ADVANCED TELEVISION TECHNOLOGY CENTER

Digital Audio Broadcasting

Supplementary Analog SCA Compatibility Tests

Summary of Test Results

Document #02-16

April 2002

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1. Introduction

1.1. Background

The Advanced Television Technology Center (ATTC) has conducted an extensive DAB test program over the course of the past two years. This program has primarily focused on fulfilling the laboratory test requirements of the National Radio System Committee's (NRSC) DAB Subcommittee in evaluating iBiquity Digital's IBOC system. As such, many of the test program objectives, methodologies, and test conditions have been well defined by the various NRSC Working Groups.

However, other parties expressed an interest in conducting IBOC DAB tests that were outside the scope of the NRSC process, in order to examine certain aspects of IBOC compatibility in more detail than originally required by the NRSC. In particular, National Public Radio (NPR) and the International Association of Audio Information Services (IAAIS) were interested in further evaluating the compatibility of FM IBOC with existing analog SCA services (e.g. "Reading For The Blind" SCA services).

iBiquity, NPR, IAAIS, and ATTC collaborated to develop test procedures that could be readily executed in the laboratory. Initially, NPR and IAAIS presented a test plan outline to the group that was gradually refined, until everyone was in agreement that the tests were practical and met all appropriate objectives. Once it became apparent that ATTC's test bed automation system could collect a much larger quantity of data than the group originally expected, the methodologies were adjusted such that full SNR vs. D/U graphs could be obtained. These graphs were able to provide test results for the complete range of possible D/U ratios - from the point of no impairment to the point of complete failure, using very fine step sizes. In addition, it was decided that *all* of the available SCA receivers would be tested in adjacent channel reception conditions.

As the test effort progressed, the group developed several static multipath profiles to include in the test program. Since the multipath profiles could not be controlled by the automation system, these tests were executed manually, and a larger step size was used in these cases. A subset of SCA receivers was selected for inclusion in the multipath impaired test conditions.

In many cases, the tests were witnessed by a representative from NPR and/or iBiquity. In other cases, the test bed automation system was allowed to run unattended or overnight. In these cases, an NPR representative collected the test results data shortly thereafter.

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1.2. Scope

This document contains a summary of the test results and methodologies used for Supplementary Analog SCA Compatibility tests.

1.3. Related Documents

The tests results summarized in this document were performed according to the test plan and procedures, as documented in:

ATTC Doc. 02-15, Digital Audio Broadcasting, Supplementary Analog SCA Compatibility Tests, Test Plan and Procedures, April 2002

For information regarding the original Analog SCA Compatibility tests please refer to the following ATTC documents:

ATTC Document No. 01-03, Digital Audio Broadcasting, IBOC Laboratory Test Procedures – FM Band, Revision 4.2, August 2001
ATTC Document No. 01-16B, Digital Audio Broadcasting, SCA Compatibility of the IBOC System in the FM Band, Summary of Test Results, October 2001

Details of the construction and performance of the ATTC IBOC DAB test platform may be found in:

ATTC Document No. 01-20, Digital Audio Broadcasting, Test Bed Proof of Performance Plan, Revision 2.0, November 2001
ATTC Document No. 01-01, Digital Audio Broadcasting, Test Bed Proof of Performance Record, Revision 2.0, November 2001
ATTC Document No. 01-16, Digital Audio Broadcasting, Test Bed Daily Calibration Procedure, Revision 4.0, October 2001
Digital Audio Broadcasting, Test Bed Daily Calibration Record of Test Results"(open ATTC Document)

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2. Summary of Methodology

Various adjacent channel interference and multipath reception conditions were simulated in the laboratory. For each channel condition, tests were conducted to determine the impact of IBOC, if any, on existing SCA services.

Each of these tests included channel impairments that are commonly observed in the FM broadcast band. These interference scenarios were created in the laboratory and the performance of certain commercially available SCA receivers[1] was evaluated. The receivers were tested in the presence and absence of an IBOC signal on either the "host" or adjacent channel. The test conditions utilized were:

1. First adjacent channel interference
2. Second adjacent channel interference
3. "Host" channel interference
4. "Host" channel interference in the presence of multipath

The performance of the SCA receivers was determined *objectively* in the conditions listed. Objective evaluation of an SCA receiver requires the use of standard audio test equipment to measure and objectively quantify audio quality in an accurate and repeatable manner. Audio quality was measured in terms of the audio signal-to-noise ratio (SNR).

An in-depth discussion of the test methodologies and procedures may be found in the test plan and procedures documentation (as referenced in section 1.3).

[1] NPR and the IAAIS chose the SCA receivers that were tested. The tested receivers are listed in section 3.6 of this document.

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3. Description of the Test System and Parameters

3.1. Test Bed Description

The ATTC DAB Test Bed was used to create the test conditions and numerically quantify the Signal-to-Noise ratios (SNR) of SCA receivers under various channel impairments. The performance of the ATTC IBOC DAB Test Bed was verified according to the proof of performance plan detailed in ATTC Document No. 00-05, the results of which are documented in ATTC Document No. 01-01. Both of these documents are referenced in section 1.3.

3.2. FM Band Signals

3.2.1. Desired Analog – Type I

A desired analog Type I signal is designed for use in tests of analog host compatibility with multipath. This type of signal was used in the tests of both 67kHz and 92kHz subcarriers. The injection of both subcarriers for this type of signal is 10% regardless of which SCA is being tested. However, the audio only modulates the SCA being evaluated. When the 67kHz SCA was tested, for example, there was no audio present on the 92kHz SCA (resulting in 0kHz Deviation). This signal type yields a total channel modulation of 110% when configured as shown in Table 3-1.

Table 3-1 - Desired Analog – Type I Signal Characteristics

Main Channel	Main Channel Audio	Power	67kHz Subcarrier	92kHz Subcarrier
1) 97.9MHz 2) Stereo Transmission 3) 10% Pilot Injection 4) 75µs Pre-emphasis 5) Total Modulation = 110%	Clipped USASI with peaks equal 80% modulation (60kHz Peak Deviation)	Moderate (-62dBm)	1) 10% injection 2) 150µs pre-emphasis 3) 6kHz Peak Deviation with a 400Hz Tone – 0kHz with Silence 4) Test Dependent Audio – 400Hz Tone or Silence	1) 10% injection 2) 150µs pre-emphasis 3) 7kHz Peak Deviation with a 400Hz Tone – 0kHz with Silence 4) Test Dependent Audio – 400Hz Tone or Silence

3.2.2. Desired Analog – Type II

A desired analog Type II signal is designed for use in first adjacent interference tests, second adjacent interference tests, and analog host compatibility with no multipath. The injection of the SCA under test was 10% while the other SCA was turned off (0% injection). This configuration yields a total channel modulation of 105% when configured as shown in Table 3-2.

Table 3-2 - Desired Analog – Type II Signal Characteristics

Main Channel	Main Channel Audio	Power	67kHz Subcarrier	92kHz Subcarrier
1) 97.9MHz 2) Stereo Transmission 3) 10% Pilot Injection 4) 75µs Pre-emphasis 5) Total Modulation = 105%	Clipped USASI with peaks equal 85% modulation (63.75kHz Peak Deviation)	Moderate (-62dBm)	1) 10% injection or Off 2) 150µs pre-emphasis 3) 6kHz Peak Deviation with a 400Hz Tone 4) Test Dependent Audio – 400Hz Tone or Silence	1) 10% injection or Off 2) 150µs pre-emphasis 3) 7kHz Peak Deviation with a 400Hz Tone 4) Test Dependent Audio – 400Hz Tone or Silence

3.2.3. Desired Analog – Type III

The Desired Analog Type III signal is the same as a Desired Analog Type I signal, except that a Type III signal specifies no modulation on the main (host) carrier. This signal was also used in tests of analog host compatibility with multipath. The injection of both subcarriers for this type of signal is 10% regardless of which SCA is being tested. However, the audio only modulated the SCA being evaluated. When the 67kHz SCA was tested, for example, there was no audio present on the 92kHz SCA (resulting in 0kHz Deviation). This type of signal yields a total channel modulation of 30%. A Type III signal has the characteristics listed in Table 3-3.

Table 3-3 - Desired Analog – Type III Signal Characteristics

Main Channel	Main Channel Audio	Power	67kHz Subcarrier	92kHz Subcarrier
1) 97.9MHz 2) Stereo Transmission 3) 10% Pilot Injection 4) 75µs Pre-emphasis 5) Total Modulation = 30%	**None**	Moderate (-62dBm)	1) 10% injection 2) 150µs pre-emphasis 3) 6kHz Peak Deviation with a 400Hz Tone – 0kHz with Silence 4) Test Dependent Audio – 400Hz Tone or Silence	1) 10% injection 2) 150µs pre-emphasis 3) 7kHz Peak Deviation with a 400Hz Tone – 0kHz with Silence 4) Test Dependent Audio – 400Hz Tone or Silence

3.2.4. Desired Hybrid – Type I

This signal is defined as the spectral sum of an analog desired signal Type I (as defined in section 3.2.1) and the digital carriers as generated by an iBiquity Digital IBOC exciter in hybrid mode. The digital carriers utilize OFDM modulation. The power sum of *all* digital carriers in the hybrid signal has an *average* power that is 20dB less than the average power in the analog carrier.

3.2.5. Desired Hybrid – Type II

A desired hybrid Type II signal is defined as the spectral sum of an analog desired signal Type II (section 3.2.2) and the digital carriers as generated by an iBiquity Digital IBOC exciter in hybrid mode. The digital carriers utilize OFDM modulation. The power sum of *all* digital carriers in the hybrid signal has an *average* power that is 20dB less than the average power in the analog carrier.

3.2.6. Desired Hybrid – Type III

A Type III desired hybrid signal is defined as the spectral sum of an analog desired signal Type III (section 3.2.3) and the digital carriers as generated by an iBiquity Digital IBOC exciter in hybrid mode. The digital carriers utilize OFDM modulation. The power sum of *all* digital carriers in the hybrid signal has an *average* power that is 20dB less than the average power in the analog carrier.

3.2.7. Undesired Analog

An undesired analog interferer signal was designed for adjacent channel interference tests that employed objective evaluation. Such a signal had the following characteristics:

Table 3-4 - Undesired Analog Signal Characteristics

Main Channel	Main Channel Audio	Power	67kHz Subcarrier	92kHz Subcarrier
1) Frequency: a) Upper First: 98.1MHz b) Lower First: 97.7MHz c) Upper Second: 98.3MHz d) Lower second: 97.5MHz 2) Stereo Transmission 3) 10% Pilot Injection 4) 75µs Pre-emphasis 5) Total Modulation = 100%	Clipped USASI Noise with peaks equal 90% modulation (67.5kHz Peak Deviation)	Variable	Off	Off

3.2.8. Undesired Hybrid

An undesired hybrid interferer is designed to be used in adjacent channel interference tests that employ objective evaluation.

This signal is defined as the spectral sum of an analog undesired signal and the digital carriers as generated by an iBiquity IBOC exciter in hybrid mode. The digital carriers utilize OFDM modulation; further details are proprietary to iBiquity. The analog portion of the signal is defined in section 3.2.7.

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The sum of *all* digital carriers in the hybrid signal has an *average* power that is 20dB below the average analog power. The measurement method for setting and verifying this power ratio is outlined in the test plan.

3.2.9. Additive White Gaussian Noise

Where AWGN noise was specified, a broadband noise signal was added to the spectrum at the specified power level. This noise had flat spectral characteristics between 88MHz and 108MHz. Beyond these frequency limits, the noise was sharply attenuated with a bandpass filter. The peak amplitude excursions of the noise signal had a Gaussian probability distribution.

3.3. Clipped USASI Interferer

In order to simulate the programming of a typical FM rock station, an audio signal referred to as "Clipped USASI" was developed and recorded on CD. This CD modulated the undesired analog channel where necessary. For a detailed description of the development of this interferer, please see the test plan referenced in section 1.3 of this document.

3.4. SNR Measurement Method

All of the results summarized in this document are shown in the form of a weighted quasi peak (WQP) signal-to-noise ratio (SNR), where the reference signal was a 400 Hz tone. The weighted quasi peak method calls for the use of a CCIR-468 filter in order to simulate the frequency response of the human auditory system. This type of SNR measurement will yield a numerical result that is *significantly* lower than the traditional root mean squared (RMS) unweighted method.

Figure 3-1 illustrates the difference between the WQP and the RMS methods of measuring SNR with a 1kHz tone. This plot also shows the different WQP SNR that will result from using either a 1kHz tone or a 400Hz tone. The reader should bear these important differences in mind when interpreting all subsequent test results.

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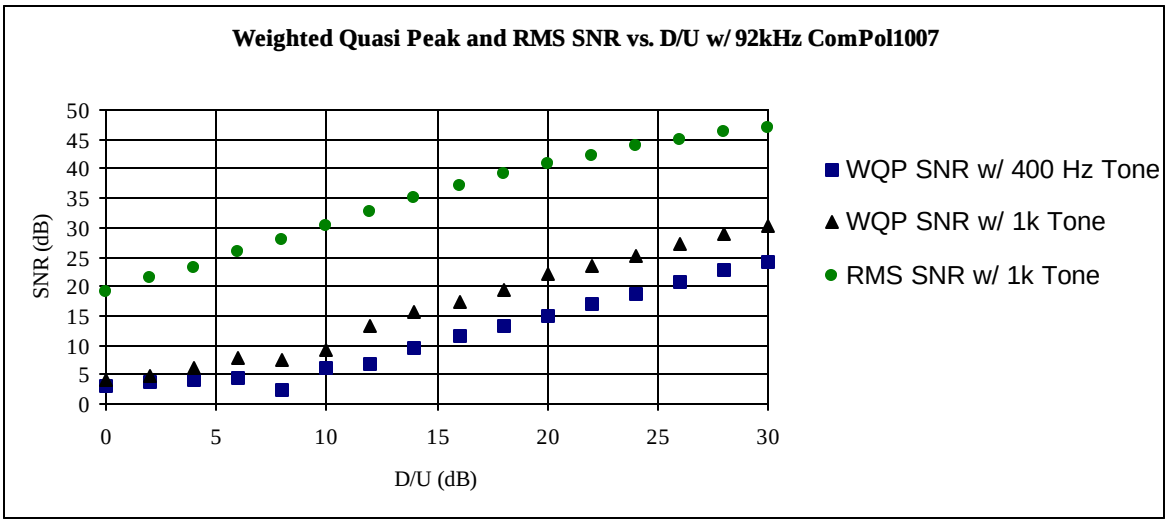

Figure 3-1 - Illustration of Three SNR Measurement Methods

3.5. Multipath Scenarios

Due to the fact that signal-to-noise ratio measurements in the presence of dynamic multipath may not be repeatable without averaging the results of an impracticably large number of measurements, all parties agreed to the use of static multipath scenarios.

It was decided that there would be three static multipath profiles developed, each with one main path and one echo path of varying phase offset. The three multipath profiles are referred to as *StaticMP1*, *StaticMP2* and *StaticMP3*. For a detailed discussion of the development of these static multipath scenarios, please see the test plan as referenced in section 1.3 of this document. Spectrum analyzer magnitude response plots for each profile may also be found in the test plan.

Table 3-5 StaticMP1 Multipath Profile

Path #	Path Type	Speed (km/h)	Loss (dB)	Delay (uS)	Phase (degrees)
1	Doppler*	0.0	0.0	0.0	0.0
2	Doppler*	0.0	6.0	1.2	Variable: +173, -142, -97, -52, or –7

*Note that although the "path type" is listed as "Doppler" in the multipath simulator, the speed is 0.0km/h. Consequently, *no* doppler offset is actually applied to the paths.

Table 3-6 StaticMP2 Multipath Profile

Path #	Path Type	Speed (km/h)	Loss (dB)	Delay (uS)	Phase (degrees)
1	Doppler*	0.0	0.0	0.0	0.0
2	Doppler*	0.0	10.0	1.2	Variable: +173, -142, -97, -52, or –7

*Note that although the "path type" is listed as "Doppler" in the multipath simulator, the speed is 0.0km/h. Consequently, *no* doppler offset is actually applied to the paths.

Table 3-7 Static MP3 Multipath Profile

Path #	Path Type	Speed (km/h)	Loss (dB)	Delay (uS)	Phase (degrees)
1	Doppler*	0.0	0.0	0.0	0.0
2	Doppler*	0.0	10.0	3.0	Variable: -16, 29, 74, 119, or 164

*Note that although the "path type" is listed as "Doppler" in the multipath simulator, the speed is 0.0km/h. Consequently, *no* doppler offset is actually applied to the paths.

3.6. Description of Test Receivers

The FM SCA receivers, listed in Table 3-8, were used for the adjacent channel and host with no multipath SCA compatibility tests.

Table 3-8 - SCA Receivers Tested in first adjacent channel conditions, second adjacent channel conditions, and host compatibility with no multipath

Radio Make/Model No:	Type	Serial No:
Dayton AF210 (REF)	67 kHz and 92 kHz Settings	2101341
McMartin TR-E5/55M	67 kHz	286834
Norver 67 kHz	67 kHz	A0012461
Dayton AF200	67 kHz	810239
ComPol SCA-RLA	67 kHz	1004
ComPol SCA-RLA	67 kHz	1005
CozmoCom 92 kHz	92 kHz	0073696
Dayton AF200	92 kHz	810238
ComPol SCA-RLA	92 kHz	1006
ComPol SCA-RLA	92 kHz	1007

The receivers listed in Table 3-9 were tested for host compatibility in the presence of multipath.

Table 3-9 – SCA Receivers Tested in multipath impaired channel conditions

Radio Make/Model No:	Type	Serial No:
McMartin TR-E5/55M	67 kHz	286834
ComPol SCA-RLA	67 kHz	1005
CozmoCom 92 kHz	92 kHz	0073696
ComPol SCA-RLA	92 kHz	1006

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4. Adjacent Channel Interference Test Results Summary

The Weighted Quasi-Peak Signal-to-Noise Ratio (WQP SNR) of each receiver listed in Table 3-8 was objectively measured with either a first or a second adjacent channel interferer over a range of D/U signal ratios[2]. The test results are presented in the plots of the following subsections.

The table below illustrates the test conditions for each of the adjacent channel impairment tests. For each of the tests listed in the table below, the desired signal type was Analog Type II (for descriptions of analog type II and analog / hybrid undesired signals see section 3.2 of this document). The following information may be useful in understanding Table 4-1:

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, power level, and the SCA frequency to be tested on the desired channel. The SCA frequency to be tested is either *67kHz* or *92kHz*. The desired mode is *Analog* and the power level is *Moderate* (-62dBm) for all of these tests.
3. In the interferer columns (*Lower 1st adj*, etc.), the mode of the interferer is indicated as *Analog* or *Hybrid*. Next to the mode of the interferer is the range of D/U to be used. D/U is the ratio of the power in the desired signal to the power in the undesired signal. This value is expressed in dB units.
4. The *AWGN* column indicates the presence or absence of a broadband noise floor in the test scenario. If additional noise is present in a test, the absolute power level is indicated in Kelvin units.

Table 4-1 Adjacent Channel Interference Scenarios

#	Lower 2nd adj.	Lower 1st adj.	Desired	Upper 1st adj.	Upper 2nd adj.	AWGN
1701		Analog: +30→0	Analog: 67kHz: Moderate			None
1702		Hybrid: +30→0	Analog: 67kHz: Moderate			None
1703		Analog: +30→0	Analog: 67kHz: Moderate			30,000K
1704		Hybrid: +30→0	Analog: 67kHz: Moderate			30,000K
1705			Analog: 67kHz: Moderate	Analog: +30→0		None
1706			Analog: 67kHz: Moderate	Hybrid: +30→0		None
1707			Analog: 67kHz: Moderate	Analog: +30→0		30,000K
1708			Analog: 67kHz: Moderate	Hybrid: +30→0		30,000K
1709	Analog: 0→-42		Analog: 67kHz: Moderate			None
1710	Hybrid: 0→-42		Analog: 67kHz: Moderate			None
1711	Analog: 0→-42		Analog: 67kHz: Moderate			30,000K
1712	Hybrid: 0→-42		Analog: 67kHz: Moderate			30,000K
1713			Analog:67kHz: Moderate		Analog: 0→-42	None
1714			Analog:67kHz: Moderate		Hybrid: 0→-42	None
1715			Analog:67kHz: Moderate		Analog: 0→-42	30,000K

[2] Throughout the remainder of this document, the following conventions are used: D refers to a desired analog signal; U refers to a single undesired interferer (which could be either analog or hybrid). If a D/U ratio is positive, then the desired signal has *more* power than the undesired signal.

