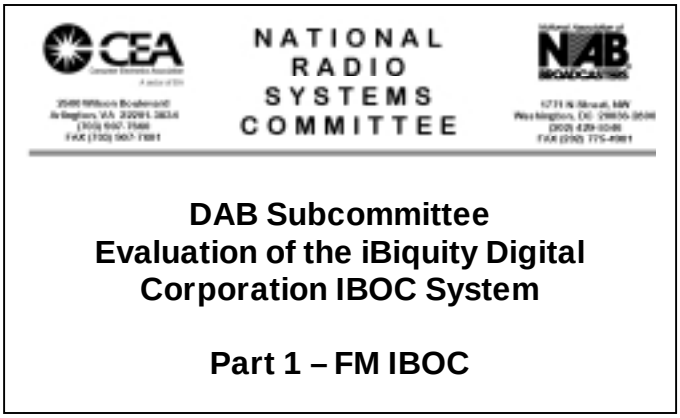
Appendix G –
Discussion of stereo-mono blending in analog receivers



FM stereo automobile radios use a circuit called blend to reduce the audible effects of multipath, adjacent channel interference, and stereo noise. Blending from stereo to mono accomplishes the noise reduction. The choice of blend characteristics is radio manufacturer dependent. Any or all of the following controls the amount of FM stereo blend: RF signal level, 1st adjacent interference, and 2nd through 20th adjacent channel interference. The effects of these blend controlling factors on stereo separations for the two automobile radios used in the IBOC laboratory and field tests are described in this report.

Signal Level Dependent Blend

Table 1 shows the results of stereo separation tests conducted by an independent laboratory with varying levels of RF power at the input of two automobile radios. These radios are the same model used for the IBOC field and laboratory tests. Assuming acceptable stereo to have a separation of 15 dB, the lowest signal level where acceptable stereo can be expected is at a RF power level of -67dBm for both radios. At RF signal levels of –70 dBm and lower, both radios are essentially mono.

Table 1. Signal Level/Stereo Separation
(bold text indicates blending transition region)

AUTOMOBILE RADIO SCENARIO			
LAB RF POWER (DBM)	FIELD STRENGTH AT 30FT ABOVE GROUND (DBU)	SEPARATION (DB)	
		DELPHI	PIONEER
-100	22	0	0
-95	27	0	0
-90	32	0	0
-85	37	0	0
-80	42	0	2
-75	47	3	4
-70	**52**	**7**	**12**
-65	**57**	**17**	**28**
-60	62	37	38
-55	67	31	39
-50	72	31	39

FM Stereo Separation with 1st Adjacent Analog Interferer

Table 2 shows the results of stereo separation tests conducted at four signal levels and four D/U ratios. The table lists the stereo separation for each receiver under varying interference conditions. At signal levels of –62 dBm or stronger and D/U of 6 dB or lower the stereo separation is 28 dB or larger. Only the Pioneer maintained separation at the –62 dBm or stronger signal levels with a D/U of –4 dB or higher. At the –72 dBm and lower signal levels the stereo separation ranged from 0.0 dB to 8.0 dB. Again, assuming acceptable stereo to have a separation of 15 dB or higher, the A-> A D/U ratio of no more than 6 dB and signal level of at least -62 dBm is necessary to produce stereo on the Delphi.

Table 2. FM stereo separation with 1st adjacent analog interference

LAB RF POWER (DBM)	FIELD STRENGTH AT 30FT. ABOVE GROUND (DBU)	STEREO SEPARATION			
		16 DB D/U	6 DB D/U	-4 DB D/U	-14 DB D/U
		SEPARATION DEL/PIO (DB)	SEPARATION DEL/PIO (DB)	SEPARATION DEL/PIO (DB)	SEPARATION DEL/PIO (DB)
-47	75	37/39	37/39	0/39	0/35
-62	60	28/38	28/38	0/38	0/32
-72	50	5/8	5/8	0/8	0/8
-82	40	0/0	0/0	0/0	0/0

FM Stereo Separation with 2nd Adjacent Single Analog Interferer

Table 3 shows the test results of 2nd adjacent stereo separation tests conducted at two signal levels. The Pioneer stereo separation was reduced to 10 dB at the -30 dB D/U at both signal levels. The Delphi lost stereo at the -40 dB D/U.

Table 3. FM stereo separation reduction caused by 2nd adjacent channel

DESIRE SIGNAL LEVEL	D/U –20DB DEL/PIO (DB)	D/U –30DB DEL/PIO (DB)	D/U –40DB DEL/PIO (DB)	D/U –50DB DEL/PIO (DB)
-47dBm	37/37	22/10	5/2	0/0
-62dBm	28/36	18/10	3/2	0/0

FM Stereo Separation with 5th through 20th Adjacent Channels

Table 4 and Table 5 show the results of 5th, 10th, and 20th adjacent A->A channel tests at two signal levels. At the -40 dB D/U the Delphi stereo separation was below 15 dB for 5 of the 6 tests and the Pioneer for 2 of 6 tests. For the -50 dB D/U the best separation was 7 dB for both receivers for all three adjacent channels tested and both signal levels.

Table 4. FM stereo separation controlled by adjacent channels (bold text indicates blending transition region)

5TH THROUGH 20TH -47 DBM				
ADJACENT CHANNEL	D/U –20DB DEL/PIO (DB)	D/U –30DB DEL/PIO (DB)	D/U –40DB DEL/PIO (DB)	D/U –50DB DEL/PIO (DB)
5th	37/41	29/34	**6/8**	0/2
10th	(not tested)	38/40	**10/19**	2/3
20th	(not tested)	37/40	**19/33**	4/7

Table 5. FM stereo separation controlled by adjacent channels (bold text indicates blending transition region)

5TH THROUGH 20TH -62 DBM				
ADJACENT CHANNEL	D/U –20DB DEL/PIO (DB)	D/U –30DB DEL/PIO (DB)	D/U –40DB DEL/PIO (DB)	D/U –50DB DEL/PIO (DB)
5th	28/36	20/36	**4/8**	0/1
10th	(not tested)	26/36	**6/20**	0/3
20th	(not tested)	27/36	**11/36**	2/7

Temporal Blend

During the laboratory characterization test it was found that the blend decay times for the two automobile radios used for the IBOC tests differed by several seconds. To measure this characteristic on a broader base two automobile radios, a Kenwood and Sony, were added to Delphi and Pioneer for the temporal blend tests. It was found that blend off-to-on time was less than one second for all four radios. The decay time for the Pioneer, Sony, and Kenwood radios was less than one second. The Delphi radio's blend decay time was four seconds long.

Conclusion

The threshold of blend to mono system in the automobile FM stereo radio is manufacturer dependent. The predominant controlling factors vary. The blend decay characteristic for one radio is much longer than the other three radios. The two automobile FM stereo radios selected for the IBOC tests represent a cross section of blend performance.