Appendix C
Intermodulation Test Procedures and Recorded Data

The marine VHF radios were tested for susceptibility to 3rd and 5th order intermodulation products by using two signal generators as interfering transmitters that could possibly generate intermodulation products on channel 67 within the receiver of the radio being tested. A diagram of the test set-up is shown below in Figure C-1.

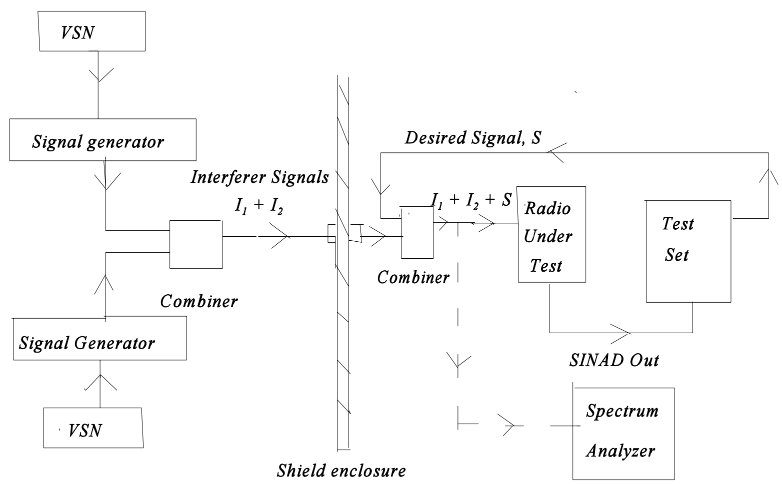

Figure C-1
Intermodulation Susceptibility Test Set-up

The following steps which were taken to perform the intermodulation tests.

1. The receiver of the radio under test was tuned to marine channel 67. The test set which was used as the desired signal transmitter was also tuned to channel 67 and was modulated by an internal 1 kHz tone adjusted in amplitude for a 3 kHz signal deviation.

2. The power of the desired signal, S, from the RF output of the test set was adjusted and its value recorded in dBm when the SINAD of the radio receiver under test was 15 dB.

3. The frequencies of the signal generators were set to values that could generate the 3rd or 5th order intermodulation products on channel 67 within the radio's receiver. Two pairs of frequencies were chosen so that both frequencies of each pair were either in the marine band (156-174 MHz) or both out of the marine band.

4. The RF outputs of the signal generators were FM modulated by voice-shaped noise (VSN) played from tapes in cassette players. The peak amplitudes of the VSN signals from the cassette tapes were

matched as closely as possible to the amplitude of a 1 kHz tone that would produce a 2.5 kHz signal deviation.

5. The RF outputs of the signal generators, I_1 and I_2, were combined and fed through the shielded enclosure. This composite signal was then combined with the desired signal, S, from the test set and connected to the RF input of the radio.

6. The RF power of each signal generator was increased from -139 dBm in equal increments (i.e. , the signal generator RF output levels were kept approximately equal) until the SINAD of the radio being tested dropped from 15 to 12 dB.

7. The SINAD reduction due to intermodulation products was verified by turning each of the signal generators off and observing the SINAD meter on the test set. If the SINAD did not recover to 15 dB with only one signal generator present, then receiver saturation was presumed to be the dominant interference mechanism rather than intermodulation.

7. Once the SINAD reduction due to the intermodulation product was verified, the RF power of each signal generator, I_1 and I_2 , at the RF input to the radio was measured in dBm with a spectrum analyzer and recorded.

8. If receiver saturation occurred, then it was so noted and the tests continued.

The CCIT audio weighting filter in the test set was not activated during these tests.

Setting Frequency Generators

Using equation C-1, two frequencies were selected to generate the 3rd order in-band intermodulation product on channel 67. Note: F1 is tuned below F2.

In band frequencies: F1=158.700 MHz, F2=161.025 MHz

(Eq. C-1) $F_{IM3} = 2F1 - F2$

$F_{IM3} = 2*158.700 - 161.025$

$F_{IM3} = 156.375$ MHz, which is the carrier frequency of marine channel 67

Equation C-2 was used to select frequencies to generate the 3rd order out-of-band intermodulation products on channel 67.

Out-of-band frequencies: F1=151.725 MHz, F2=154.050 MHz

(Eq. C-2) $F_{IM3} = 2F2 - F1$

$F_{IM3} = 2*154.050 - 151.725$

$F_{IM3} = 156.375$ MHz, which is the carrier frequency of marine channel 67

Using equation C-3, two frequencies were selected to generate the 5th order in-band intermodulation product on channel 67. Note: F1 is tuned below F2.