#	Lower 2nd adj.	Lower 1st adj.	Desired	Upper 1st adj.	Upper 2nd adj.	AWGN
1716			Analog:67kHz: Moderate		Hybrid: 0→-42	30,000K
1717		Analog: +30→0	Analog: 92kHz: Moderate			None
1718		Hybrid: +30→0	Analog: 92kHz: Moderate			None
1719		Analog: +30→0	Analog: 92kHz: Moderate			30,000K
1720		Hybrid: +30→0	Analog: 92kHz: Moderate			30,000K
1721			Analog: 92kHz: Moderate	Analog: +30→0		None
1722			Analog: 92kHz: Moderate	Hybrid: +30→0		None
1723			Analog: 92kHz: Moderate	Analog: +30→0		30,000K
1724			Analog: 92kHz: Moderate	Hybrid: +30→0		30,000K
1725	Analog: 0→-42		Analog: 92kHz: Moderate			None
1726	Hybrid: 0→-42		Analog: 92kHz: Moderate			None
1727	Analog: 0→-42		Analog: 92kHz: Moderate			30,000K
1728	Hybrid: 0→-42		Analog: 92kHz: Moderate			30,000K
1729			Analog: 92kHz: Moderate		Analog: 0→-42	None
1730			Analog: 92kHz: Moderate		Hybrid: 0→-42	None
1731			Analog: 92kHz: Moderate		Analog: 0→-42	30,000K
1732			Analog: 92kHz: Moderate		Hybrid: 0→-42	30,000K

The following subsections illustrate the results of these tests. Each plot illustrates the results of four tests; an analog interferer, a hybrid interferer, an analog interferer in AWGN conditions, and a hybrid interferer in AWGN conditions.

4.1. 67kHz SCA Receiver Performance in the Presence of an Analog or an IBOC First Adjacent Channel Interferer

Figure 4-1 through Figure 4-12 show the results of first adjacent interferers on all of the 67kHz SCA receivers listed in Table 3-8.

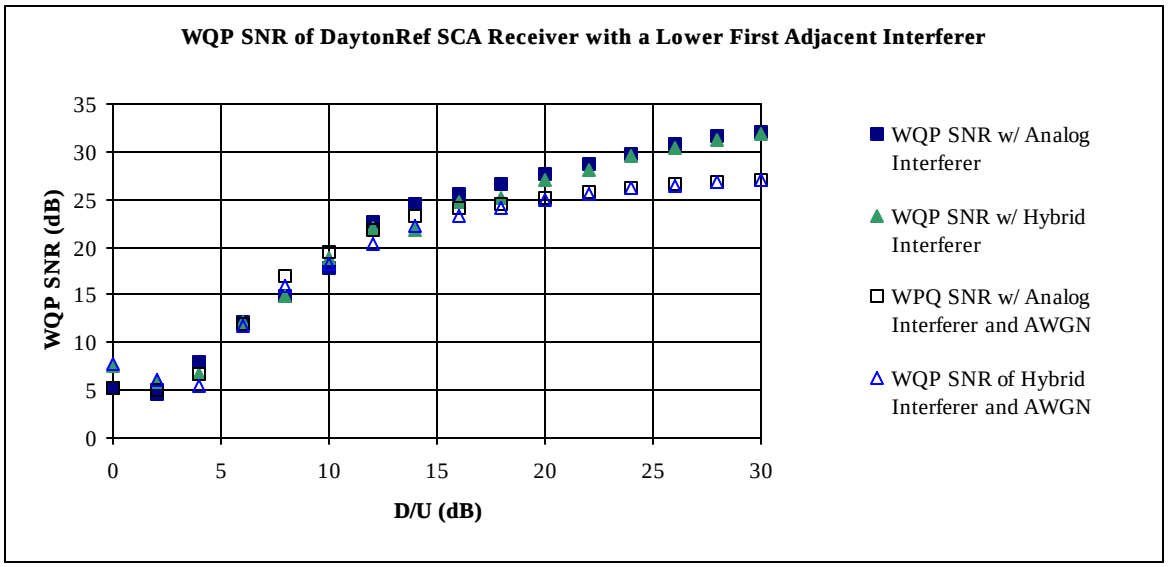

Figure 4-1 - WQP SNR of the Dayton AF210 Receiver on the 67kHz SCA Setting with a Lower First Adjacent Channel Interferer

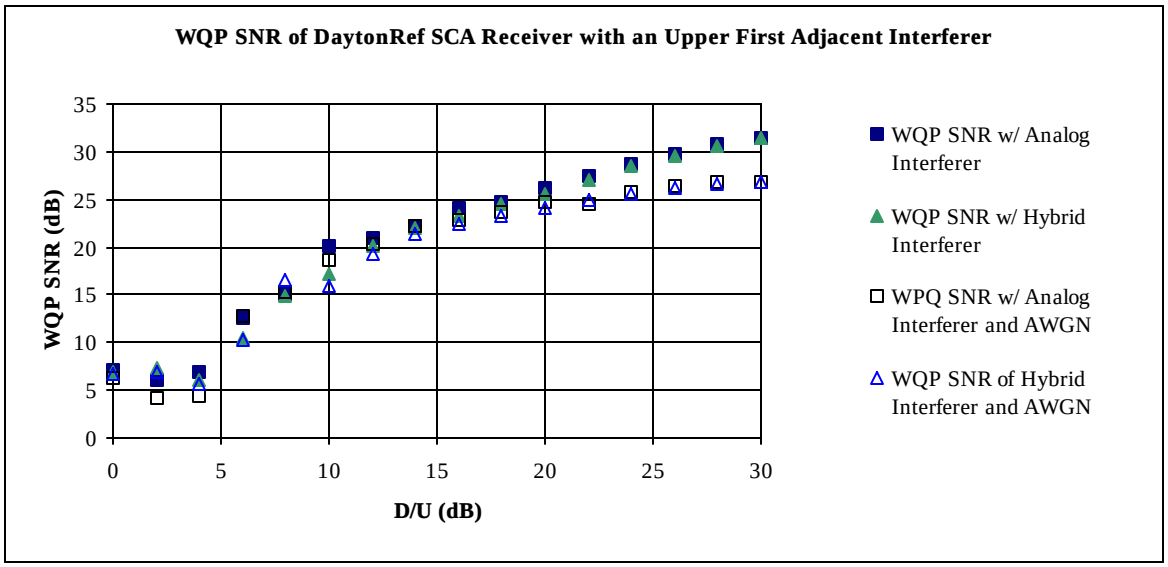

Figure 4-2 - WQP SNR of the Dayton AF210 Receiver on the 67kHz SCA Setting with an Upper First Adjacent Channel Interferer

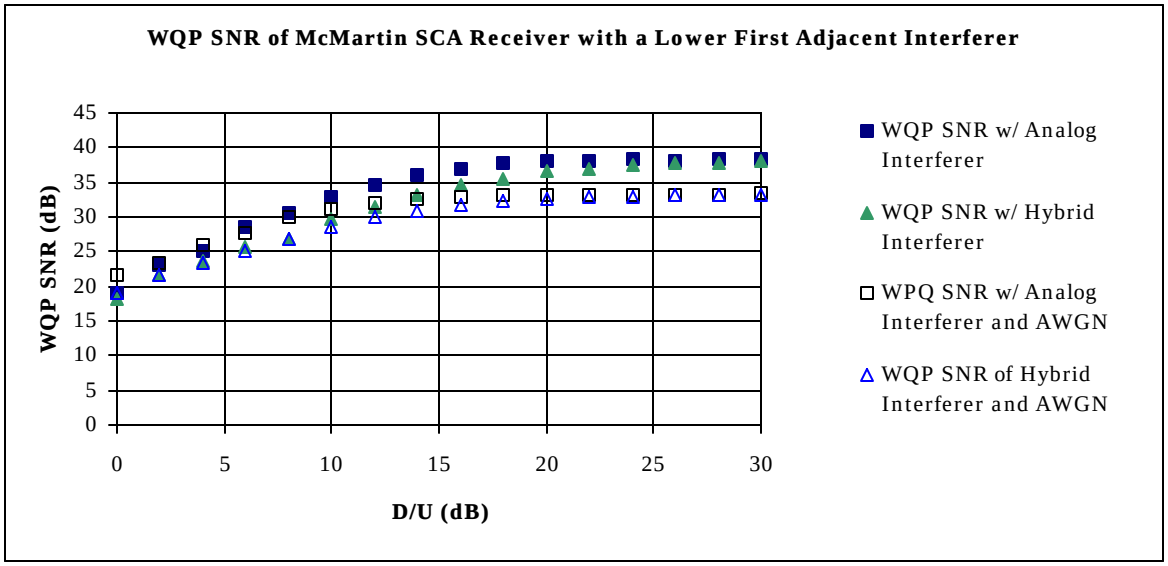

Figure 4-3 - McMartin TR-E5/55M 67kHz SCA Receiver WQP SNR with a Lower First Adjacent Channel Interferer

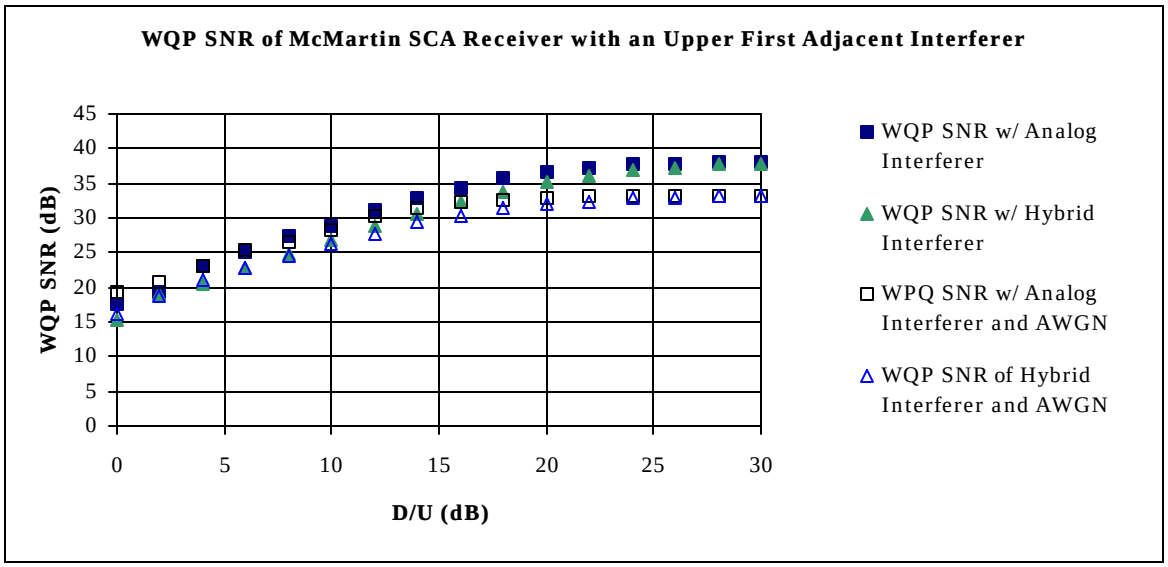

Figure 4-4 - McMartin TR-E5/55M 67kHz SCA Receiver WQP SNR with an Upper First Adjacent Channel Interferer

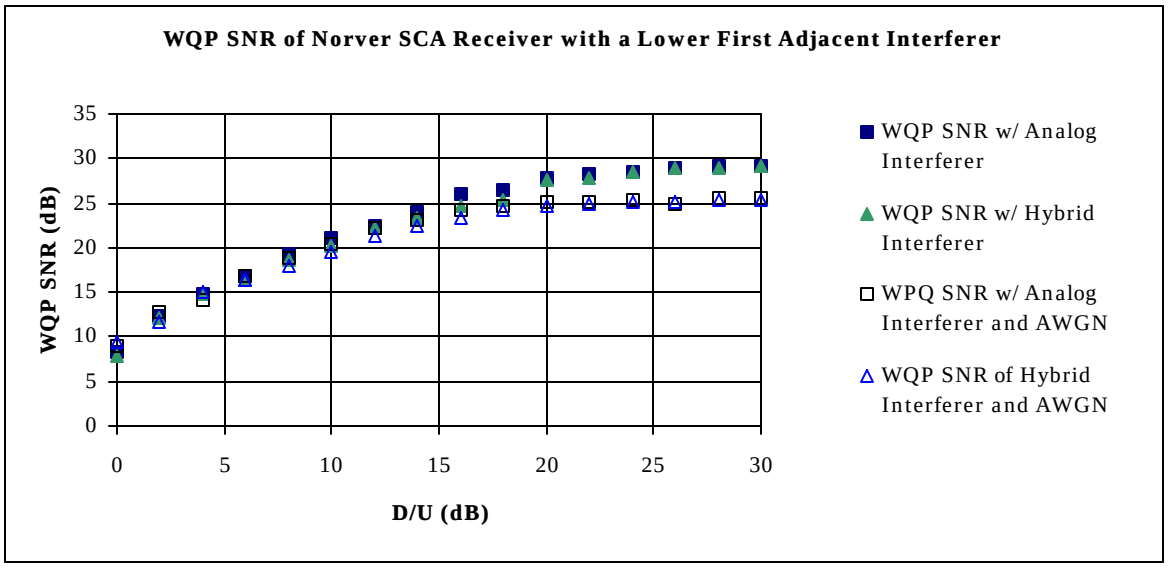

Figure 4-5 - Norver 67kHz SCA Receiver WQP SNR with a Lower First Adjacent Channel Interferer

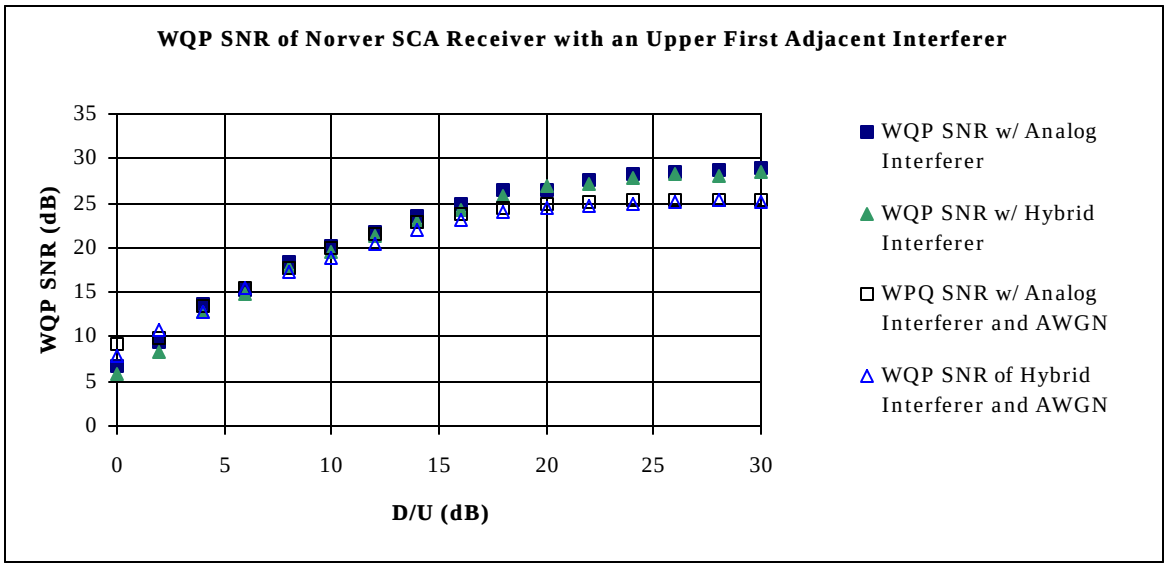

Figure 4-6 - Norver 67kHz SCA Receiver WQP SNR with an Upper First Adjacent Channel Interferer

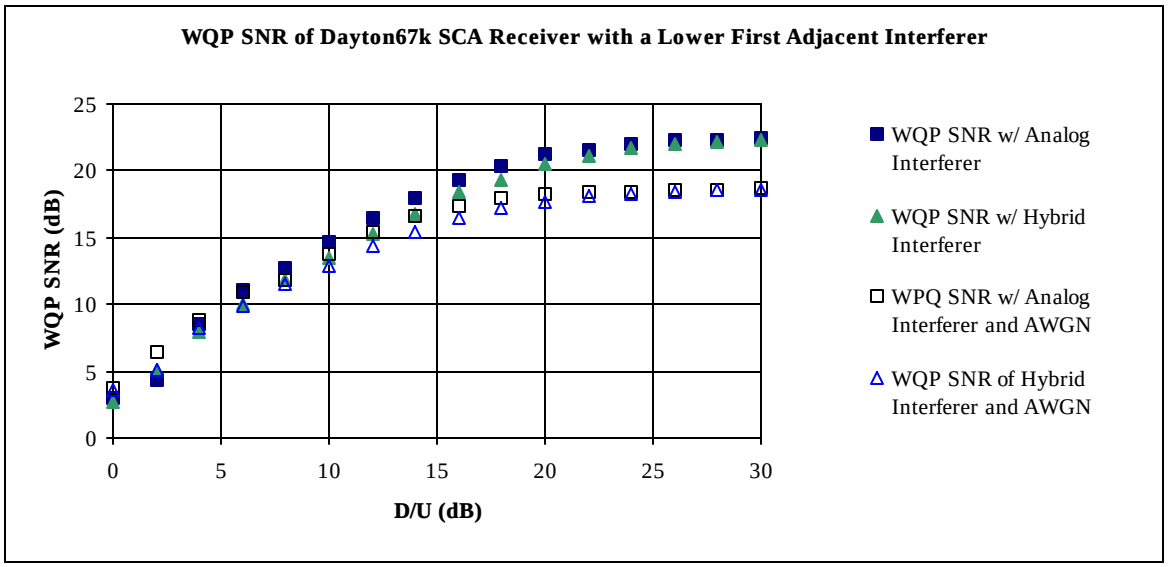

Figure 4-7 - Dayton AF200 67kHz SCA Receiver WQP SNR with a Lower First Adjacent Channel Interferer

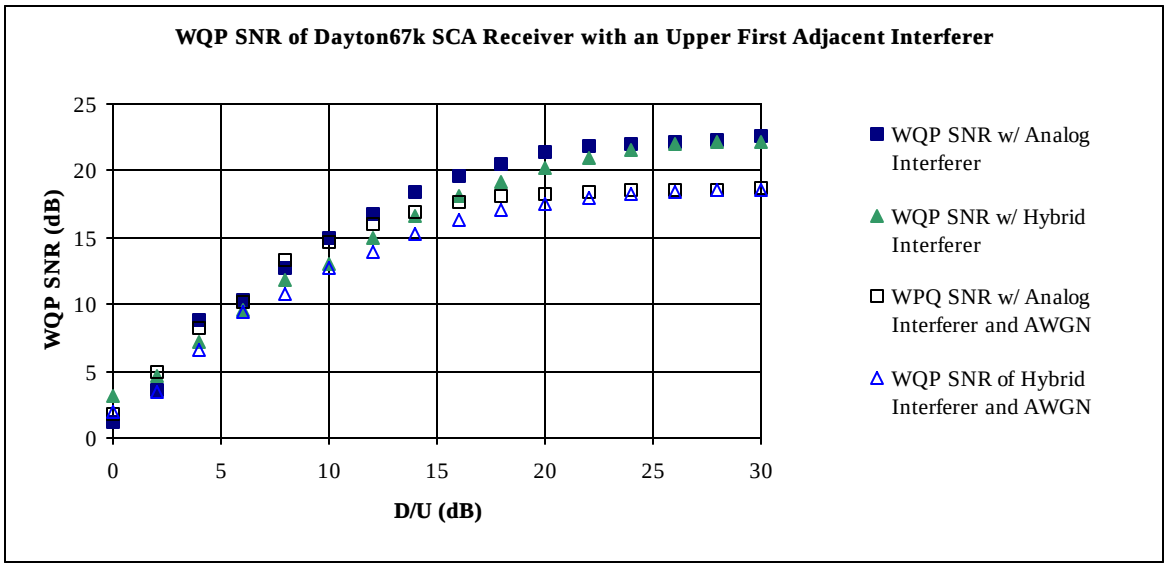

Figure 4-8 - Dayton AF200 67kHz SCA Receiver WQP SNR with an Upper First Adjacent Channel Interferer

