Preparation of Audio Samples of Analog FM Stereo Reception In a Mobile Environment, Demonstrating Impairments With First-Adjacent Interference from Analog, 1% Hybrid and 10% Hybrid Signals

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A set of audio samples were prepared by NPR Labs at its Washington, DC laboratory, to provide a realistic demonstration of IBOC noise impairment at -20 dBc (1% hybrid) and -10 dBc (10% hybrid). The samples represent the mobile analog FM stereo reception at the FCC F(50,50) 60 dBu contour, after taking adjustments for height gain and mobile antenna efficiency.

All samples were prepared with Raleigh fading parameters selected to represent obstructed-path reception at a vehicular speed of 60 km/hr. The receiver is a Chevy Suburban radio (one of the better-performing analog receivers supplied to NPR Labs by the CEA as part of the NRSC's AMSTG project).

The Desired Channel was modulated by an Audemat FMX480 stereo generator, with its compression and FM limiting set to the unit's maximum processing levels. The first adjacent interferer was modulated by dense pop music processed by a Telos Omnia 6EX-HD, to provide a wide FM spectral emission. The levels of the desired and first-adjacent channel interferer were set to a D/U ratio of 6 dB, which is the allocation limit provided by the FCC rules. Additive White Gaussian Noise was injected at approximately 245,500 degrees Kelvin, nearly 10 dB above the 30,000 degrees Kelvin used by the NRSC in the 2001 studies.

The recordings were made as WAV files directly from the speaker outputs of the receiver, with tone controls set to "flat" position. The three recordings represent:

- Analog-only interference, (#01)
- Interference at 1% IBOC (#02) and
- Interference at 10% IBOC (#03).

One should be able to hear the clicks, pops and multipath distortion "hits" with the analog-only interference, as the signal fades over a range of 20-30 dB. The other two recordings are identical, except for the addition of IBOC at the specified levels.

A link budget for the RF test bed is shown below. Since the FCC's F(50,50) curves represent the field strength at 9.1 meters above ground, a reduction of 8.0 dB was made in the signal to the receiver, in addition to an antenna factor (loss) of 5.0 dB. Taking other gains and losses in the RF test bed into account, the equivalent received field at 1.5 meters above ground is 47.4 dBuV (0.23 mV/m). Additive white Gaussian noise at 245,539 degrees Kelvin was inserted into the receiver input, after the 13 dB adjustment described above, to represent environmental noise in FM reception.

FM Host Power — Desired Channel (60 dBuV)

Antenna Factor and Height Gain Adjustments			
Height gain adjustment @ 1.5 m	8.0	dB	relative to FCC F(50,50) field strength
mobile antenna loss factor	5.0	dB	relative to ideal dipole
Equiv. Field	13.0	dB	
Desired Channel Signal Calculation			
Test Frequency	89.7	MHz	
FM Gen output	2.8	dBm	
Dexstar output	2.8	dBm	
1st combiner loss	3.2	dB	
Chan. Sim. Input Pads	11.0	dB	
Chan. Sim. Loss (w/combiners)	33.8	dB	with +10 dBm LO inputs to HP 11759C
Amplifier Gain	25.0	dB	
RF Attenuator setting	43	dB	
Combiner loss	5.7	dB	
Chan. Sim. Output	-68.9	dBm	[B3-B6-B7-B8+B9-B10-B11]
Rcvr. Input	1.3E-10	watts	same as Chan. Sim. Output
Received Field	0.23	mV/m	SQRT(480*PI()^2*(B13)/(300/B2)^2)*1000
Received Field	47.4	dBuV	[60+20*LOG(B14)]
Ant. Factor & Height Gain adj.	13.0	dB	
Equiv. FCC F(50,50) field strength	60.4	dBuV	verification of signal level
AWGN Signal Calculation			
Noise gen. out	-82.0	dBm/Hz	NoiseCom 1110A module
Channel noise power	-29.0	dBm/200kHz	FM receiver equiv. noise power bandwidth
AWGN attenuator	0.0	dB	
RF Attenuator setting	57	dB	
Combiner loss	5.7	dB	
Chan. Sim. Output	-91.7	dBm	
Rcvr. Input	6.8E-13	watts	same as Chan. Sim. Output
Noise Temp.	245,539	deg. K	
Received Field	0.0169	mV/m	dipole reference
Equiv. FCC F(50,50) field strength	24.6	dBuV	before ant. factor & height gain
Ant. Factor & Height Gain adj.	13.0	dB	mobile antenna correction
Received Field	11.6	dBuV	equiv. field at 1.5 meters