

**PHYSICAL TEST REPORT
FOR THE
L3 COMMUNICATIONS
AVIATION RECORDERS CORPORATION
AUTOMATIC IDENTIFICATION SYSTEM
PERFORMANCE TESTS**

Prepared for:

L3 Communications Aviation Recorders Corp.
6000 Fruitville Road
Sarasota, FL 34232
USA

Submitted by:

Green Mountain Electromagnetics, Inc.



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L3 Communications Aviation Recorders Corporation
Physical Tests
By
Green Mountain Electromagnetics, Inc.
Middlebury, Vermont

Unit: Automatic Identification System (AIS)

Evaluated: May 27 to July 25, 2003

I. Applicable Standards:

The unit described in this report was evaluated for compliance with paragraph 15, "Physical Tests" of IEC 61993-2, "Maritime Navigation and Radiocommunication Equipment and Systems – Automatic Identification Systems (AIS), Part 2: Class A Shipborne Equipment of the Universal AIS – Operational and Performance Requirements, Methods of Test and Required Test Results (December 2001)."

The unit described in this report was also measured for compliance with paragraph 7, "Power Supply" and paragraph 11.1, "Acoustic Noise" of European Standard EN 60945, "Maritime Navigation and Radiocommunication Equipment and Systems – General Requirements – Methods of Testing and Required Test Results (1997)." All procedures and equipment are in accordance with EN 61993 and EN 60945.

II. Unit Tested:

The L3 Communications Aviation Recorders Corporation, Automatic Identification System provides continuous signal and data transmission for ship identification. The AIS uses 24-VDC power and has TDMA/DSC transmitters and TDMA/GPS/DSC receivers. It consists of the two-piece metal enclosure with connector hardware, the transmit/receive circuits, the micro-processor/data-storage electronics, and the antenna interface. The table below describes the unit tested to determine compliance with the standards:

Model/P/N	Manufacturer	H/W/D in cm	Serial Number
AIS/AISA1-000-00	L3 Communications	8/15/20	210455

III. Summary of Results:

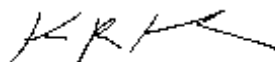
The L3 Communications Aviation Recorders Corporation AIS complies with the requirements in IEC 61993-2, paragraph 15 and EN 60945, paragraphs 7 and 11.1. Section VIII contains the results summarized in the table below.

	Test	Mode/Port	IEC 61993-2 Paragraph	Tolerance	Specified Value	Measured Value
1	Frequency Error	TDMA Transmit	15.1.1	±500 Hz	156,025,000 Hz	156,025,306 Hz
				±500 Hz	157,412,500 Hz	157,412,501 Hz
				±500 Hz	160,637,500 Hz	160,637,800 Hz
	Modulation Rate	DSC Transmit	15.2.1	±13 Hz	1300 Hz	1303.78 Hz
				±21 Hz	2100 Hz	2100.021 Hz
		DSC Transmit	15.2.2	±30 ppm	600.0 Hz	600.0 Hz
2	Carrier Power	TDMA Transmit	15.1.2	±1.5 dB	40.96 dBm 33.01 dBm	40.91 dBm 32.89 dBm
3	Modulation Spectrum	TDMA Transmit	15.1.3	25 kHz lmt.	61993-2 Fig. 4	Within Limit
		DSC Transmit		25 kHz lmt.	61993-2 Fig. 4	Within Limit
		TDMA Transmit	15.1.4	12.5 kHz lt.	61993-2 Fig. 5	Within Limit
4	Attack Time	TDMA Transmit	15.1.5	+1.5 dB	80% <1 ms	80% <0.2 ms
	Release Time		15.1.6	-50 dBPe	<1 ms	<0.1 ms
5	Sensitivity	TDMA Receive	15.3.1	20% PER	-107 dBm	-107 dBm
			15.3.2	20% PER	-98 dBm	-98 dBm
	Error at High Input	DSC Receive	15.4.1	0.01 BER	-107 dBm	-107 dBm
		TDMA Receive	15.3.3	1% PER	-7 dBm	-7 dBm
		DSC Receive	15.4.2	0.01 BER	-7 dBm	-7 dBm
6	Co-channel Rejection	TDMA Receive	15.3.4	-10 dB	0 dB	0 dB
			15.3.5	-18 dB	0 dB	0 dB
		DSC Receive	15.4.3	-10 dB	0 dB	0 dB
7	Adjacent Channel Selectivity	TDMA Receive	15.3.6	20% PER	70 dB	70 dB
			15.3.7	20% PER	50 dB	50 dB
		DSC Receive	15.4.4	0.01 BER	70 dB	70 dB
8	Spurious Rejection	TDMA Receive	15.3.8	20% PER	70 dB	70 dB
		DSC Receive	15.4.5	0.01 BER	70 dB	70 dB
9	Inter-modulation Rejection	TDMA Receive	15.3.9	0% PER	20% PER	0% PER
		DSC Receive	15.4.6	0.01 BER	65 dB	65 dB
10	T/R Switching Time	TDMA Receive	15.3.10	20% PER	-107 dBm	-107 dBm
11	Blocking Desensitization	DSC Receive	15.4.7	0.01 BER	84 dB	84 dB