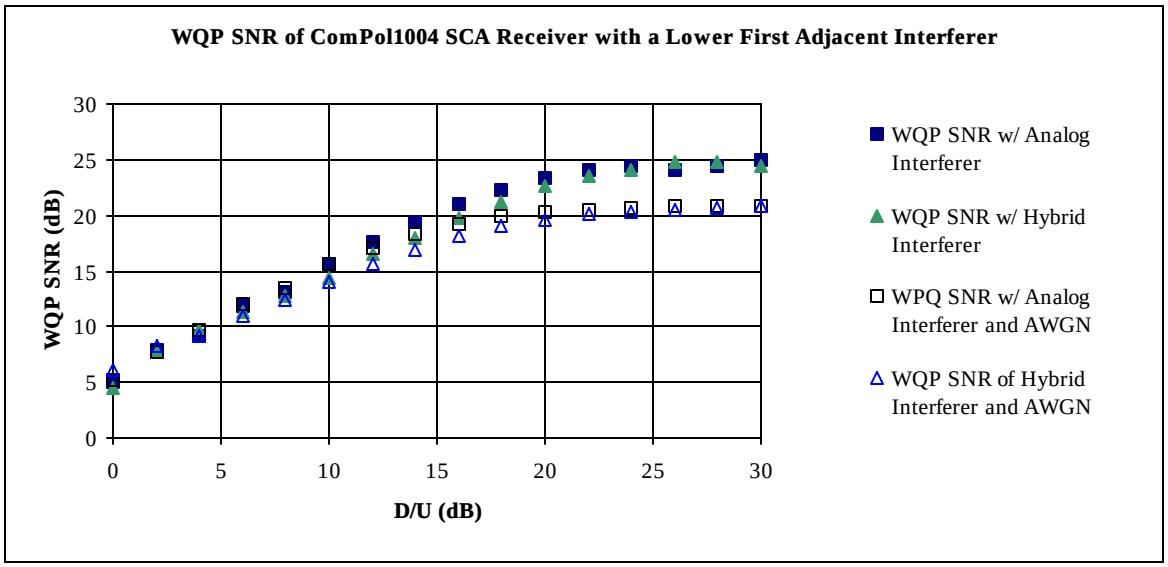

Figure 4-9 - ComPol SCA-RLA SN:1004 67kHz SCA Receiver WQP SNR with a Lower First Adjacent Channel Interferer

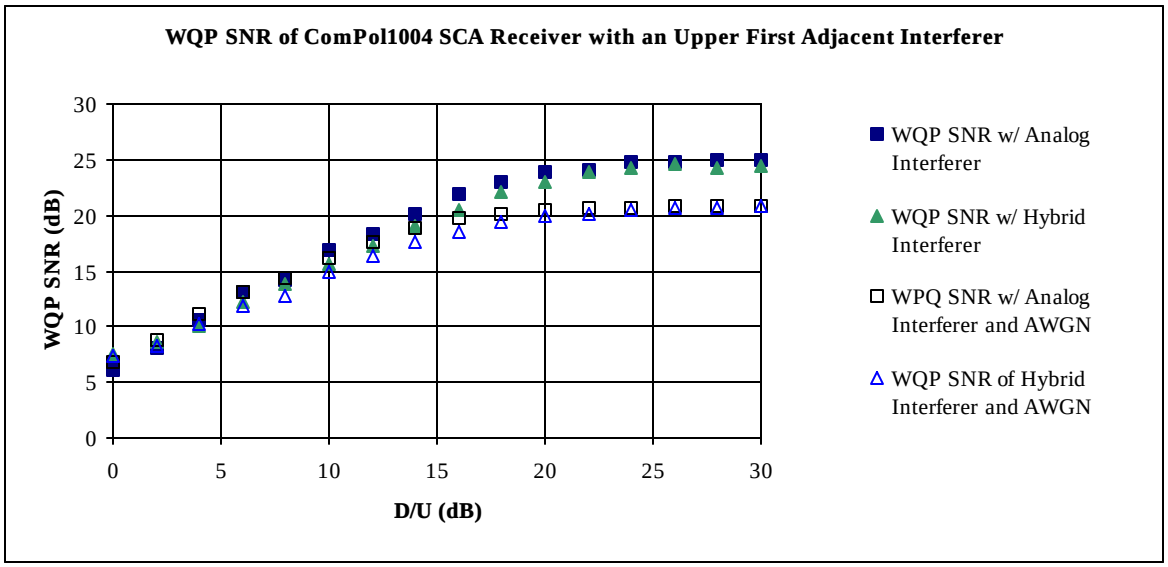

Figure 4-10 - ComPol SCA-RLA SN:1004 67kHz SCA Receiver WQP SNR with an Upper First Adjacent Channel Interferer

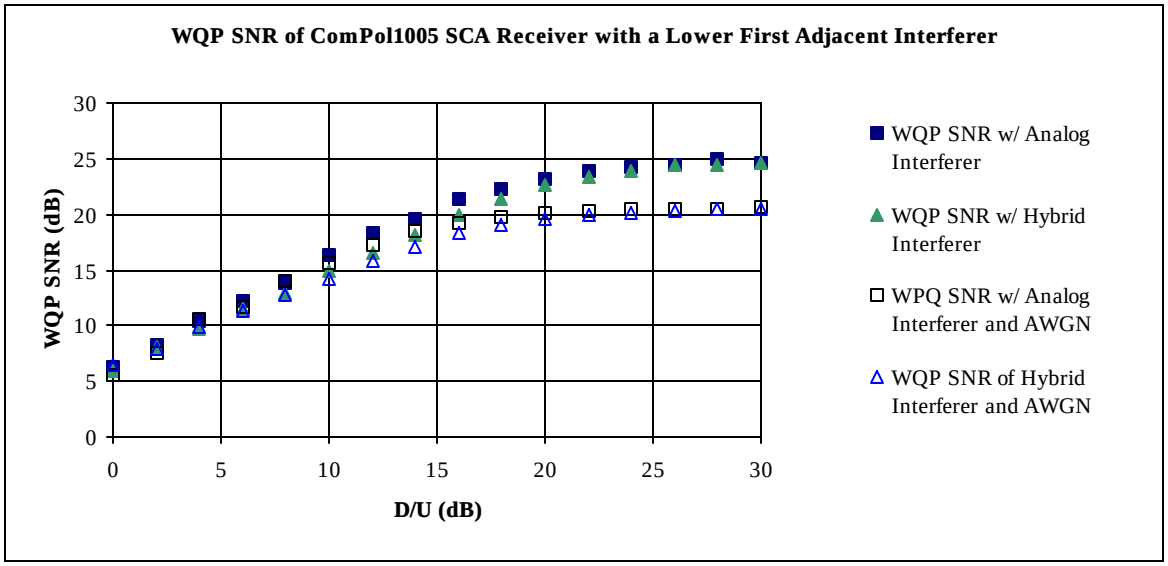

Figure 4-11 - ComPol SCA-RLA SN:1005 67kHz SCA Receiver WQP SNR with a Lower First Adjacent Channel Interferer

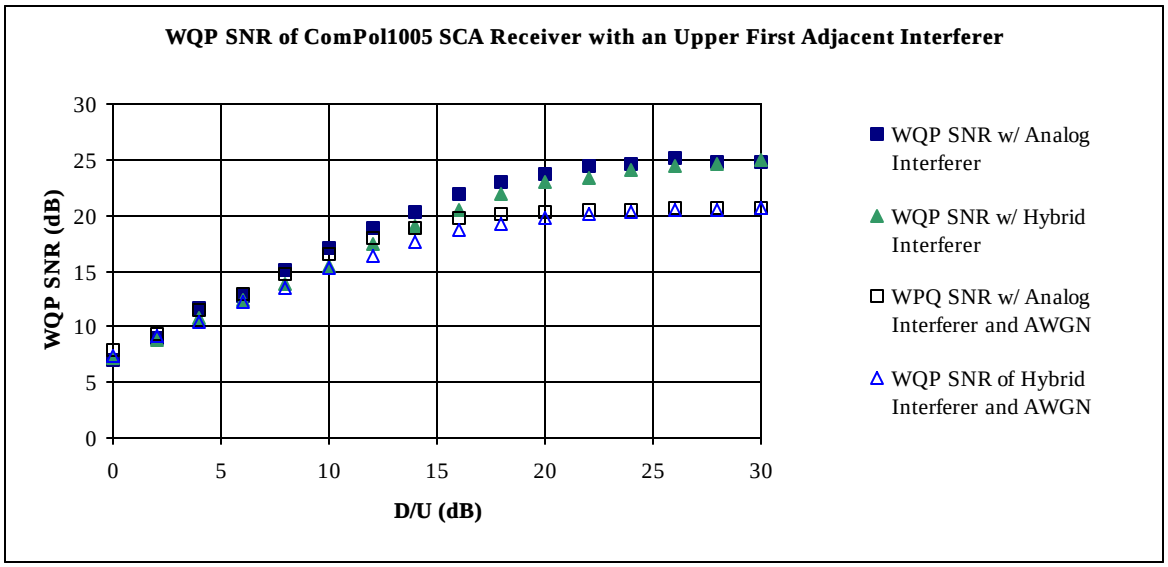

Figure 4-12 - ComPol SCA-RLA SN:1005 67kHz SCA Receiver WQP SNR with an Upper First Adjacent Channel Interferer

4.2. 67kHz SCA Receiver Performance in the Presence of an Analog or an IBOC Second Adjacent Channel Interferer

Figure 4-13 through Figure 4-24 show the results of second adjacent interferers on all of the 67kHz SCA receivers listed in Table 3-8.

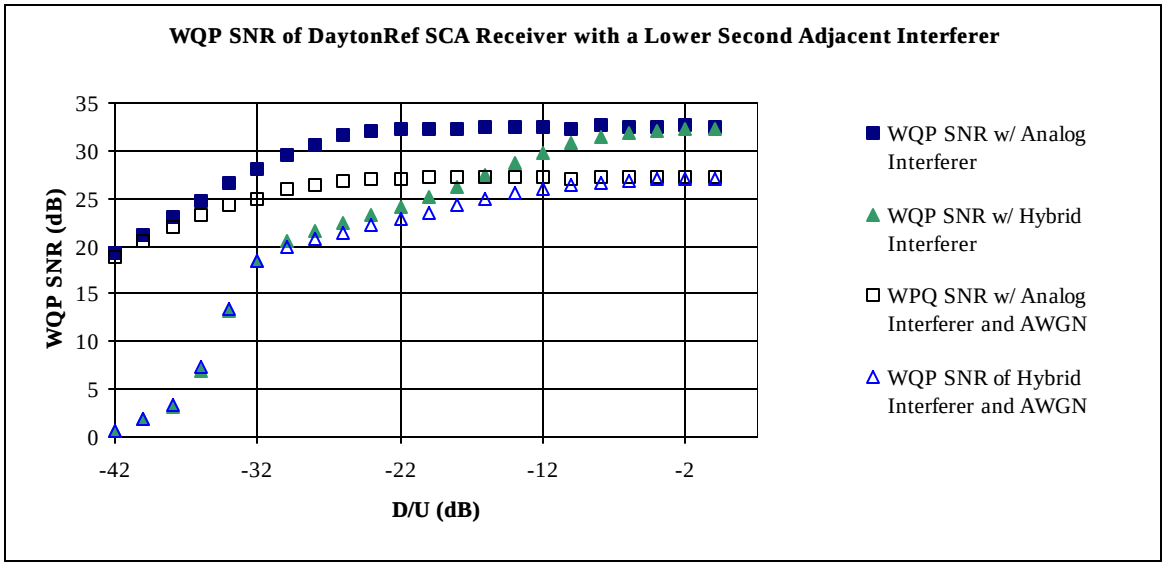

Figure 4-13 - WQP SNR of the Dayton AF210 Receiver on the 67kHz SCA Setting with a Lower Second Adjacent Channel Interferer

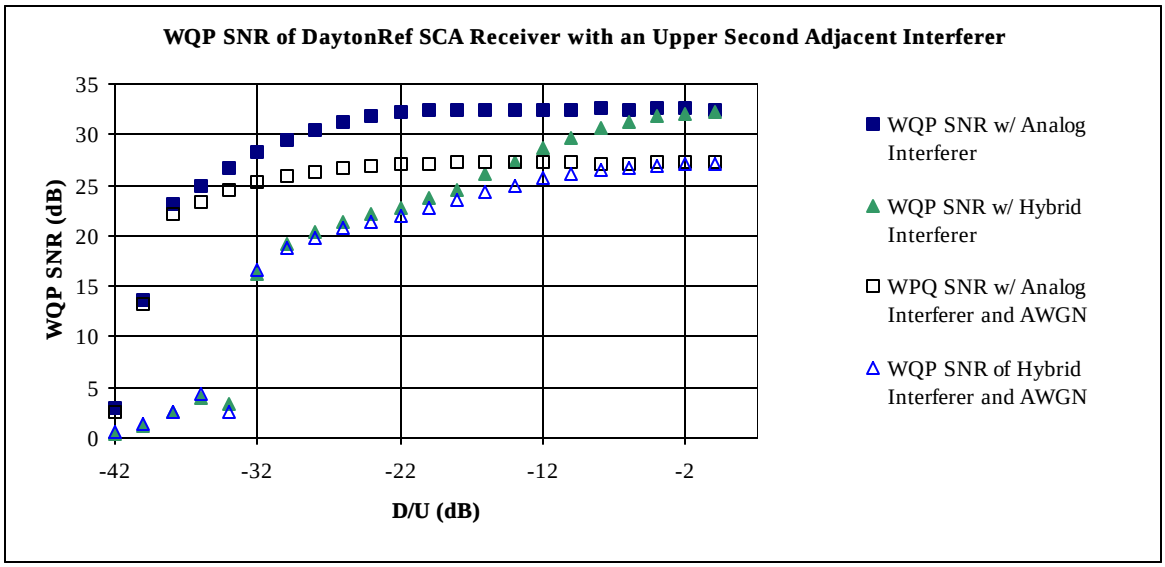

Figure 4-14 - WQP SNR of the Dayton AF210 Receiver on the 67kHz SCA Setting with an Upper Second Adjacent Channel Interferer

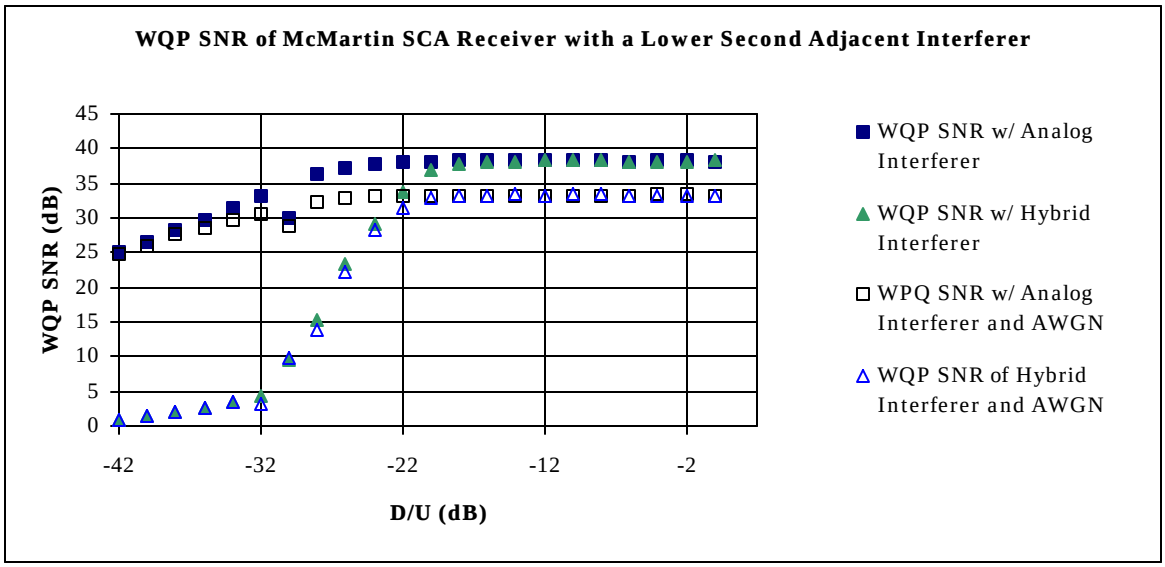

Figure 4-15 - McMartin TR-E5/55M 67kHz SCA Receiver WQP SNR with a Lower Second Adjacent Channel Interferer

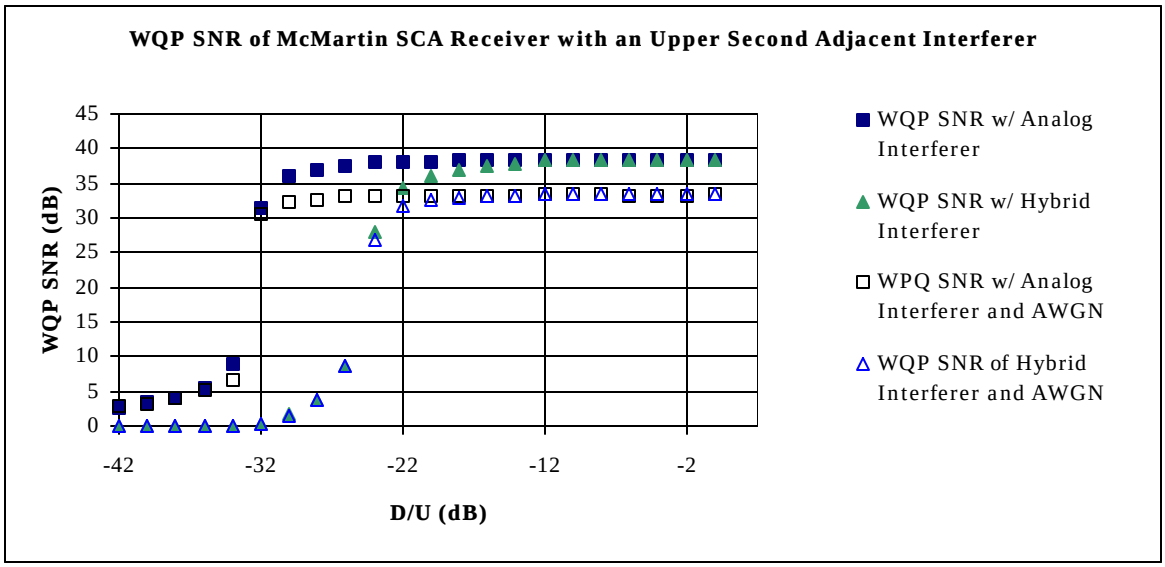

Figure 4-16 - McMartin TR-E5/55M 67kHz SCA Receiver WQP SNR with an Upper Second Adjacent Channel Interferer

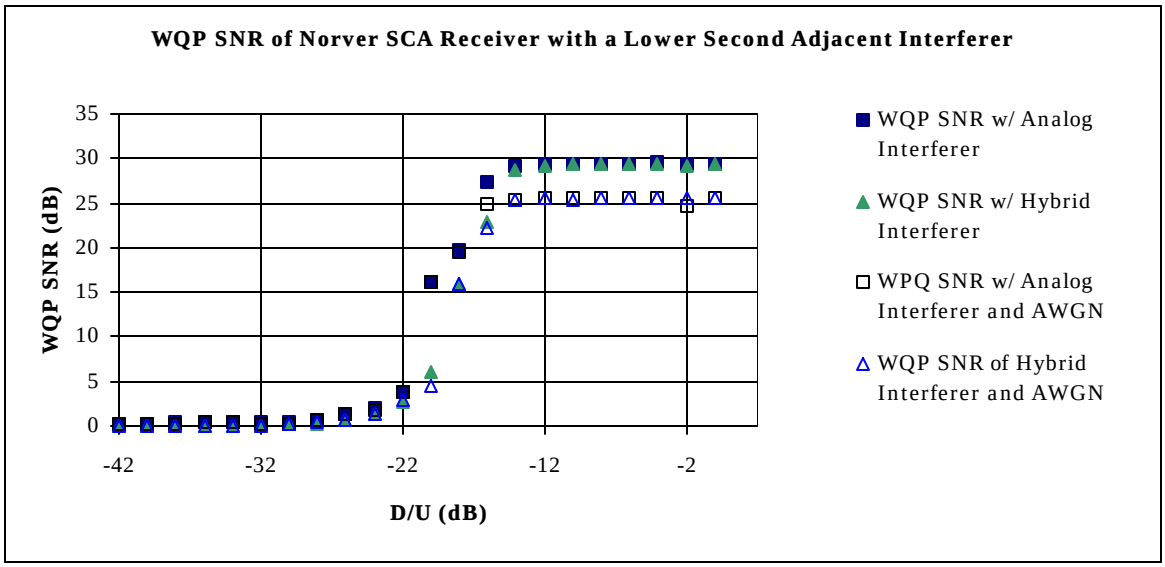

Figure 4-17 - Norver 67kHz SCA Receiver WQP SNR with a Lower Second Adjacent Channel Interferer

