72	32	38	-2	-2	-1	-1.5	1
L SSB	41	1	70	30	36	-4	0	1	0.5	3
R SSB	41	1	70	30	36	-4	0	1	0.5	3
RF Level	60	dB attn. =	-60	dBm						
Left Ch. Out	40 dB SNR						D/U rel.			
Undesired	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	51	-9	95	35	47	-13	ref	ref	ref	ref
L DSB	49	-11	92	32	47	-13	2	0	1	3
R DSB	49	-11	92	32	47	-13	2	0	1	3
L-R DSB	52	-8	92	32	52	-8	-1	-5	-3	3
L-R SSB	51	-9	93	33	51	-9	0	-4	-2	2
L SSB	51	-9	91	31	48	-12	0	-1	-0.5	4
R SSB	52	-8	91	31	48	-12	-1	-1	-1	4
RF Level	40	dB attn. =	-40	dBm						
Left Ch. Out	30 dB SNR						D/U rel.			
Undesired (MHz)	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	27	-13	63	23	25	-15	ref	ref	ref	ref
L DSB	33	-7	60	20	26	-14	-6	-1	-3.5	3
R DSB	33	-7	60	20	26	-14	-6	-1	-3.5	3
L-R DSB	34	-6	59	19	28	-12	-7	-3	-5	4
L-R SSB	36	-4	70	30	30	-10	-9	-5	-7	-7
L SSB	27	-13	70	30	27	-13	0	-2	-1	-7
R SSB	27	-13	70	30	27	-13	0	-2	-1	-7
RF Level	60	dB attn. =	-60	dBm						
Left Ch. Out	30 dB SNR						D/U rel.			
Undesired	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	48	-12	83	23	45	-15	ref	ref	ref	ref
L DSB	*	*	80	20	44	-16	*	1	1	3
R DSB	*	*	80	20	44	-16	*	1	1	3
L-R DSB	*	*	81	21	44	-16	*	1	1	2
L-R SSB	48	-12	94	34	46	-14	0	-1	-0.5	-11
L SSB	48	-12	93	33	45	-15	0	0	0	-10
R SSB	48	-12	93	33	45	-15	0	0	0	-10

* Indicates that data was not collected (e.g., range of signal attenuator was exceeded, psophometer could not read)

Table 8 - Protection Ratios for Sony STR-DE-197 Home Stereo Receiver

RF Level	40 dB attn. =		-40 dBm							
Left Ch. Out	40 dB SNR						D/U rel.			
Undesired (MHz)	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	40	0	76	36	36	-4	ref	ref	ref	ref
L DSB	42	2	72	32	40	0	-2	-4	-3	4
R DSB	42	2	72	32	40	0	-2	-4	-3	4
L-R DSB	43	3	72	32	42	2	-3	-6	-4.5	4
L-R SSB	44	4	72	32	42	2	-4	-6	-5	4
L SSB	42	2	72	32	40	0	-2	-4	-3	4
R SSB	42	2	72	32	40	0	-2	-4	-3	4
RF Level	60	dB attn. =	-60	dBm						
Left Ch. Out	40 dB SNR						D/U rel.			
Undesired	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	57	-3	94	34	54	-6	ref	ref	ref	ref
L DSB	56	-4	94	34	54	-6	1	0	0.5	0
R DSB	56	-4	94	34	54	-6	1	0	0.5	0
L-R DSB	56	-4	94	34	56	-4	1	-2	-0.5	0
L-R SSB	57	-3	96	36	55	-5	0	-1	-0.5	-2
L SSB	57	-3	94	34	55	-5	0	-1	-0.5	0
R SSB	57	-3	95	35	55	-5	0	-1	-0.5	-1
RF Level	40	dB attn. =	-40	dBm						
Left Ch. Out	30 dB SNR						D/U rel.			
Undesired (MHz)	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	37	-3	65	25	33	-7	ref	ref	ref	ref
L DSB	37	-3	62	22	35	-5	0	-2	-1	3
R DSB	37	-3	62	22	35	-5	0	-2	-1	3
L-R DSB	38	-2	61	21	37	-3	-1	-4	-2.5	4
L-R SSB	39	-1	63	23	37	-3	-2	-4	-3	2
L SSB	37	-3	62	22	36	-4	0	-3	-1.5	3
R SSB	37	-3	62	22	36	-4	0	-3	-1.5	3
RF Level	60	dB attn. =	-60	dBm						
Left Ch. Out	30 dB SNR						D/U rel.			
Undesired	97.3		97.5		97.7		L+R DSB			
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	*	*	84	24	*	*	*	*	*	ref
L DSB	*	*	83	23	*	*	*	*	*	1
R DSB	*	*	83	23	*	*	*	*	*	1
L-R DSB	*	*	81	21	*	*	*	*	*	3
L-R SSB	*	*	83	23	*	*	*	*	*	1
L SSB	*	*	81	21	*	*	*	*	*	3
R SSB	*	*	82	22	*	*	*	*	*	2