In band frequencies: F1=158.700 MHz, F2=159.8625 MHz

(Eq. C-3) $F_{IM5} = 3F1 - 2F2$

$F_{IM5} = 3*158.700 - 2*159.8625$

F_{IM5} = 156.375 MHz, which is the carrier frequency of marine channel 67

Equation C-4 was used to select frequencies to generate the 5th order out-of-band intermodulation product on channel 67.

Out-of-band frequencies: F1=152.8875 MHz, F2=154.050 MHz

(Eq. C-4) $F_{IM5} = 3F2 - 2F1$

$F_{IM5} = 3*154.050 - 2*152.8875$

F_{IM5} = 156.375 MHz, which is the carrier frequency of marine channel 67

Calculating Intermodulation Rejection Ratio

The intermodulation rejection ratio (IMR) of the victim receiver was calculated using equation C-5:

(Eq. C-5) $$IMR = S - I$$

where:

IMR= Intermodulation rejection ratio of victim receiver, in dB

S = Desired signal power for 15 dB SINAD, in dBm

I = Power of interferer, in dBm

The IMR, S, and I for each receiver is shown below in Tables C-1 through C-4. Table C-1 contains the data for the out-of-band response and Table C-2 contains data for the in-band response for 3rd order IMR. The powers of each interferer are almost equal, therefore the S/I was calculated using the nominal value.

Table C-1
In-Band 3rd Order IMR Response

Radio	Desired Signal, S (dBm)	F1= 158.700 MHz F2= 161.025 MHz		
		IMR (dB)	I_1 (dBm)	I_2 (dBm)
Receiver A	-114	-63	-50.8	-50.5
Receiver B	-119	-81	-38.7	-38.2
Receiver C	-117	-77	-40.0	-39.6
Receiver D	-119	-80	-40.6	-40.2
Receiver E	-115	-62	-53.5	-53.2
Receiver F	-116	-78	-38.7	-38.2
Receiver G	-115	-61	-54.2	-53.8
Receiver G	-115	-72	-43.5	-43.2
Receiver I	-117	-67	-50.5	-49.8
Receiver K	-118	-66	-52	-52

Table C-2
Out-of-Band 3rd Order IMR Response

Radio	Desired Signal, S (dBm)	F1= 151.725 MHz F2= 154.050 MHz		
		IMR (dB)	I_1 (dBm)	I_2 (dBm)
Receiver A	-114	-68	-46.0	-46.3
Receiver B	-119	saturation	*	*
Receiver C	-117	-84	-33..5	-32.8
Receiver D	-119	saturation	*	*
Receiver E	-115	-71	-44.3	-42.3
Receiver F	-116	-83	-33.2	-32.6
Receiver G	-115	-71	-44.8	-44.2
Receiver H	-115	saturation	*	*
Receiver I	-117	-71	-46.6	-46.2
Receiver K	-118	-69	-49	-49

Table C-3 contains the data for the out-of-band response and Table C-4 contains data for the in-band response for 5th order IMR.

Table C-3
In-Band 5th Order IMR Response

Radio	Desired Signal, S (dBm)	F1= 158.700 MHz F2= 159.8625 MHz		
		IMR (dB)	I_1 (dBm)	I_2 (dBm)
Receiver A	-114	-73	-41.3	-41.0
Receiver B	-119	saturation	*	*
Receiver D	-119	-86	-33	-33
Receiver E	-115	-76	-39	-39
Receiver F	-116	saturation	*	*
Receiver G	-115	saturation	*	*
Receiver H	-115	saturation	*	*
Receiver I	-117	saturation	*	*
Receiver K	-118	-80	-38	-38

Table C-4
Out-of-Band 5th Order IMR Response

Radio	Desired Signal, S (dBm)	F1= 152.8875 MHz F2= 154.050 MHz		
		IMR (dB)	I_1 (dBm)	I_2 (dBm)
Receiver A	-114	-77	-37	-37
Receiver B	-119	saturation	*	*
Receiver D	-119	saturation	*	*
Receiver E	-115	-81	-34	-34
Receiver F	-116	saturation	*	*
Receiver G	-115	saturation	*	*
Receiver H	-115	saturation	*	*
Receiver I	-117	-83	-35	-34
Receiver K	-118	-82	-36	-36

The saturation values were not recorded but generally occurred at higher powers than the intermodulation products.