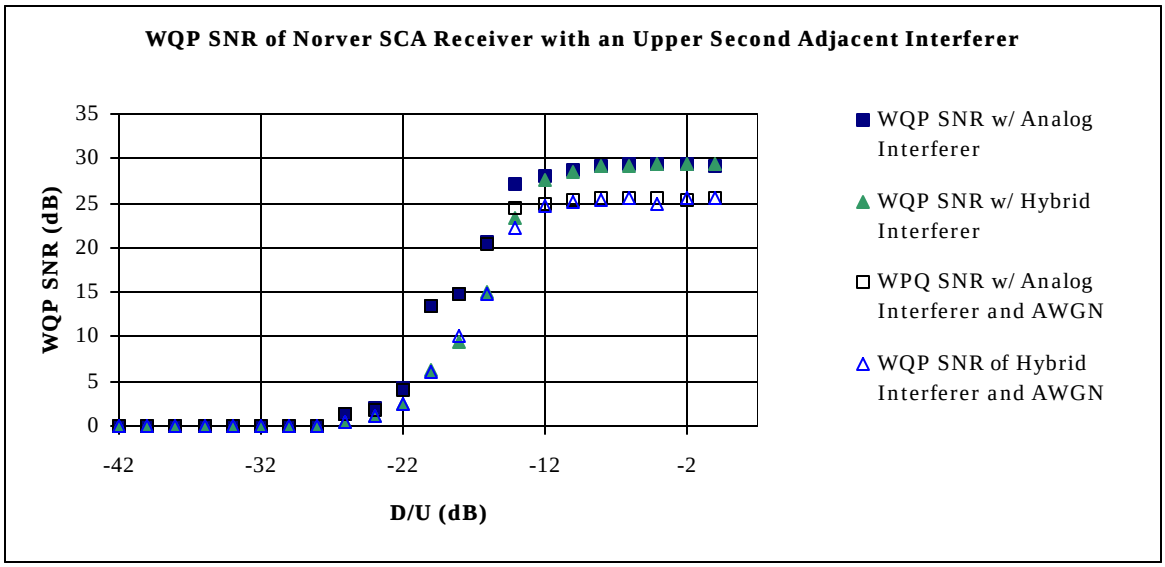

Figure 4-18 - Norver 67kHz SCA Receiver WQP SNR with an Upper Second Adjacent Channel Interferer

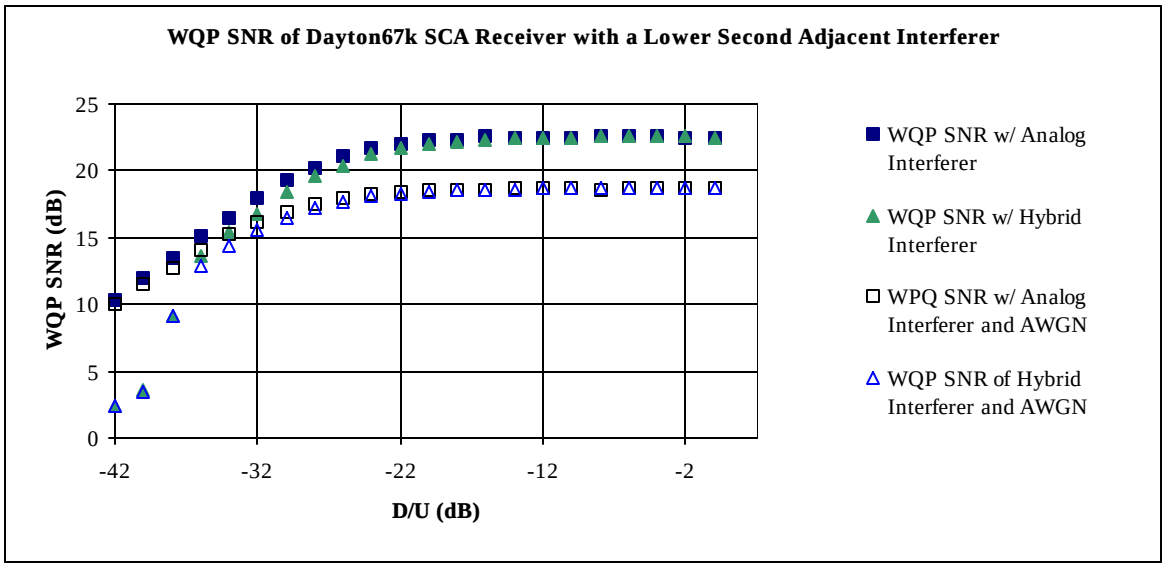

Figure 4-19 - Dayton AF200 67kHz SCA Receiver WQP SNR with a Lower Second Adjacent Channel Interferer

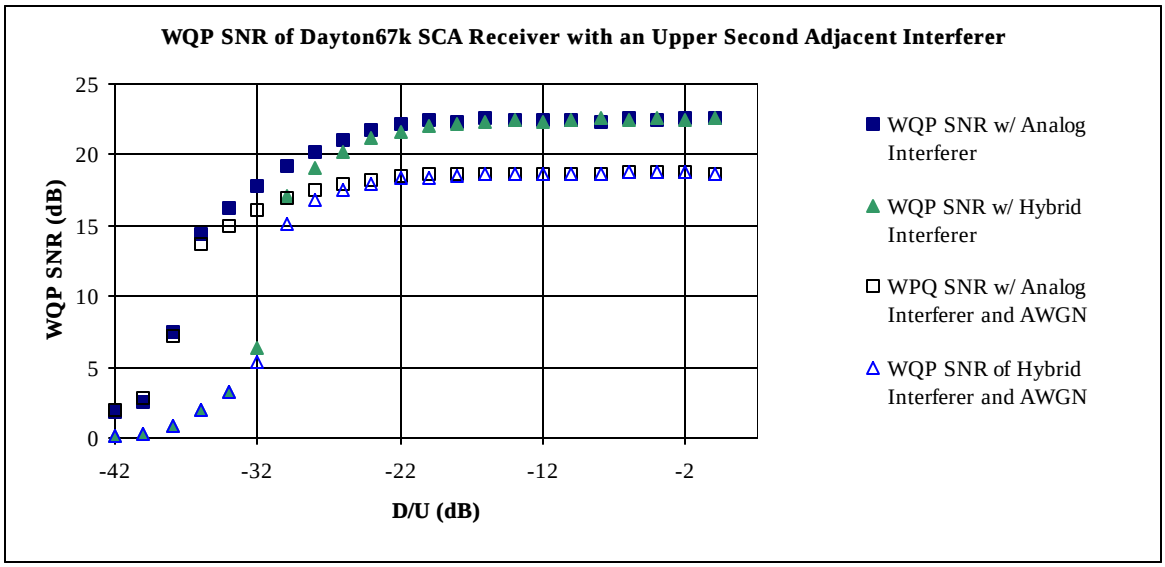

Figure 4-20 - Dayton AF200 67kHz SCA Receiver WQP SNR with an Upper Second Adjacent Channel Interferer

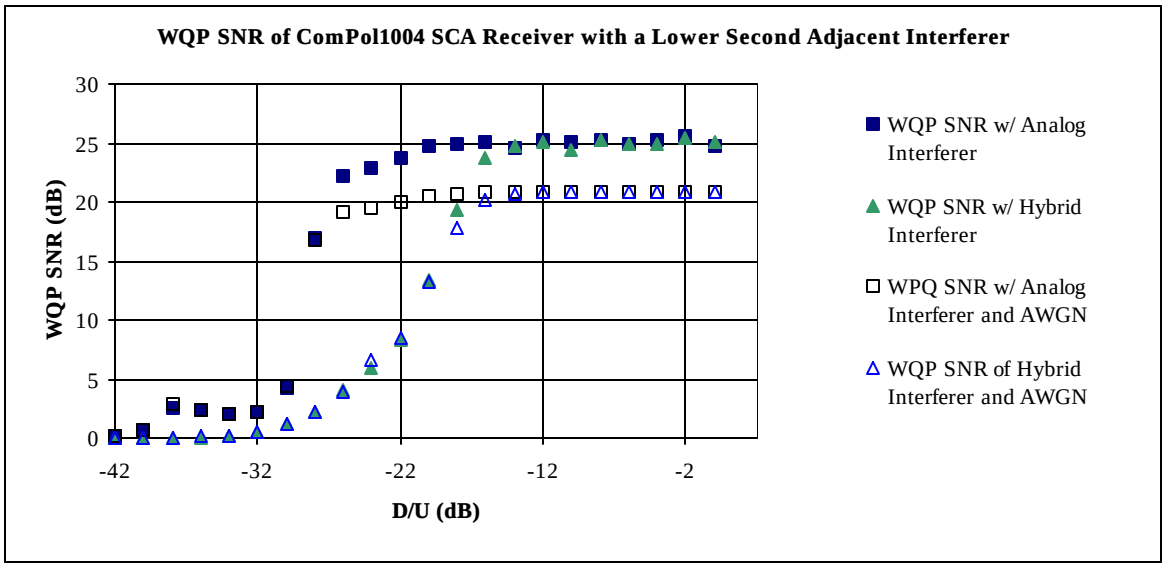

Figure 4-21 - ComPol SCA-RLA SN:1004 67kHz SCA Receiver WQP SNR with a Lower Second Adjacent Channel Interferer

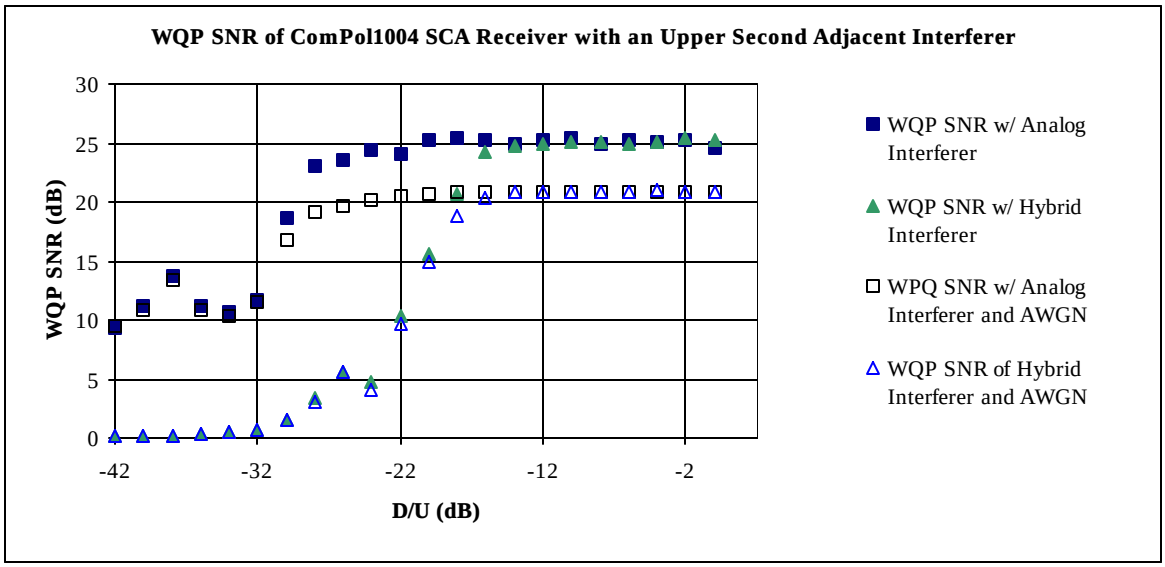

Figure 4-22 - ComPol SCA-RLA SN:1004 67kHz SCA Receiver WQP SNR with an Upper Second Adjacent Channel Interferer

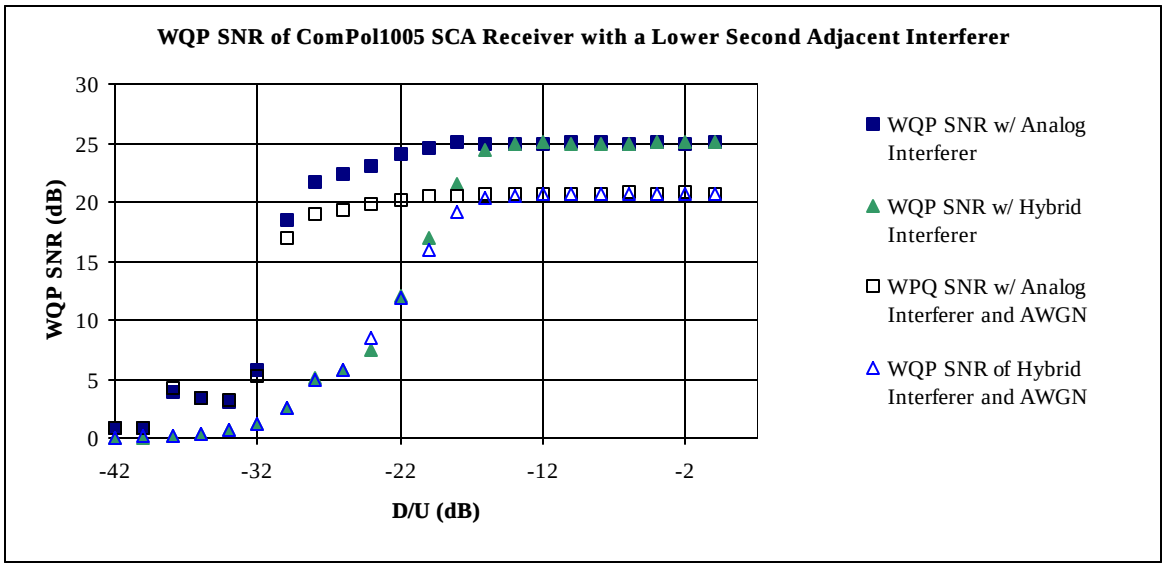

Figure 4-23 - ComPol SCA-RLA SN:1005 67kHz SCA Receiver WQP SNR with a Lower Second Adjacent Channel Interferer

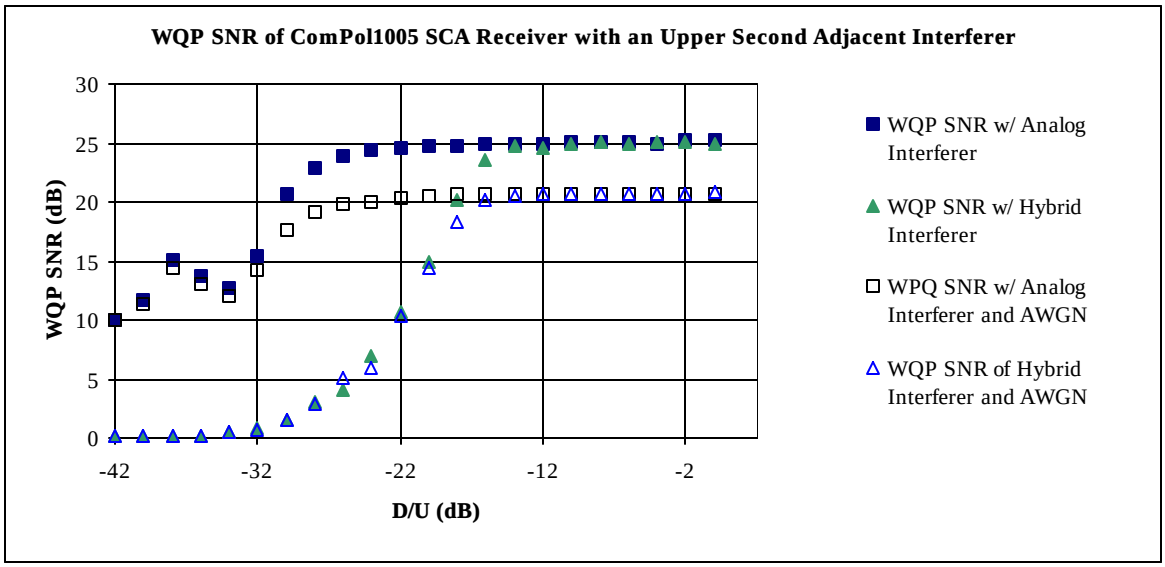

Figure 4-24 - ComPol SCA-RLA SN:1005 67kHz SCA Receiver WQP SNR with an Upper Second Adjacent Channel Interferer

4.3. 92kHz SCA Receiver Performance in the Presence of an Analog or an IBOC First Adjacent Channel Interferer

Figure 4-25 through Figure 4-34 show the results of first adjacent interferers on all of the 92kHz SCA receivers listed in Table 3-8.

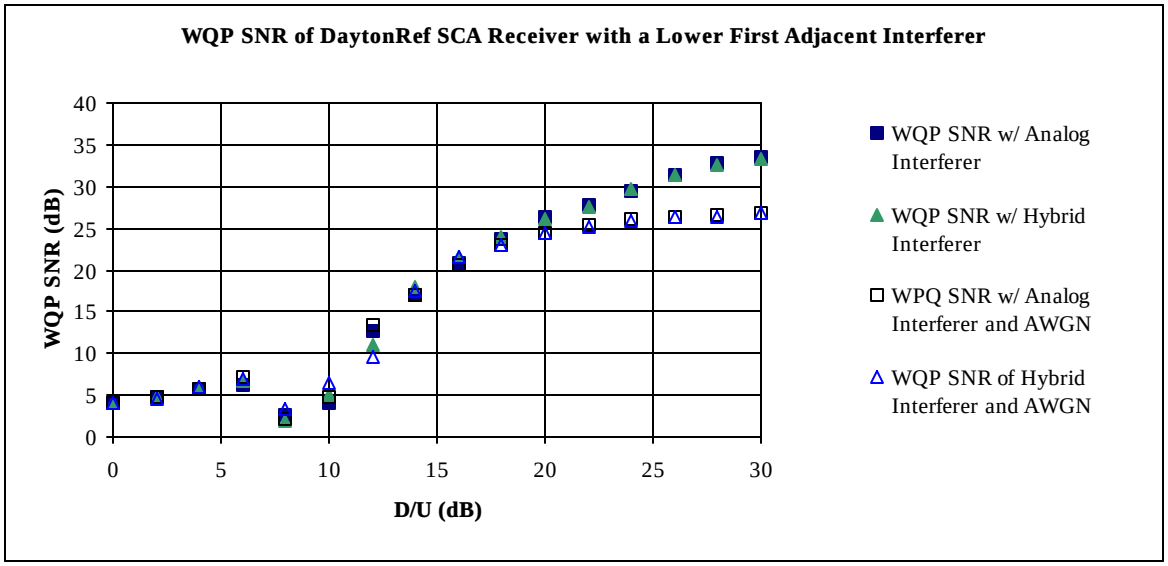

Figure 4-25 - WQP SNR of the Dayton AF210 Receiver on the 92kHz Setting with a Lower First Adjacent Channel Interferer

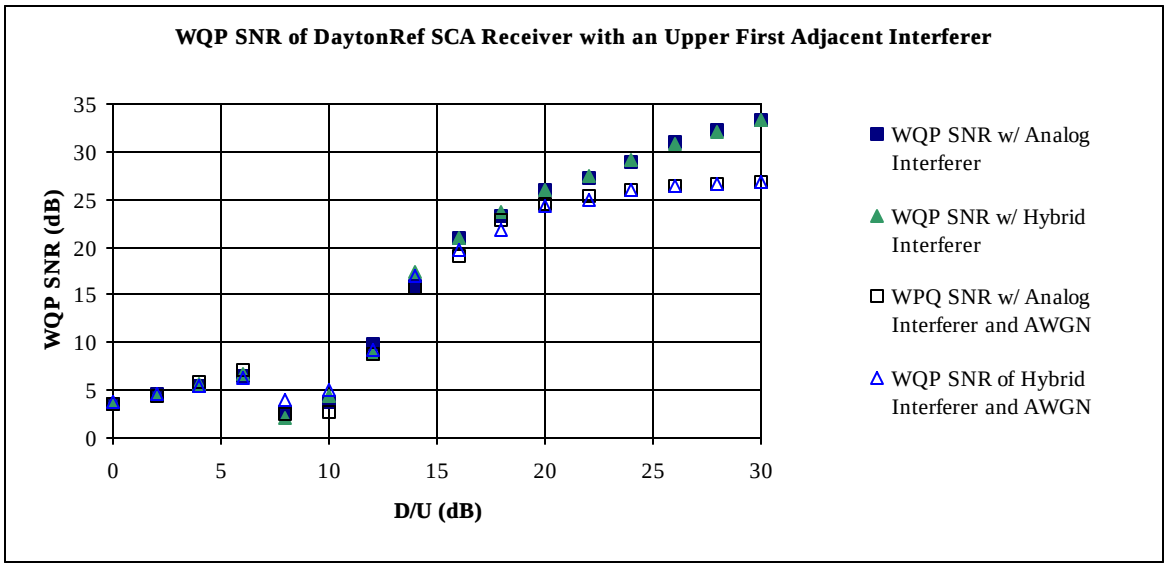

Figure 4-26 - WQP SNR of the Dayton AF210 Receiver on the 92kHz Setting with an Upper First Adjacent Channel Interferer