* Indicates that data was not collected (e.g., range of signal attenuator was exceeded, psophometer could not read)

Table 9 - Protection Ratios forTU-680NAB High Performance Tuner

RF Level	40 dB attn. =		-40 dBm							
Left Ch. Out	40 dB WQPSNR						D/U rel. L+R DSB			
Undesired (MHz)	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	26	-14	74	34	24	-16	ref	ref	ref	ref
L DSB	32	-8	71	31	30	-10	-6	-6	-6	3
R DSB	32	-8	71	31	30	-10	-6	-6	-6	3
L-R DSB	35	-5	71	31	34	-6	-9	-10	-9.5	3
L-R SSB	35	-5	72	32	33	-7	-9	-9	-9	2
L SSB	32	-8	71	31	30	-10	-6	-6	-6	3
R SSB	31	-9	71	31	29	-11	-5	-5	-5	3
RF Level	60 dB attn. =		-60 dBm							
Left Ch. Out	40 dB WQPSNR						D/U rel. L+R DSB			
Undesired	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	40	-20	91	31	39	-21	ref	ref	ref	ref
L DSB	46	-14	92	32	46	-14	-6	-7	-6.5	-1
R DSB	46	-14	92	32	46	-14	-6	-7	-6.5	-1
L-R DSB	53	-7	93	33	52	-8	-13	-13	-13	-2
L-R SSB	53	-7	94	34	52	-8	-13	-13	-13	-3
L SSB	47	-13	92	32	47	-13	-7	-8	-7.5	-1
R SSB	47	-13	92	32	47	-13	-7	-8	-7.5	-1
RF Level	40 dB attn. =		-40 dBm							
Left Ch. Out	30 dB WQPSNR						D/U rel. L+R DSB			
Undesired (MHz)	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	*	*	63	23	*	*	*	*	*	ref
L DSB	*	*	59	19	*	*	*	*	*	4
R DSB	*	*	60	20	*	*	*	*	*	3
L-R DSB	26	-14	60	20	25	-15	*	*	*	3
L-R SSB	27	-13	61	21	25	-15	*	*	*	2
L SSB	*	*	61	21	*	*	*	*	*	2
R SSB	*	*	61	21	*	*	*	*	*	2
RF Level	60 dB attn. =		-60 dBm							
Left Ch. Out	30 dB WQPSNR						D/U rel. L+R DSB			
Undesired	97.3		97.5		97.7					
	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	attn. (dB)	D/U Ratio	L	U	L&U	CoChan
L+R DSB	*	*	82	22	*	*	*	*	*	ref
L DSB	*	*	79	19	*	*	*	*	*	3
R DSB	*	*	79	19	*	*	*	*	*	3
L-R DSB	*	*	80	20	*	*	*	*	*	2
L-R SSB	42	-18	81	21	41	-19	*	*	*	1
L SSB	40	-20	79	19	40	-20	*	*	*	3
R SSB	41	-19	79	19	40	-20	*	*	*	3

* Indicates that data was not collected (e.g., range of signal attenuator was exceeded, psophometer could not read)