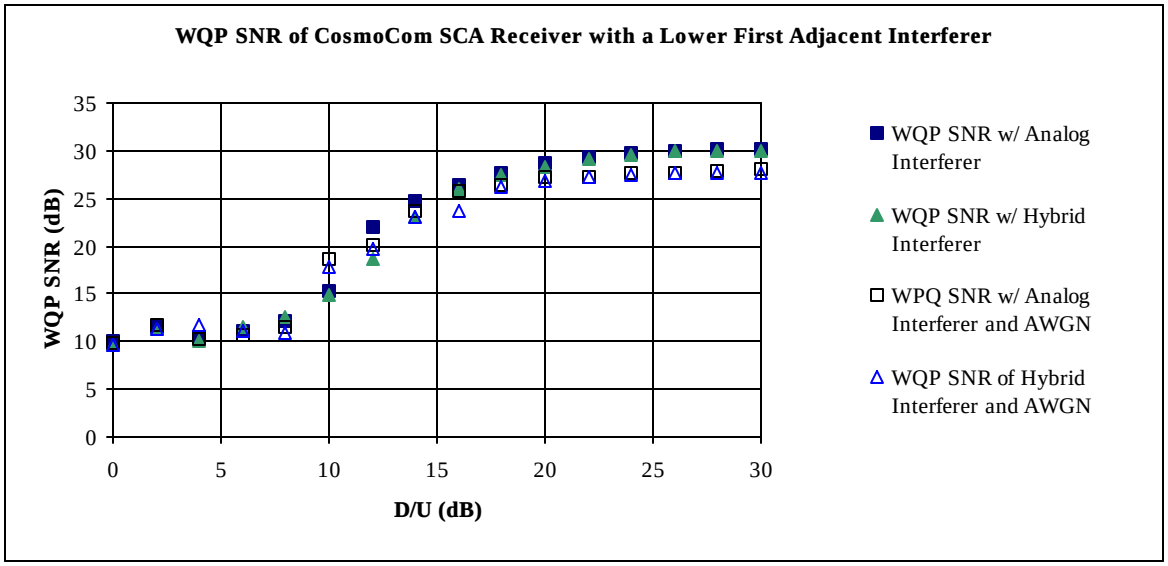

Figure 4-27 - CosmoCom 92kHz SCA Receiver WQP SNR with a Lower First Adjacent Channel Interferer

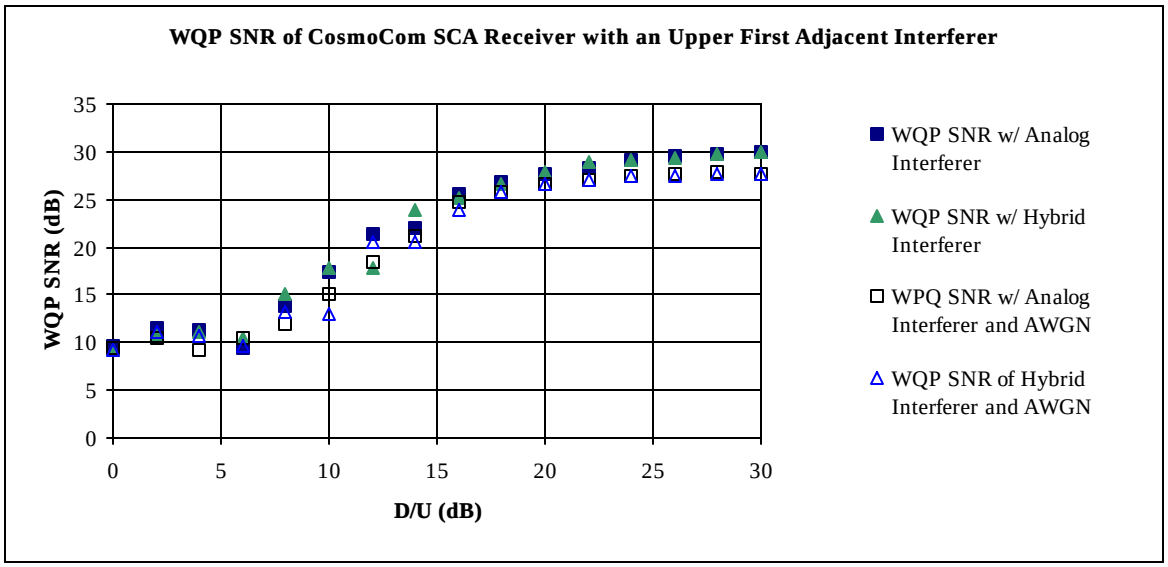

Figure 4-28 - CosmoCom 92kHz SCA Receiver WQP SNR with an Upper First Adjacent Channel Interferer

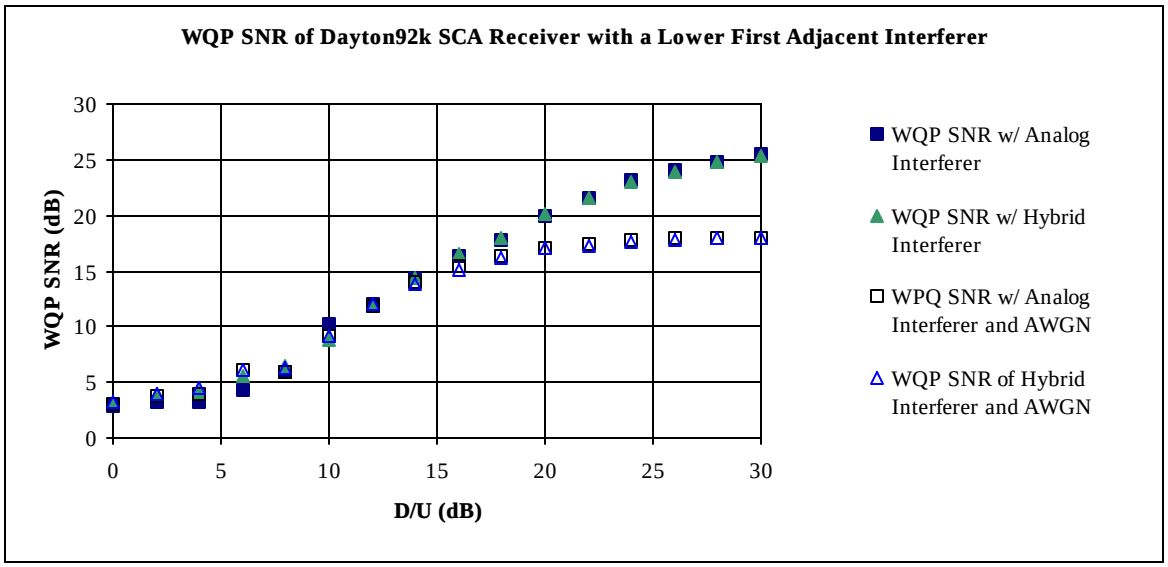

Figure 4-29 - Dayton AF200 92kHz SCA Receiver WQP SNR with a Lower First Adjacent Channel Interferer

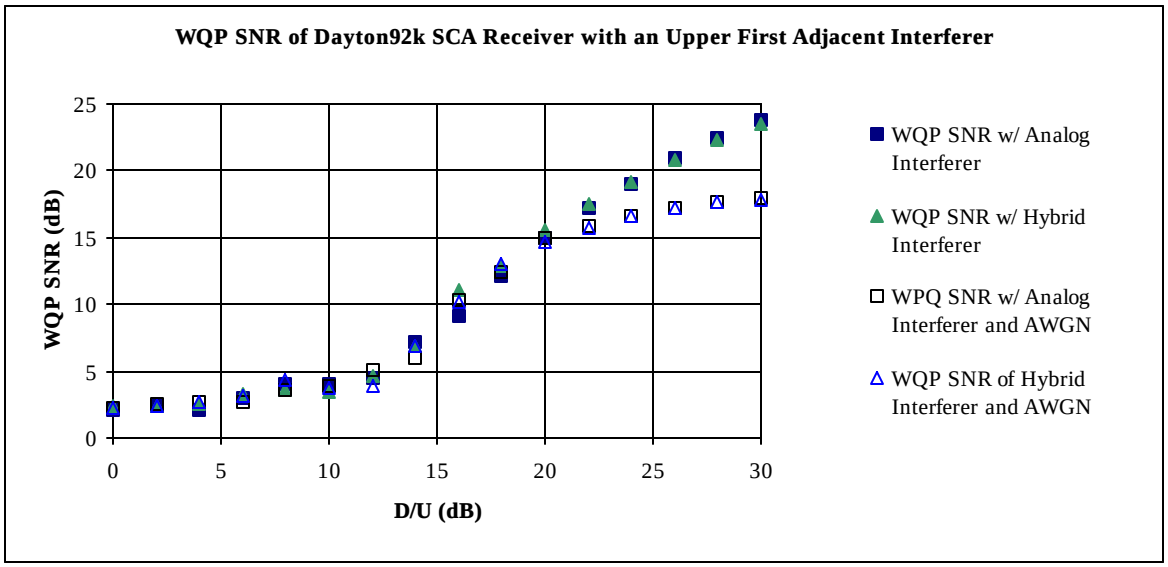

Figure 4-30 - Dayton 92kHz SCA Receiver WQP SNR with an Upper First Adjacent Channel Interferer

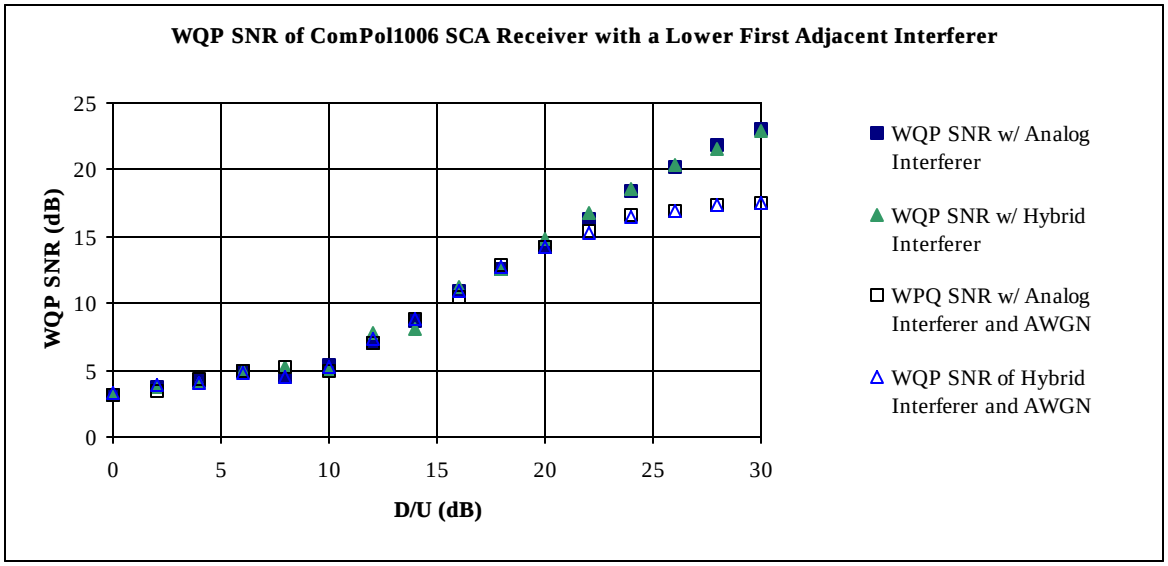

Figure 4-31 - ComPol SCA-RLA SN:1006 92kHz SCA Receiver WQP SNR with a Lower First Adjacent Channel Interferer

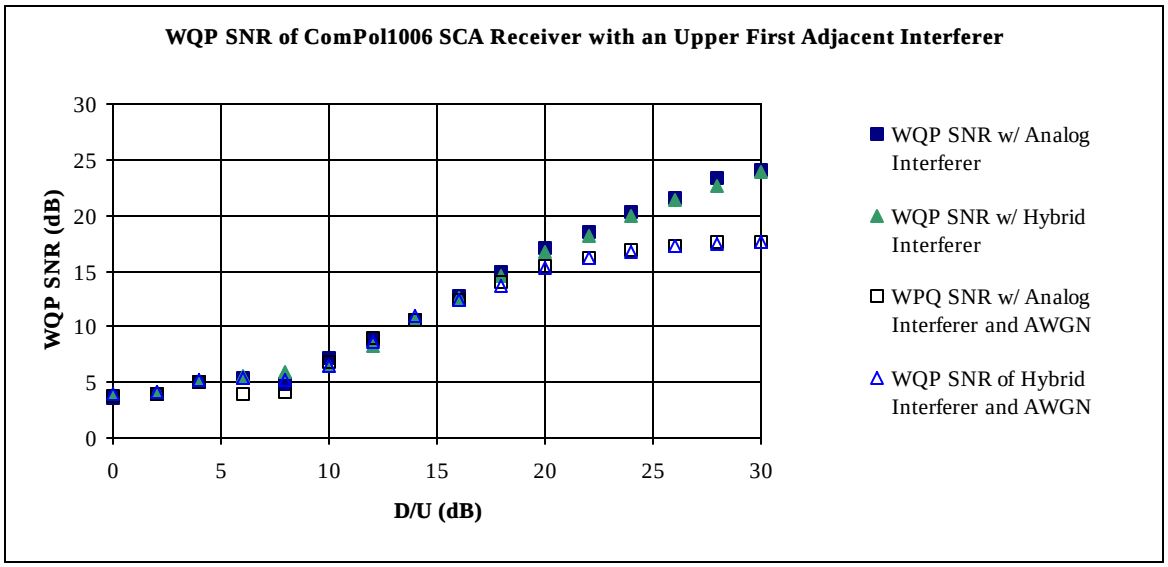

Figure 4-32 - ComPol SCA-RLA SN:1006 92kHz SCA Receiver WQP SNR with an Upper First Adjacent Channel Interferer

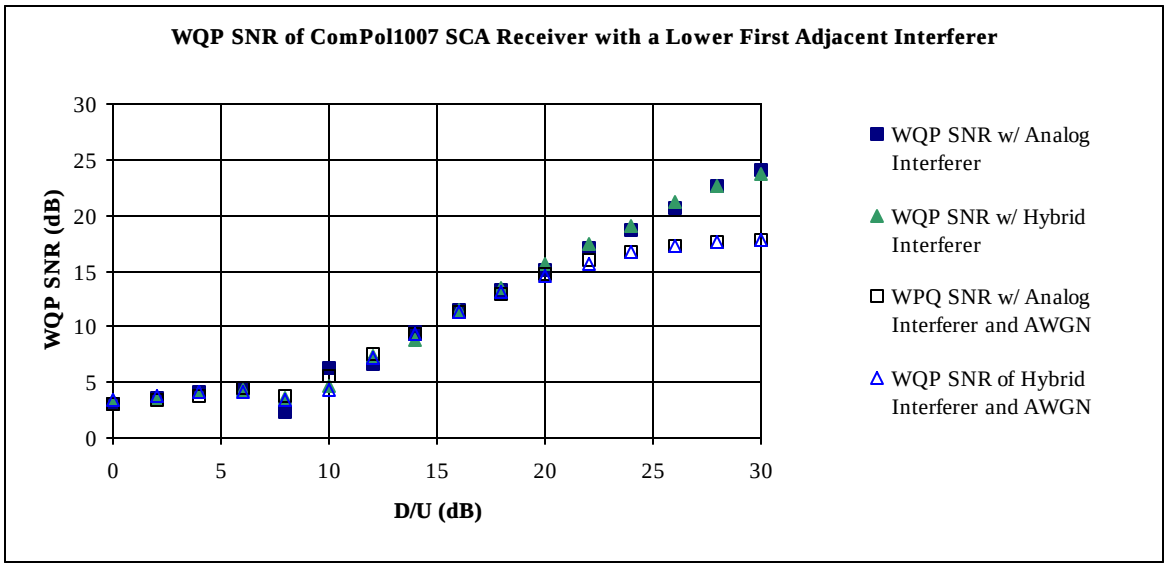

Figure 4-33 - ComPol SCA-RLA SN:1007 92kHz SCA Receiver WQP SNR with a Lower First Adjacent Channel Interferer

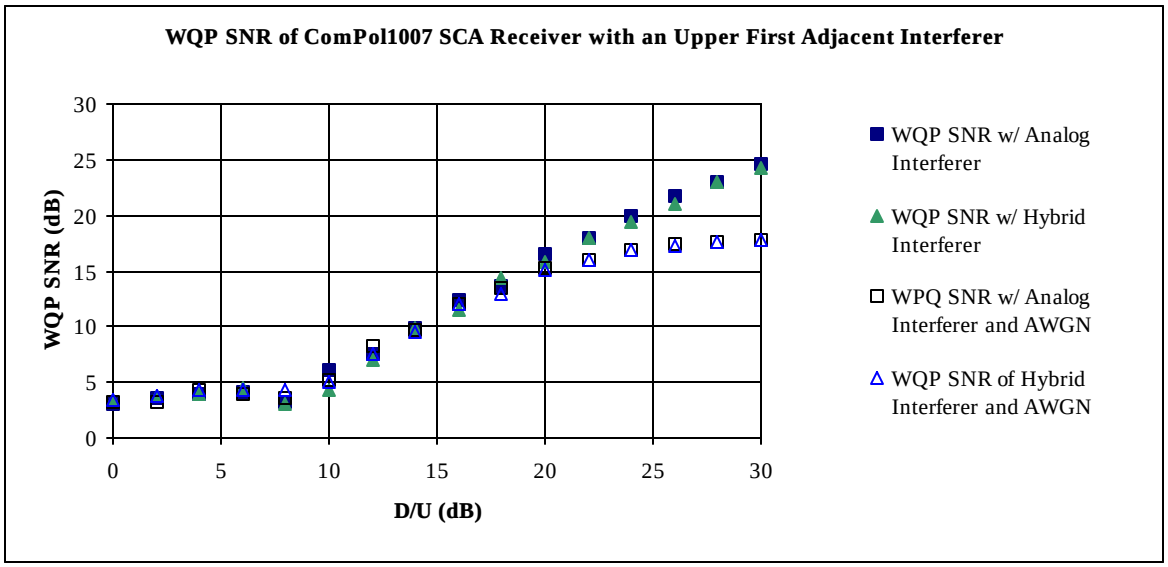

Figure 4-34 - ComPol SCA-RLA SN:1007 92kHz SCA Receiver WQP SNR with an Upper First Adjacent Channel Interferer

4.4. 92kHz SCA Receiver Performance in the Presence of an Analog or IBOC Second Adjacent Channel Interferer

The plots of Figure 4-35 through Figure 4-44 illustrate the results of second adjacent interferers on all of the 92kHz SCA receivers listed in Table 3-8.

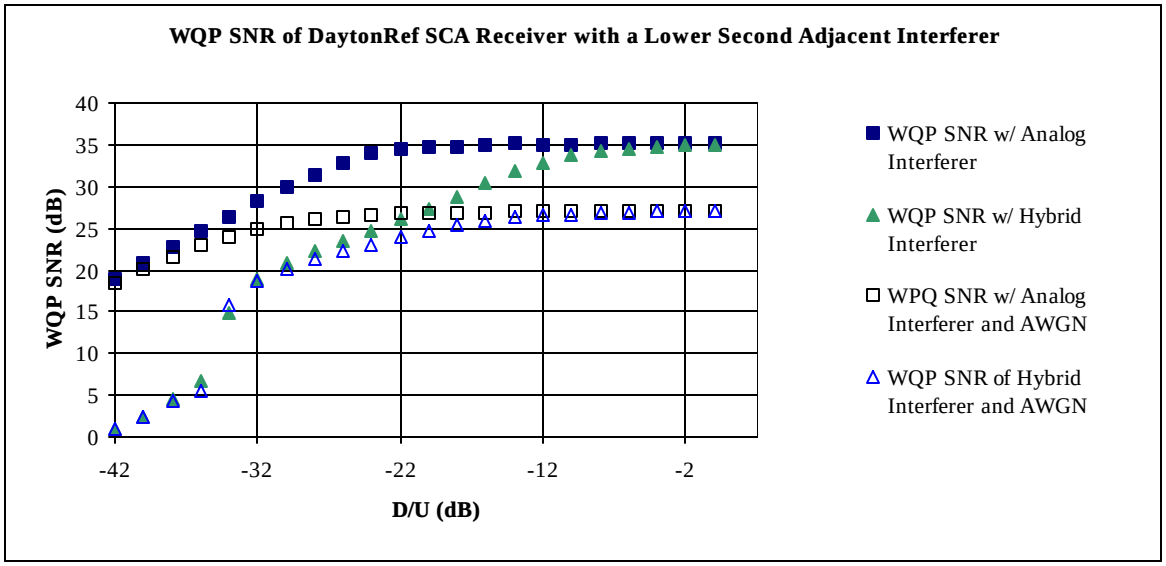

Figure 4-35 - WQP SNR of the Dayton AF210 Receiver on the 92kHz Setting with a Lower Second Adjacent Channel Interferer

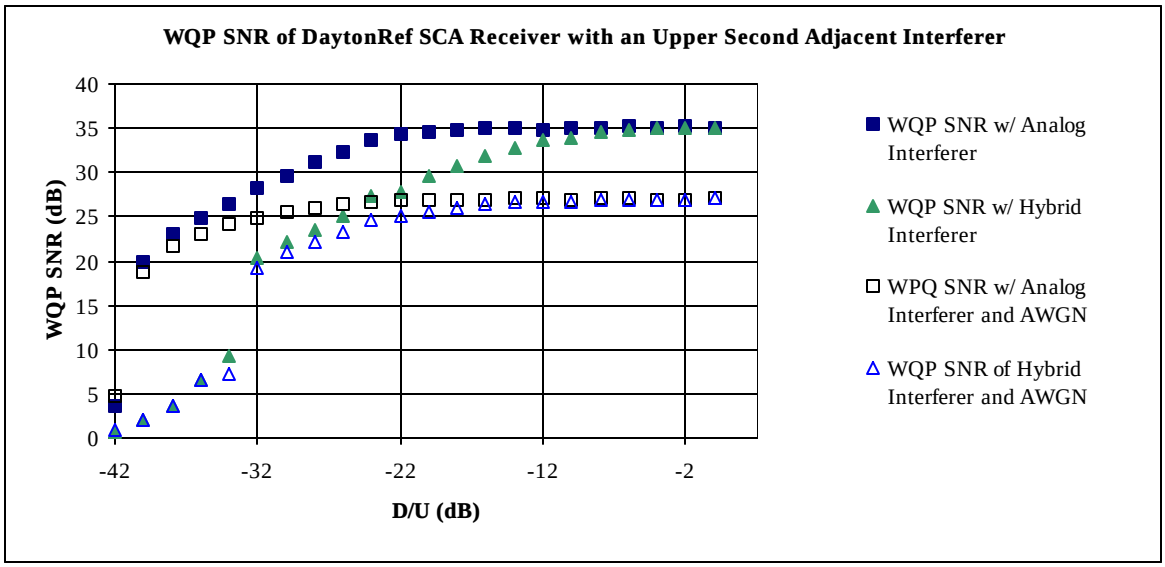

Figure 4-36 - WQP SNR of the Dayton AF210 Receiver on the 92kHz Setting with an Upper Second Adjacent Channel Interferer

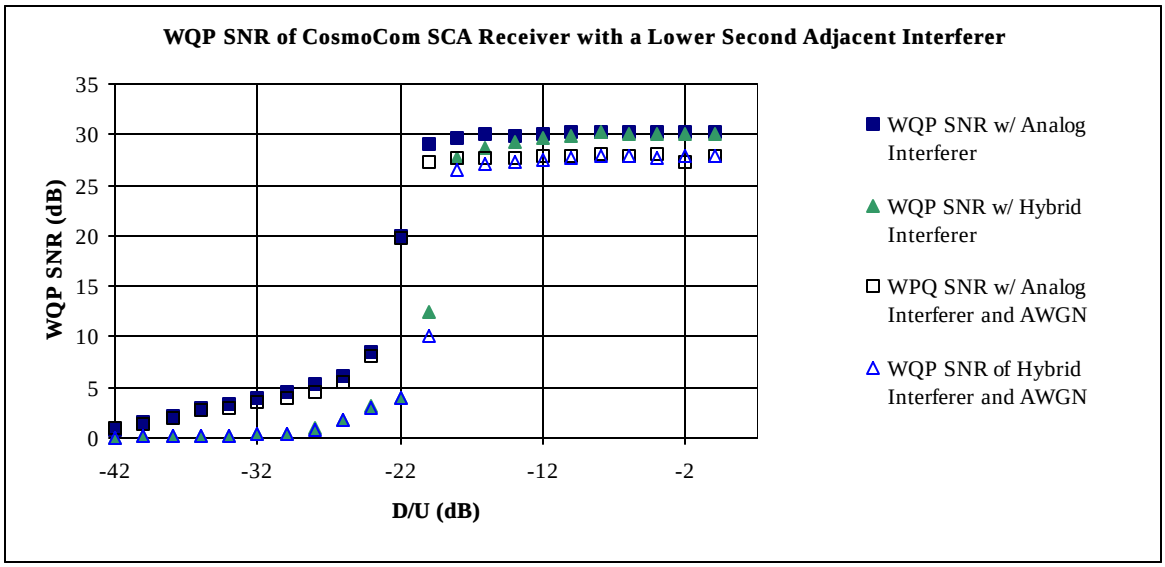

Figure 4-37 - CosmoCom 92kHz SCA Receiver WQP SNR with a Lower Second Adjacent Channel Interferer

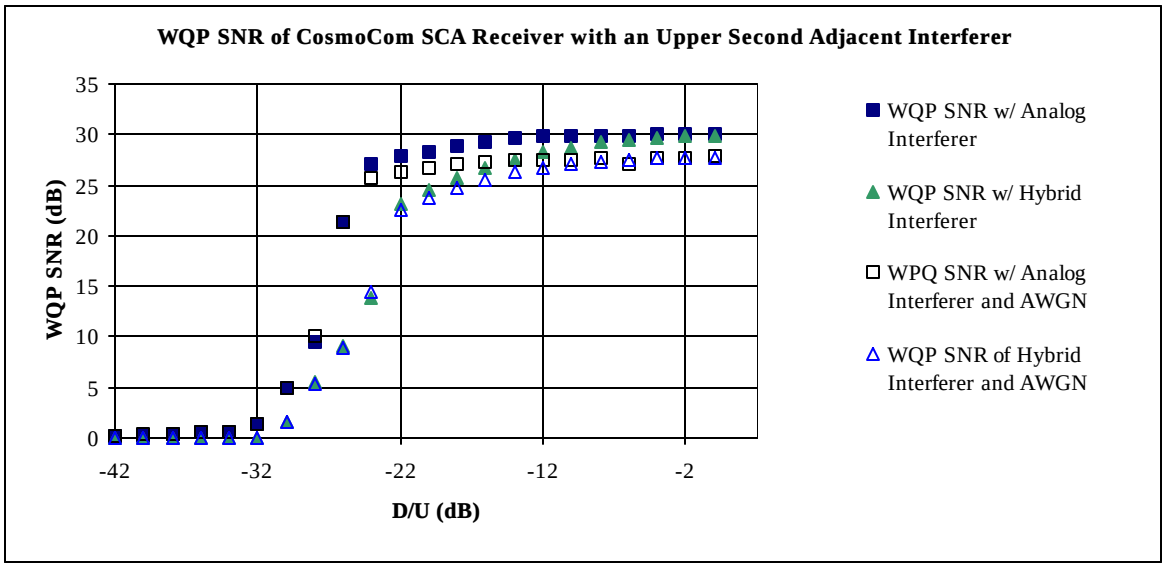

Figure 4-38 - CosmoCom 92kHz SCA Receiver WQP SNR with an Upper Second Adjacent Channel Interferer

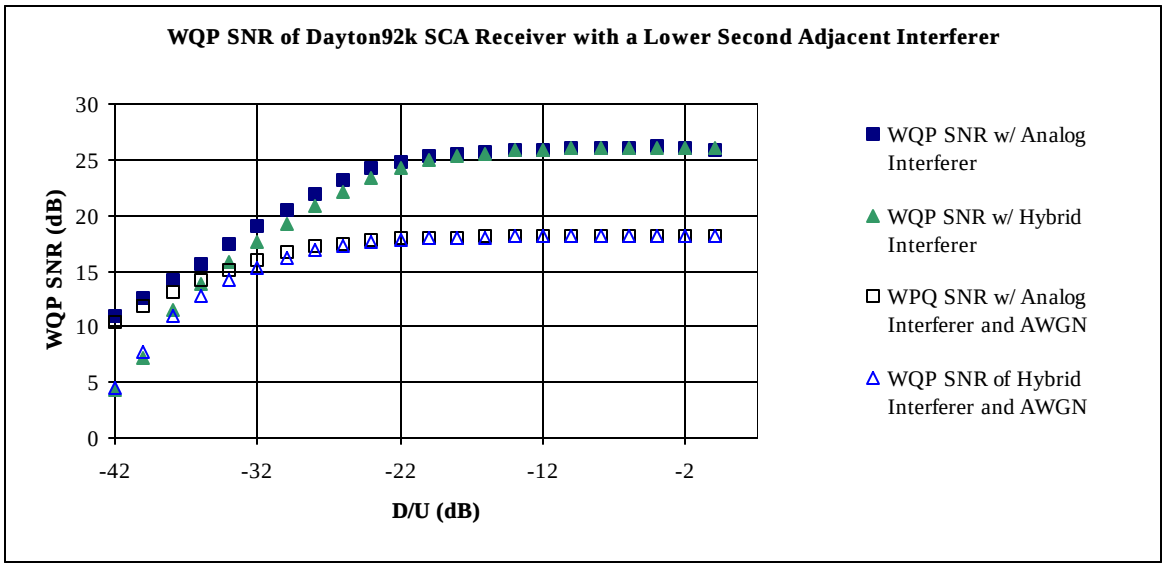

Figure 4-39 - Dayton AF200 92kHz SCA Receiver WQP SNR with a Lower Second Adjacent Channel Interferer

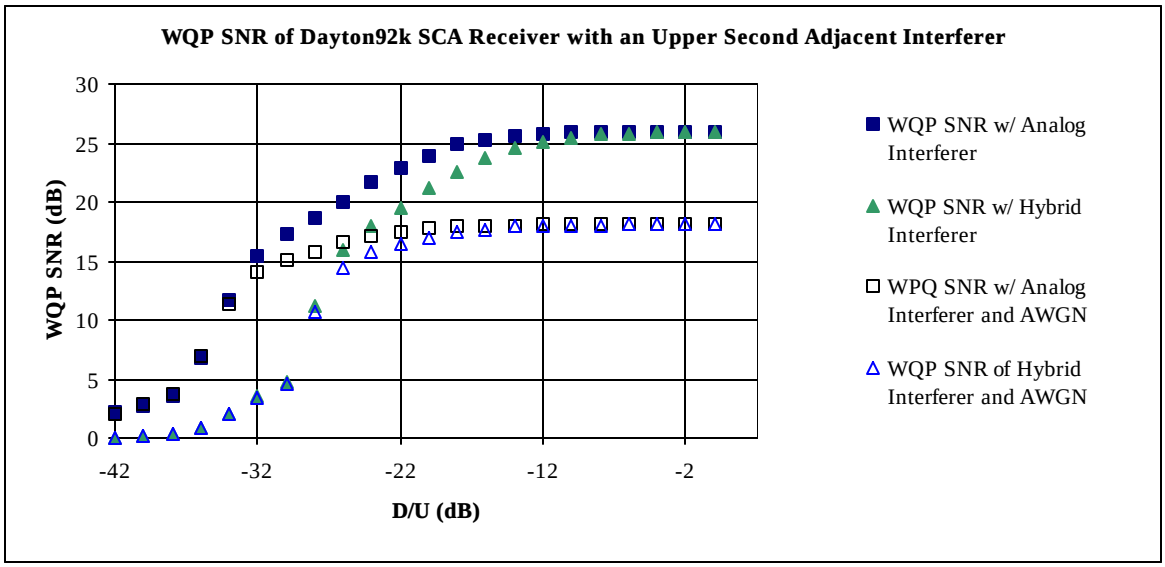

Figure 4-40 - Dayton AF200 92kHz SCA Receiver WQP SNR with an Upper Second Adjacent Channel Interferer

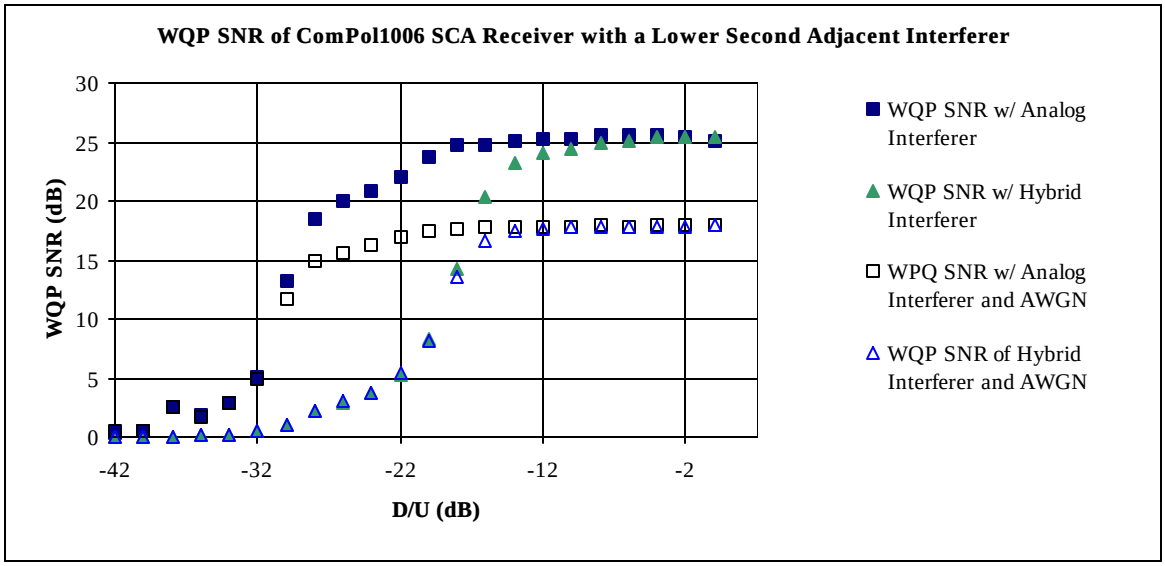

Figure 4-41 - ComPol SCA-RLA SN:1006 92kHz SCA Receiver WQP SNR with a Lower Second Adjacent Channel Interferer

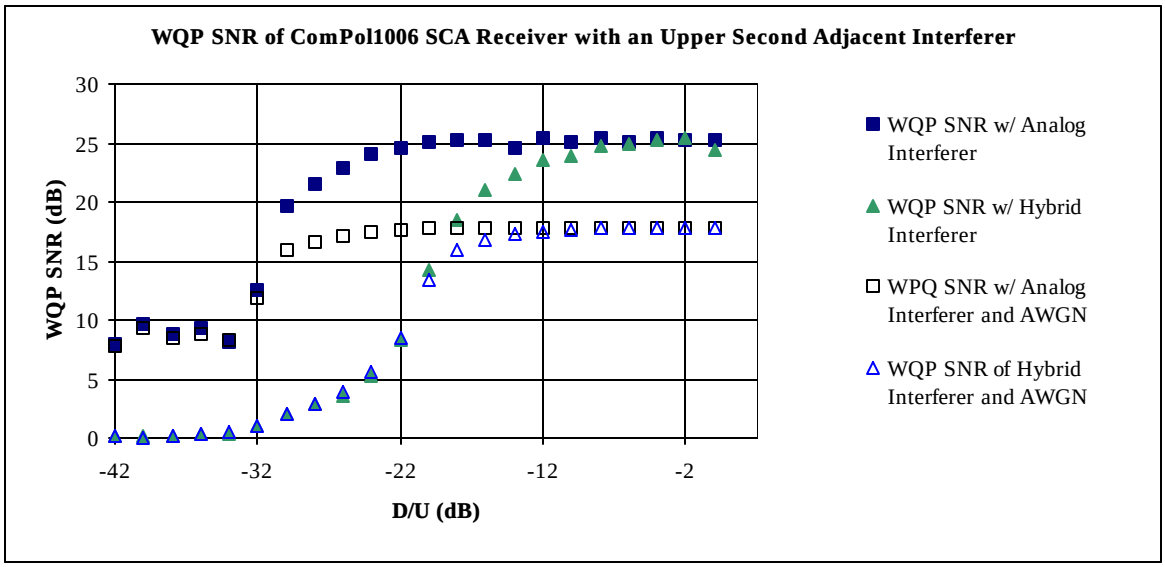

Figure 4-42 - ComPol SCA-RLA SN:1006 92kHz SCA Receiver WQP SNR with an Upper Second Adjacent Channel Interferer

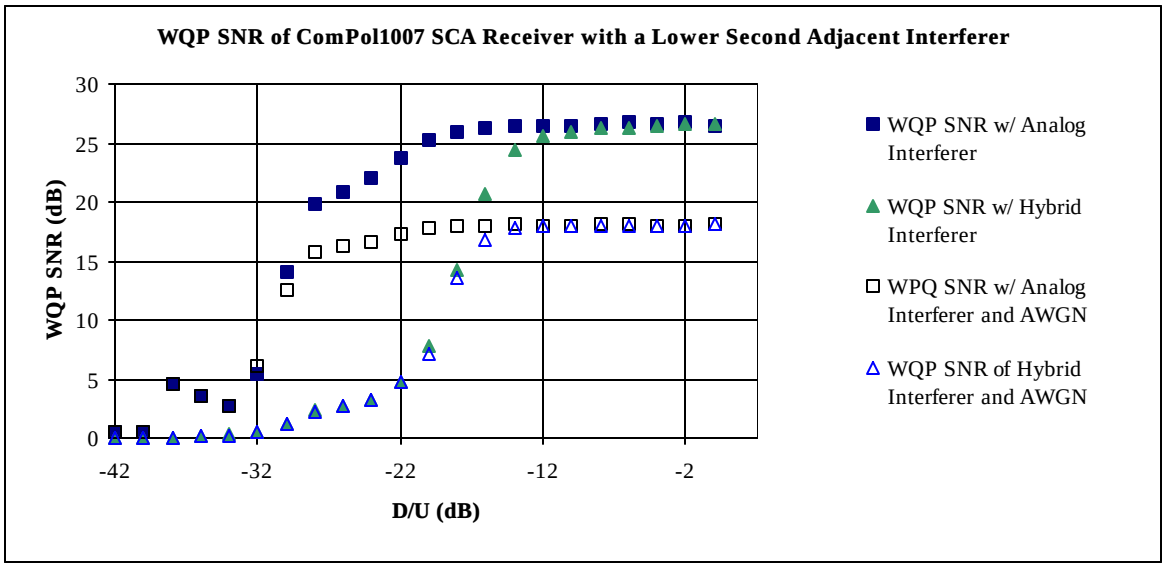

Figure 4-43 - ComPol SCA-RLA SN:1007 92kHz SCA Receiver WQP SNR with a Lower Second Adjacent Channel Interferer

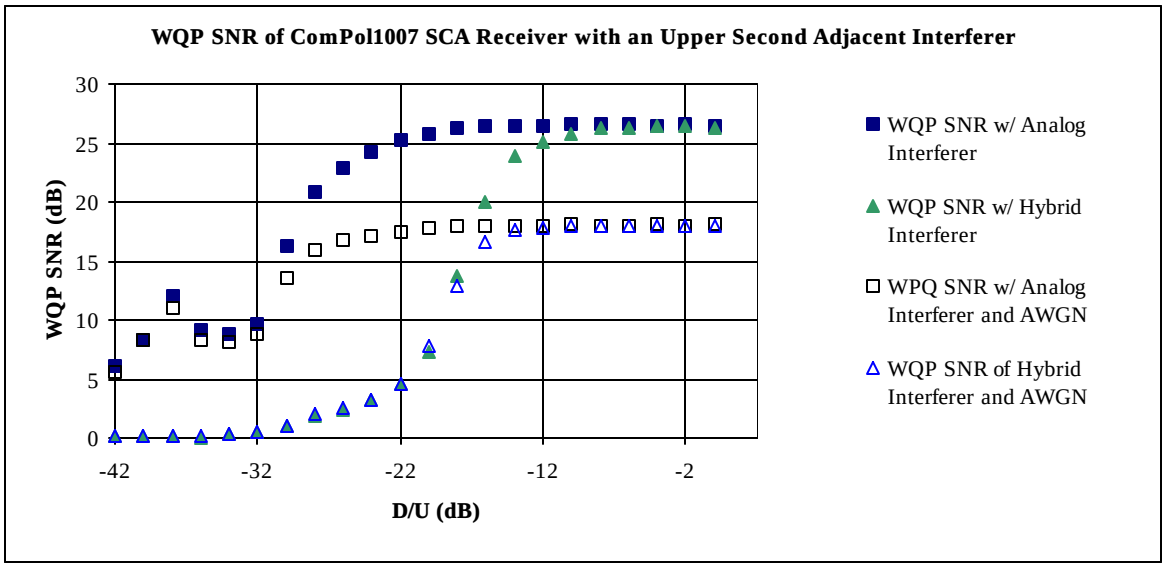

Figure 4-44 - ComPol SCA-RLA SN:1007 92kHz SCA Receiver WQP SNR with an Upper Second Adjacent Channel Interferer

5. Host Compatibility Test Results Summary

The Weighted Quasi-Peak Signal-to-Noise Ratio (WQP SNR) of each receiver listed in Table 3-8 was measured for host compatibility. Host compatibility was evaluated over a range of signal types and channel impairments. The test results are presented in the following subsections.

5.1. 67kHz SCA Receiver Performance in the Presence of an Analog or an IBOC Host

The tables below illustrate the conditions and results for the host compatibility with no multipath tests. The results are separated in to two groups; one for the 67kHz subcarrier and one for the 92kHz subcarrier. The following information may be useful in understanding the tables in this subsection:

1. Each row of the table represents one test, and each test is assigned a unique identification number in the # column.
2. The *Receiver Under Test* column lists the receiver that was tested.
3. The *Desired* column indicates the mode, signal type, power level, and the SCA frequency to be tested on the desired channel. The SCA frequency to be tested is either *67kHz* or *92kHz*. The desired mode is *Analog* and the power level is *Moderate* (-62dBm) for all of these tests.
4. The *Desired Main Ch. Modulation* column indicates main channel's modulating audio.
5. The *AWGN* column indicates the presence or absence of a broadband noise floor in the test scenario. If additional noise is present in a test, the absolute power level is indicated in Kelvin units.
6. The *WQP SNR* column shows the results of the test in dB units.

5.1.1. 67kHz SCA Receiver Test Results

Table 5-1 - WQP SNR of Dayton AF210 Receiver on 67kHz SCA Setting with An Analog or an IBOC Host

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8101	Dayton AF210 67kHz Setting	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	None	32.5
8102	Dayton AF210 67kHz Setting	Hybrid Type II: 67kHz: Moderate	Stereo Clipped USASI	None	23.8
8103	Dayton AF210 67kHz Setting	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	27.3
8104	Dayton AF210 67kHz Setting	Hybrid Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	22.5

Table 5-2 - WQP SNR of McMartin 67kHz SCA Receiver with an Analog or an IBOC Host

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8101	McMartin TR-E5/55M	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	None	38.0
8102	McMartin TR-E5/55M	Hybrid Type II: 67kHz: Moderate	Stereo Clipped USASI	None	34.5
8103	McMartin TR-E5/55M	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	33.0
8104	McMartin TR-E5/55M	Hybrid Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	31.8

Table 5-3 - WQP SNR of Norver 67kHz SCA Receiver with An Analog or an IBOC Host

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8101	Norver	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	None	30.8
8102	Norver	Hybrid Type II: 67kHz: Moderate	Stereo Clipped USASI	None	24.9
8103	Norver	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	25.9
8104	Norver	Hybrid Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	23.4

Table 5-4 - WQP SNR of Dayton AF200 67kHz SCA Receiver with An Analog or an IBOC Host

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8101	Dayton AF200	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	None	22.5
8102	Dayton AF200	Hybrid Type II: 67kHz: Moderate	Stereo Clipped USASI	None	19.1
8103	Dayton AF200	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	18.7
8104	Dayton AF200	Hybrid Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	17.0

Table 5-5 - WQP SNR of ComPol SCA-RLA SN: 1004 67kHz SCA Receiver with An Analog or an IBOC Host

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8101	ComPol SN:1004	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	None	25.3
8102	ComPol SN:1004	Hybrid Type II:	Stereo Clipped	None	20.9

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
		67kHz: Moderate	USASI		
8103	ComPol SN:1004	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	20.9
8104	ComPol SN:1004	Hybrid Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	18.9

Table 5-6 - WQP SNR of ComPol SCA-RLA SN: 1005 67kHz SCA Receiver with An Analog or an IBOC Host

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8101	ComPol SN:1005	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	None	24.4
8102	ComPol SN:1005	Hybrid Type II: 67kHz: Moderate	Stereo Clipped USASI	None	20.8
8103	ComPol SN:1005	Analog Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	20.5
8104	ComPol SN:1005	Hybrid Type II: 67kHz: Moderate	Stereo Clipped USASI	30,000K	18.9

5.1.2. 92kHz SCA Receiver Test Results

Table 5-7 - WQP SNR of the Dayton AF210 Receiver on 92kHz SCA Setting with an Analog or an IBOC Host

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8105	Dayton AF210 92kHz Setting	Analog Type II: 92kHz: Moderate	Stereo Clipped USASI	None	35.2
8106	Dayton AF210 92kHz Setting	Hybrid Type II: 92kHz: Moderate	Stereo Clipped USASI	None	20.9
8107	Dayton AF210 92kHz Setting	Analog Type II: 92kHz: Moderate	Stereo Clipped USASI	30,000K	26.9
8108	Dayton AF210 92kHz Setting	Hybrid Type II: 92kHz: Moderate	Stereo Clipped USASI	30,000K	20.1

Table 5-8 - WQP SNR of the CosmoCom 92kHz SCA Receiver with an Analog or an IBOC Host

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8105	CosmoCom	Analog Type II: 92kHz: Moderate	Stereo Clipped USASI	None	30.5
8106	CosmoCom	Hybrid Type II: 92kHz: Moderate	Stereo Clipped USASI	None	24.9
8107	CosmoCom	Analog Type II: 92kHz: Moderate	Stereo Clipped USASI	30,000K	28.1

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8108	CosmoCom	Hybrid Type II: 92kHz: Moderate	Stereo Clipped USASI	30,000K	24.2

Table 5-9 - WQP SNR of the Dayton AF200 92kHz SCA Receiver with an Analog or an IBOC Host

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8105	Dayton AF200	Analog Type II: 92kHz: Moderate	Stereo Clipped USASI	None	26.1
8106	Dayton AF200	Hybrid Type II: 92kHz: Moderate	Stereo Clipped USASI	None	11.7
8107	Dayton AF200	Analog Type II: 92kHz: Moderate	Stereo Clipped USASI	30,000K	18.1
8108	Dayton AF200	Hybrid Type II: 92kHz: Moderate	Stereo Clipped USASI	30,000K	11.3

Table 5-10 - WQP SNR of the ComPol SCA-RLA 67kHz Receiver SN: 1006 with an Analog or an IBOC Host

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8105	ComPol SN: 1006	Analog Type II: 92kHz: Moderate	Stereo Clipped USASI	None	25.4
8106	ComPol SN: 1006	Hybrid Type II: 92kHz: Moderate	Stereo Clipped USASI	None	11.3
8107	ComPol SN: 1006	Analog Type II: 92kHz: Moderate	Stereo Clipped USASI	30,000K	17.9
8108	ComPol SN: 1006	Hybrid Type II: 92kHz: Moderate	Stereo Clipped USASI	30,000K	11.0

Table 5-11 - WQP SNR of the ComPol SCA-RLA 67kHz Receiver SN: 1007 with an Analog or an IBOC Host

#	Receiver Under Test	Desired	Desired Main Ch. Modulation	AWGN	WQP SNR (dB)
8105	ComPol SN: 1007	Analog Type II: 92kHz: Moderate	Stereo Clipped USASI	None	26.8
8106	ComPol SN: 1007	Hybrid Type II: 92kHz: Moderate	Stereo Clipped USASI	None	11.3
8107	ComPol SN: 1007	Analog Type II: 92kHz: Moderate	Stereo Clipped USASI	30,000K	18.1
8108	ComPol SN: 1007	Hybrid Type II: 92kHz: Moderate	Stereo Clipped USASI	30,000K	10.9

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5.2. 67kHz and 92kHz SCA Receiver Performance with an Analog or an IBOC Host in Multipath Conditions

This section contains the results of the host compatibility with multipath tests. The IAAIS and NPR chose four of the receivers that were sent to the ATTC to be tested. For a detailed list of the receivers see Table 3-9. Table 5-12 details the conditions for these tests. The information below may be useful in understanding 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, power level of the desired channel. The desired mode is *Analog* or *Hybrid* and the power level is *Moderate* (-62dBm) for all of these tests.
3. *Signal Type* column indicates the signal type to be used for testing
4. The *Multipath* column indicates the multipath scenario that was used during testing.
5. The *Echo Phase* column indicates the range of phases to be tested. The phase will be stepped over the range indicated in steps of 45 degrees.
6. The *SCA Under Test* column indicates the subcarrier that is being evaluated (either 67kHz or 92kHz).

Table 5-12 – Host Compatibility with Multipath Scenarios

#	Desired	Signal Type	Multipath	Echo Phase	SCA Under Test
8201	Analog: Moderate	Analog III	StaticMP1	-187 → -7	67kHz
8202	Hybrid: Moderate	Hybrid III	StaticMP1	-187 → -7	67kHz
8203	Analog: Moderate	Analog I	StaticMP1	-187 → -7	67kHz
8204	Hybrid: Moderate	Hybrid I	StaticMP1	-187 → -7	67kHz
8205	Analog: Moderate	Analog III	StaticMP2	-187 → -7	67kHz
8206	Hybrid: Moderate	Hybrid III	StaticMP2	-187 → -7	67kHz
8207	Analog: Moderate	Analog I	StaticMP2	-187 → -7	67kHz
8208	Hybrid: Moderate	Hybrid I	StaticMP2	-187 → -7	67kHz
8209	Analog: Moderate	Analog III	StaticMP3	-16 → -164	67kHz
8210	Hybrid: Moderate	Hybrid III	StaticMP3	-16 → -164	67kHz
8211	Analog: Moderate	Analog I	StaticMP3	-16 → -164	67kHz
8212	Hybrid: Moderate	Hybrid I	StaticMP3	-16 → -164	67kHz
8213	Analog: Moderate	Analog III	StaticMP1	-187 → -7	92kHz
8214	Hybrid: Moderate	Hybrid III	StaticMP1	-187 → -7	92kHz
8215	Analog: Moderate	Analog I	StaticMP1	-187 → -7	92kHz
8216	Hybrid: Moderate	Hybrid I	StaticMP1	-187 → -7	92kHz
8217	Analog: Moderate	Analog III	StaticMP2	-187 → -7	92kHz
8218	Hybrid: Moderate	Hybrid III	StaticMP2	-187 → -7	92kHz
8219	Analog: Moderate	Analog I	StaticMP2	-187 → -7	92kHz
8220	Hybrid: Moderate	Hybrid I	StaticMP2	-187 → -7	92kHz
8221	Analog: Moderate	Analog III	StaticMP3	-16 → -164	92kHz
8222	Hybrid: Moderate	Hybrid III	StaticMP3	-16 → -164	92kHz
8223	Analog: Moderate	Analog I	StaticMP3	-16 → -164	92kHz
8224	Hybrid: Moderate	Hybrid I	StaticMP3	-16 → -164	92kHz

The plots in the following sections illustrate the results of these tests. Each plot shows the results of four tests; analog host unmodulated, hybrid host unmodulated, analog host modulated, and a hybrid host modulated.

5.2.1. McMartin 67kHz SCA Receiver Performance with an Analog or an IBOC Host in Multipath Conditions

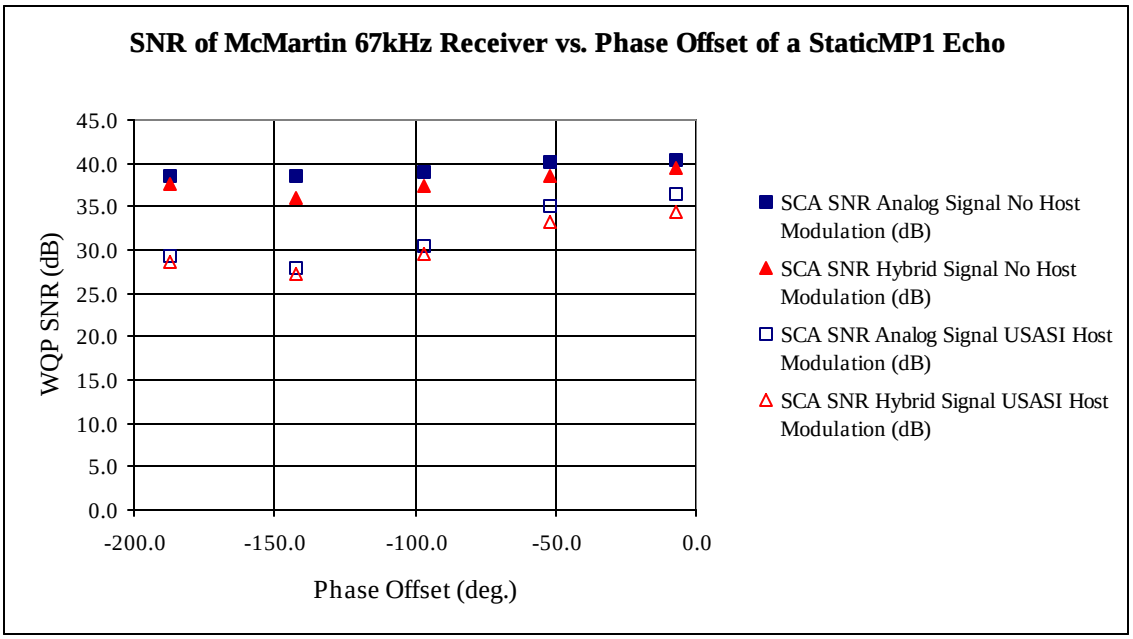

Figure 5-1 - McMartin TR-E5/55M 67kHz SCA Receiver with an Analog and an IBOC Host in StaticMP1 Multipath Conditions

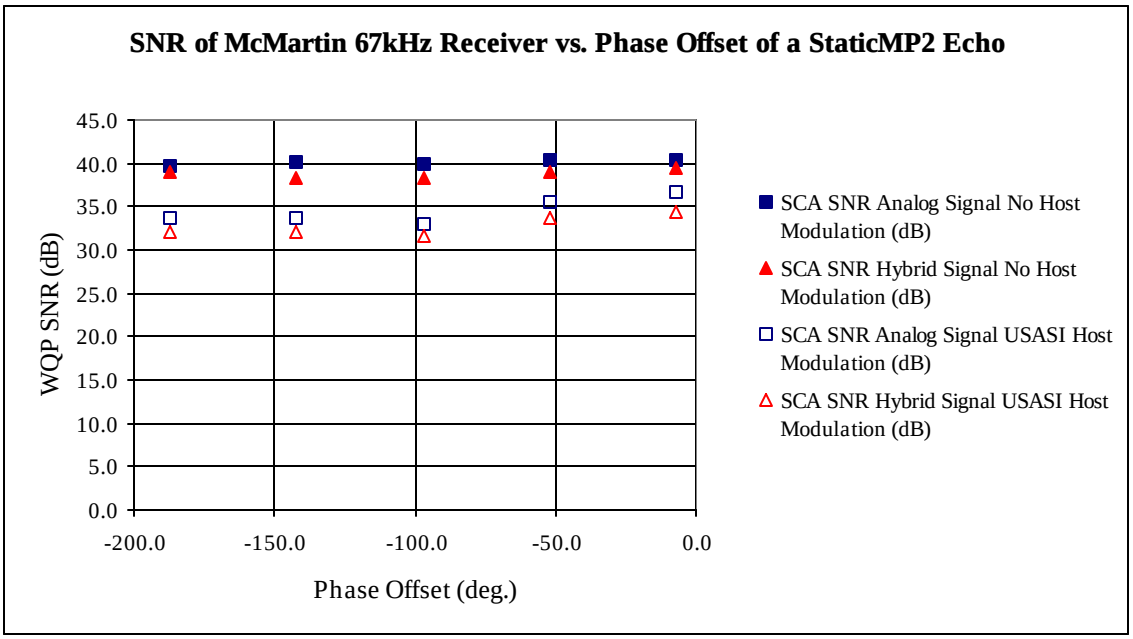

Figure 5-2 - McMartin TR-E5/55M 67kHz SCA Receiver with an Analog and an IBOC Host in StaticMP2 Multipath Conditions

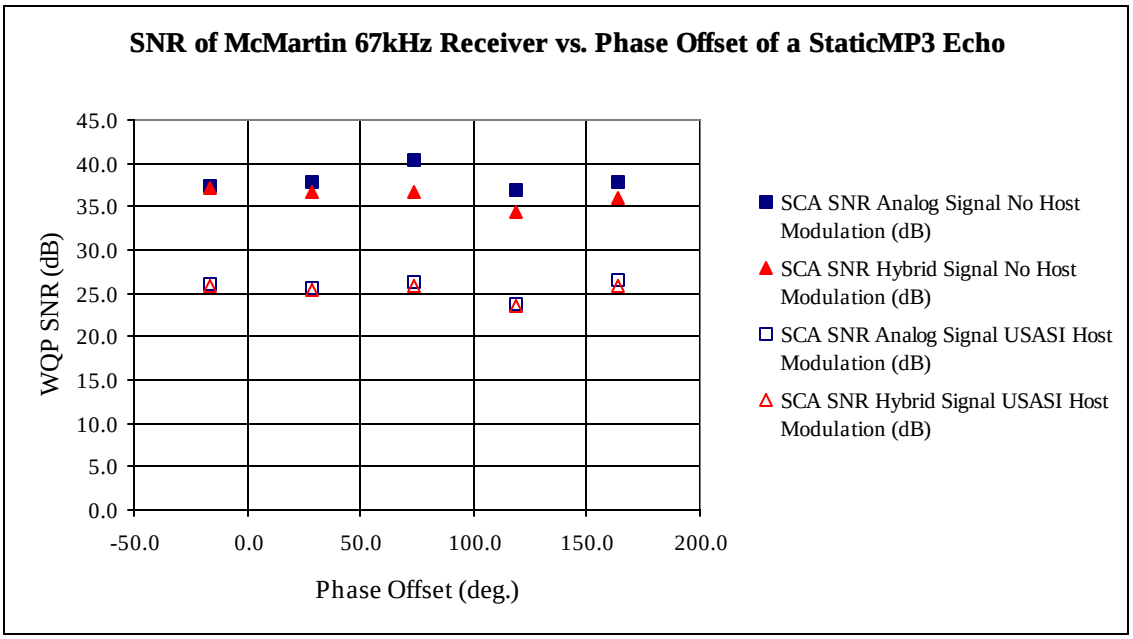

Figure 5-3 - McMartin TR-E5/55M 67kHz SCA Receiver with an Analog and an IBOC Host in StaticMP3 Multipath Conditions

5.2.2. ComPol 67kHz SCA Receiver SN: 1005 Performance with an Analog or an IBOC Host in Multipath Conditions

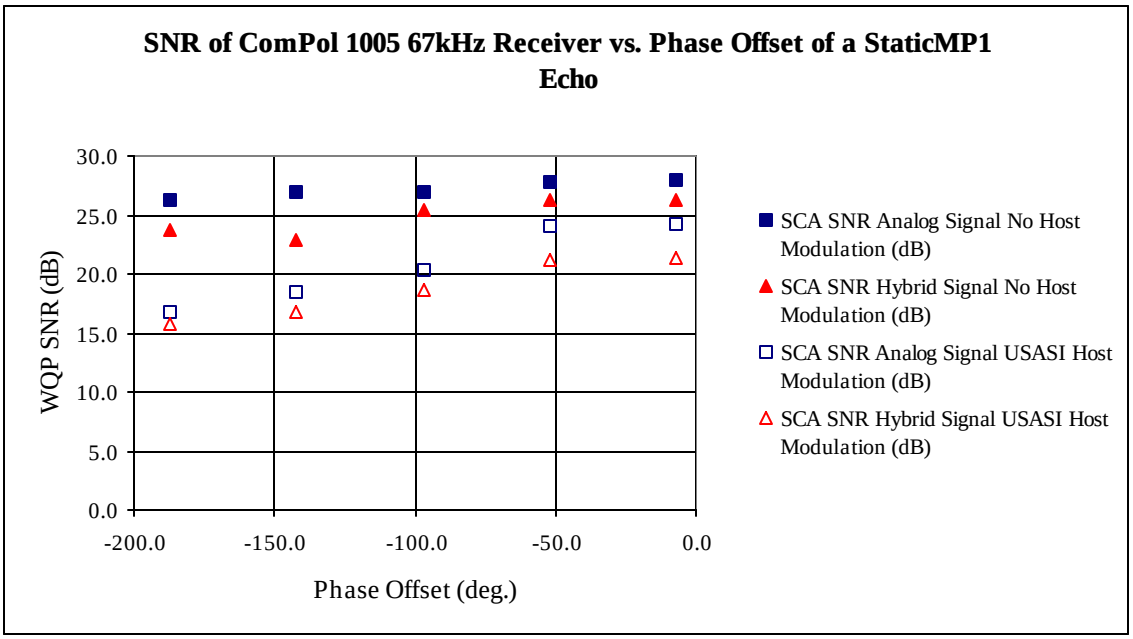

Figure 5-4 - ComPol 67kHz SCA Receiver SN: 1005 with an Analog and an IBOC Host in StaticMP1 Multipath Conditions

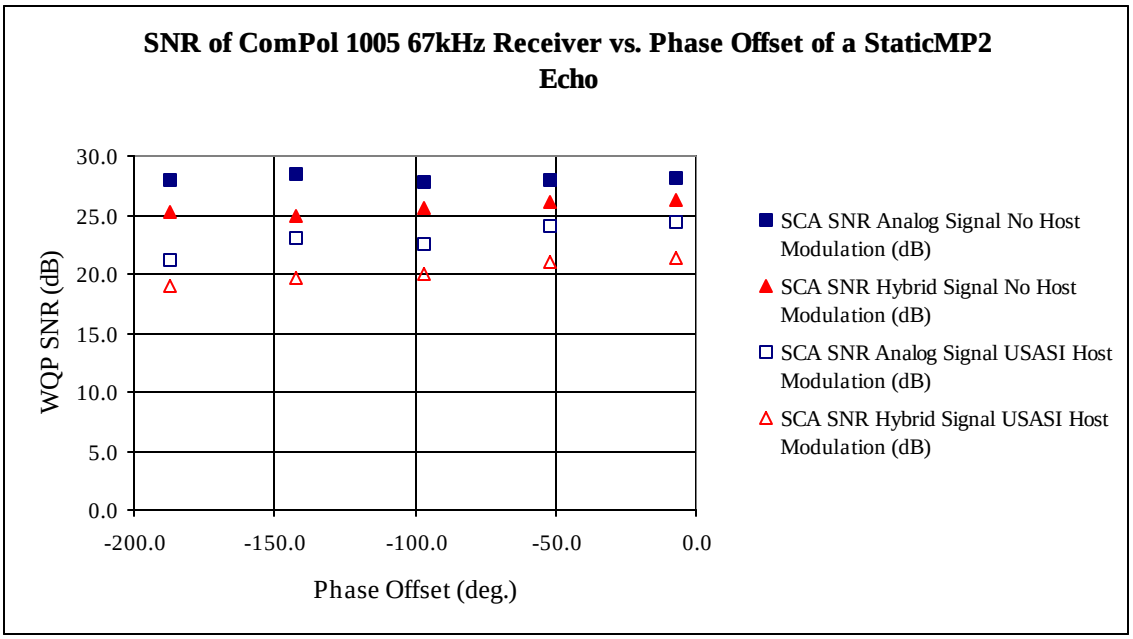

Figure 5-5 - ComPol 67kHz SCA Receiver SN: 1005 with an Analog and an IBOC Host in StaticMP2 Multipath Conditions

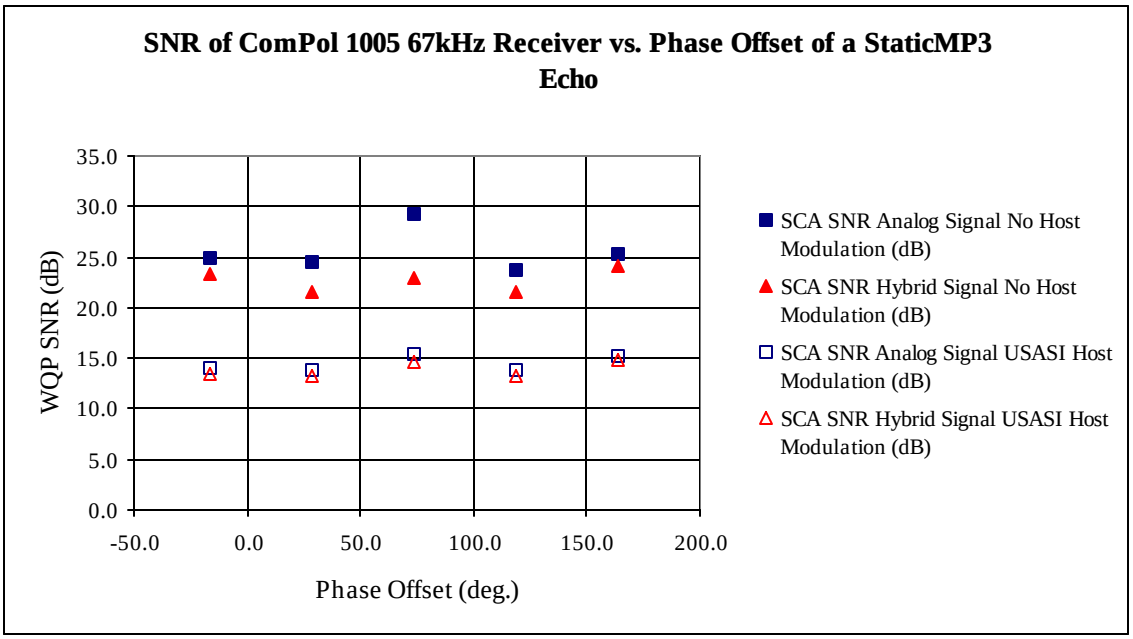

Figure 5-6 - ComPol 67kHz SCA Receiver SN: 1005 with an Analog and an IBOC Host in StaticMP3 Multipath Conditions

5.2.3. CosmoCom 92kHz Receiver Performance with an Analog or an IBOC Host in Multipath Conditions

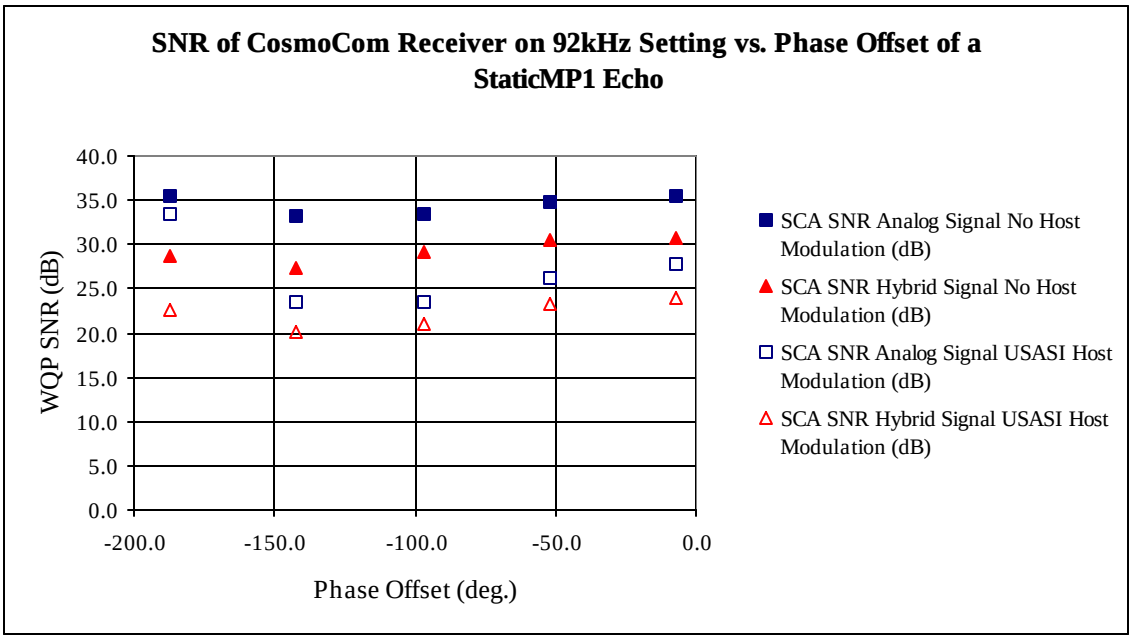

Figure 5-7 - CosmoCom 92kHz SCA Receiver with an Analog and an IBOC Host in StaticMP1 Multipath Conditions

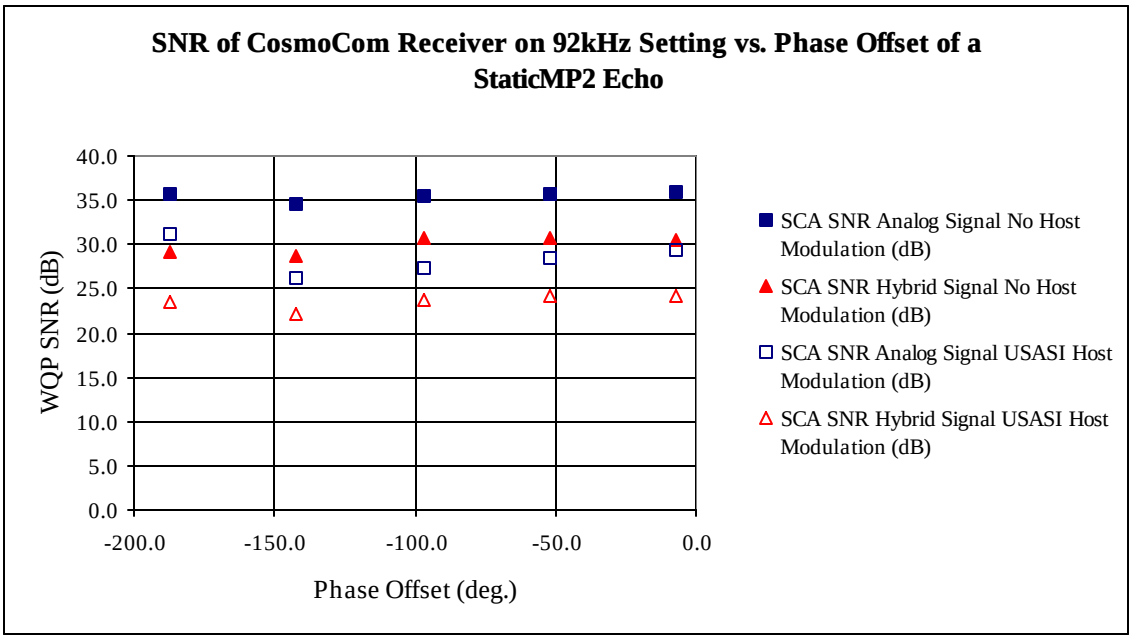

Figure 5-8 - CosmoCom 92kHz SCA Receiver with an Analog and an IBOC Host in StaticMP2 Multipath Conditions

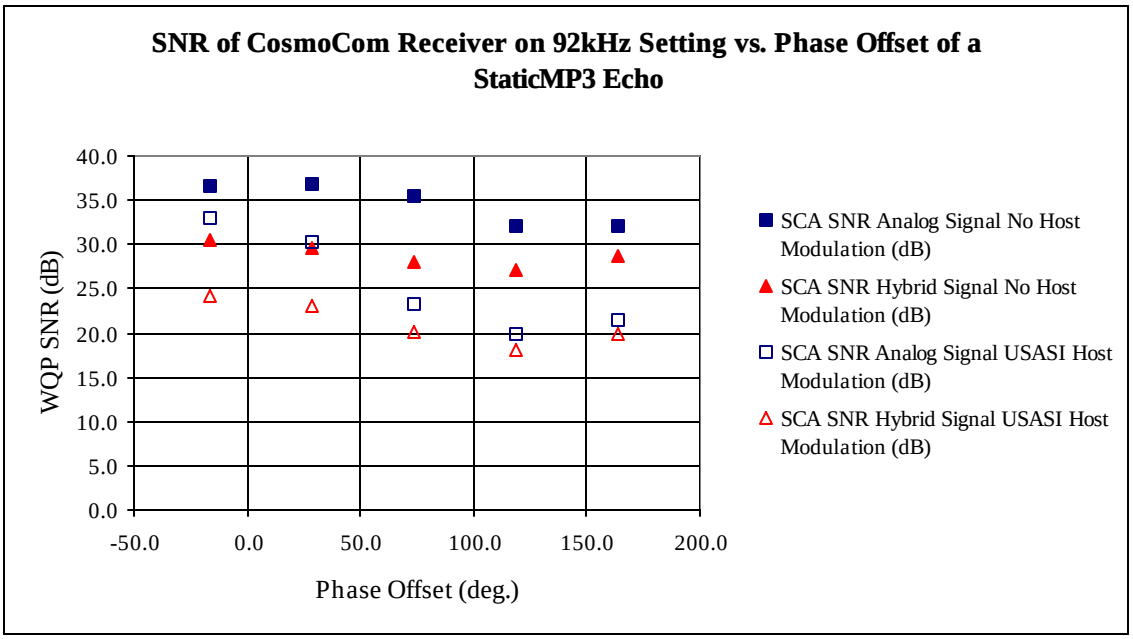

Figure 5-9 - CosmoCom 92kHz SCA Receiver with an Analog and an IBOC Host in StaticMP3 Multipath Conditions

5.2.4. ComPol 92kHz SCA Receiver SN: 1006 Performance with an Analog or an IBOC Host in Multipath Conditions

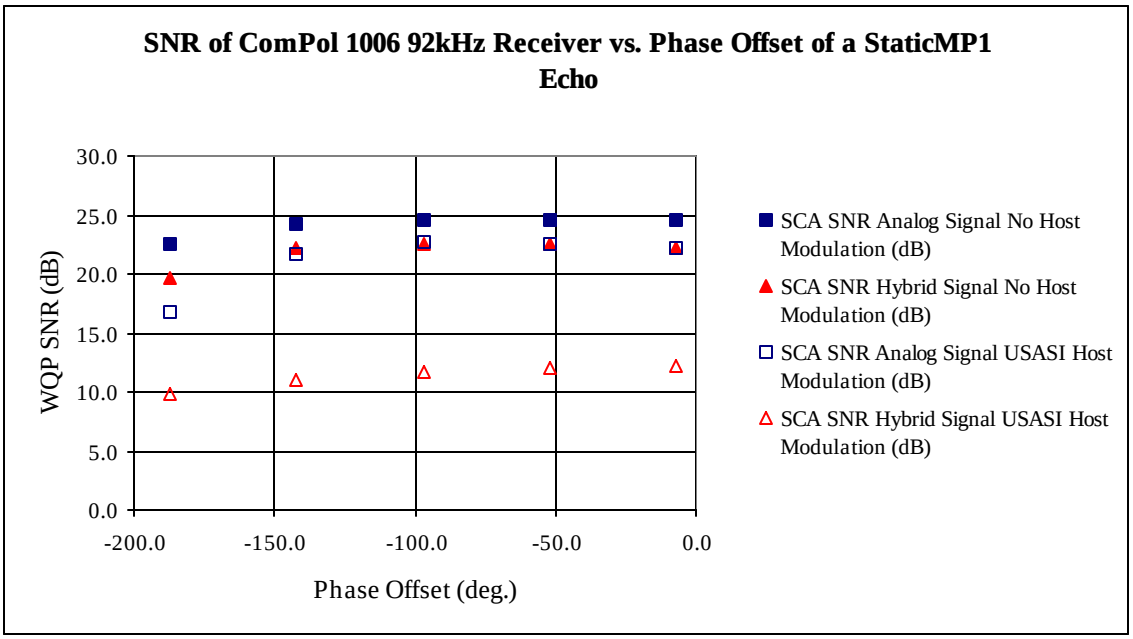

Figure 5-10 - ComPol 92kHz SCA Receiver SN: 1006 with an Analog and an IBOC Host in StaticMP1 Multipath Conditions

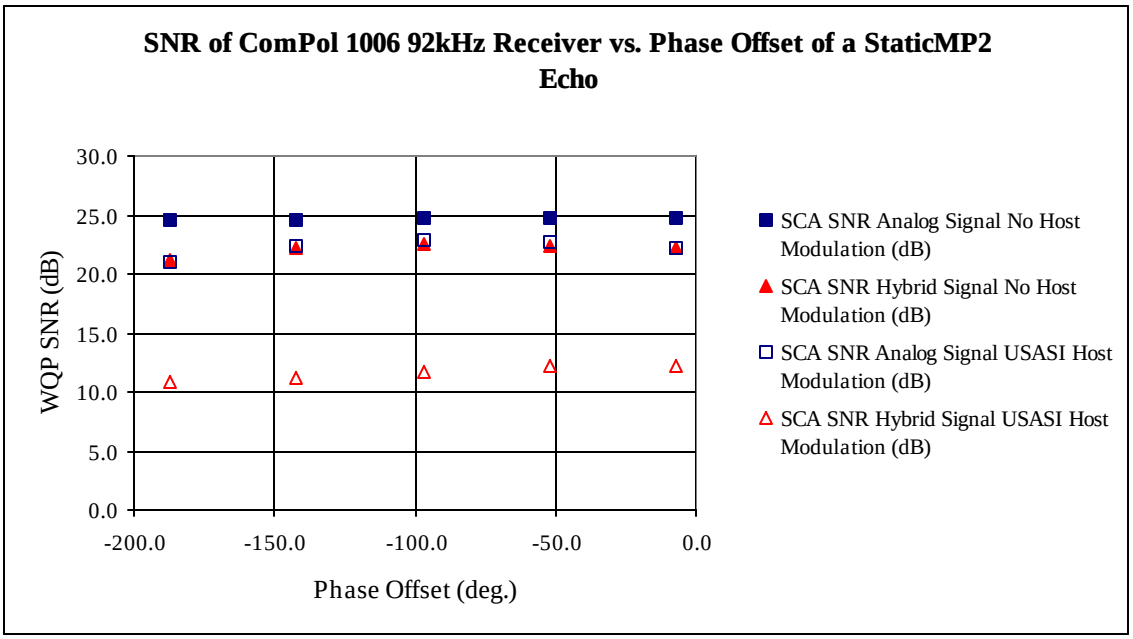

Figure 5-11 - ComPol 92kHz SCA Receiver SN: 1006 with an Analog and an IBOC Host in StaticMP2 Multipath Conditions

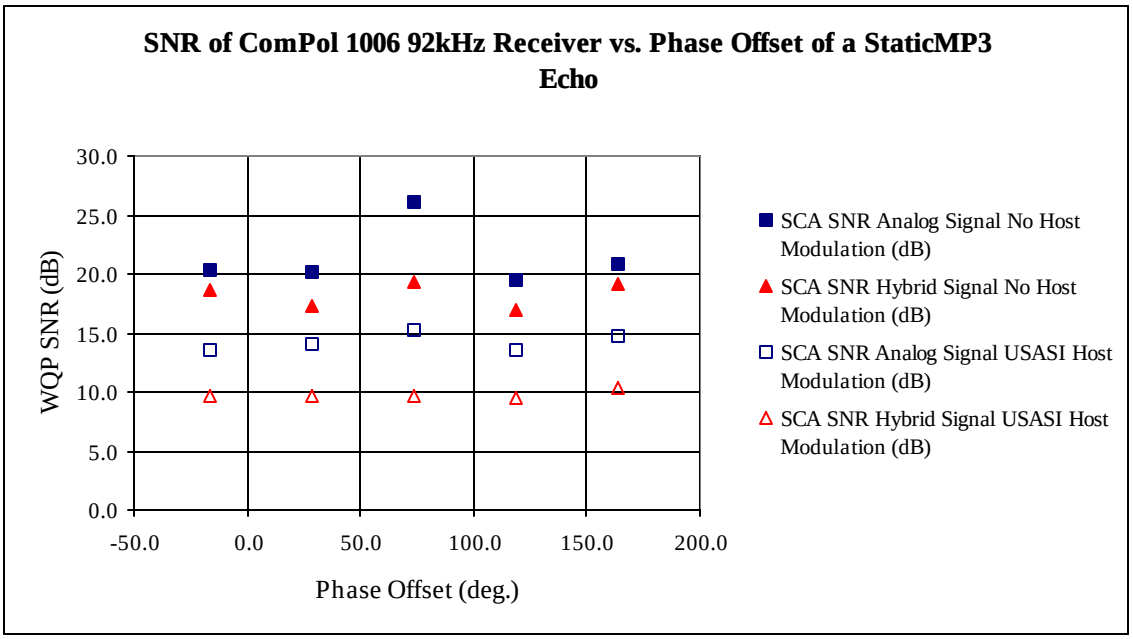

Figure 5-12 - ComPol 92kHz SCA Receiver SN: 1006 with an Analog and an IBOC Host in StaticMP3 Multipath Conditions

6. Acknowledgements

The Advanced Television Technology Center (ATTC) and its staff are grateful to the representatives of iBiquity Digital, National Public Radio, and the International Association of Audio Information Services for their support throughout this test program.

The ATTC is a private, non-profit enterprise formed by a coalition of broadcasting companies and industry organizations. The Advanced Television Technology Center has been providing independent test and measurement services to the broadcast industry for over eleven years. The work of the ATTC has been a key component of numerous broadcast industry standards and FCC rules and regulations. Through this work, the ATTC has earned an industry reputation of conducting fair and impartial tests in a manner that maintains the utmost technical quality.

For the testing of the iBiquity IBOC DAB System, ATTC project staff included: Paul K. DeGonia, *Executive Director* • Charles W. Einolf, Jr., *Deputy Executive Director* • Debbie Espinoza, *Office Administrator* • Jacob Kirkland, *RF Test Engineer* • Jonathan Kreinik, *Audio Editor* • Steve Thomas, *Technology Specialist* • Sean C. Wallace, *Systems Engineer*