12	Conducted Spurious	Receive	15.5.1	150 kHz to 1 GHz	-57 dBm	<-57 dBm
		Transmit	15.5.2	1 to 2 GHz	-47 dBm	<-47 dBm
13	Power Supply	Transceive	11 60945 par. 7	150 kHz to 1 GHz	-36 dBm	<-36 dBm
				1 to 2 GHz	-30 dBm	<-30 dBm
14	Acoustic	Transceive	11 60945 par. 7	Extreme Voltage	40 VDC	40 VDC
				Reverse Polarity	Safe	Compliant
				Voltage Variation	10.8-31.2 VDC	10.9-31.2 VDC
14	Acoustic	Transceive	11 60945 par. 11.1	Operating	≤60 dBA	<60 dBA

Testing was performed by Kyle R. Kowalczyk, president, Green Mountain Electromagnetics and requested by:

L3 Communications Aviation Recorders Corp.
6000 Fruitville Road
Sarasota, FL 34232
USA



Kyle R. Kowalczyk

8/7/03

IV. Laboratory Description:

The GME laboratory and Open Area Test Site (OATS) are located at 219 Blake Roy Road, Middlebury, VT. GME is internationally accredited by the American Association for Laboratory Accreditation (A2LA) and meets the quality requirements in EN 45001-1989 and ISO/IEC 17025 (1999), "General Requirements for the Competence of Testing and Calibration Laboratories." For scope of accreditation, contact GME.

V. Measuring Equipment:

The table below describes the instrumentation used by Green Mountain Electromagnetics to perform this testing:

Unit	Manufacturer	Model	Serial #	Last Cal.	Next Cal.
Spectrum Analyzer	Hewlett-Packard	8592	3624A00631	3/07/03	3/07/04
Amplifier	Hewlett-Packard	8447 D	2944A07313	4/01/03	4/01/04
Signal Generator	Hewlett-Packard	E4421B	US38220195	10/15/02	10/15/03
Signal Generator	Hewlett-Packard	8656A	2135A01749	5/16/03	5/16/04
Signal Generator	Hewlett-Packard	8657B	403438	8/1/02	8/1/03
Frequency Counter	Agilent	53181A	ID5112	5/2/03	5/2/04
Power Sensor	Agilent	E9301B	ID5118	5/2/03	5/2/04
Power Meter	Agilent	E4418B	ID5114	5/2/03	5/2/04
Oscilloscope	LeCroy	9354AM	501336	5/9/03	5/9/04
Communications Test Set	Marconi	n/a	501567	1/14/03	1/14/04
Logic Analyzer	Agilent	16702B	501471	11/25/03	11/25/04
Splitter	Agilent	11636B	413	5/22/03	5/22/04
Combiner	Mini-Circuits	ZSC4-1	n/a	5/22/03	5/22/04
Power Attenuator	Hewlett-Packard	8498A	R06345	5/6/03	5/6/04
Variable 110-dB Attenuator	Hewlett-Packard	8496B	R71683	2/19/03	2/19/04
Variable 11-dB Attenuator	Hewlett-Packard	8494B	R38542	2/19/03	2/19/04
RF Detector	Agilent	85902A	RO 1228	n/a	n/a
Sound Meter	Extech	407703A	9144841	5/30/03	5/30/04
Plotter	Hewlett-Packard	7475A	2517A05281	n/a	n/a
AIS TE	L3	AISAI-000-00	210454	n/a	n/a

VI. Measurement Procedures for AIS Physical Tests:

1. Frequency Error.

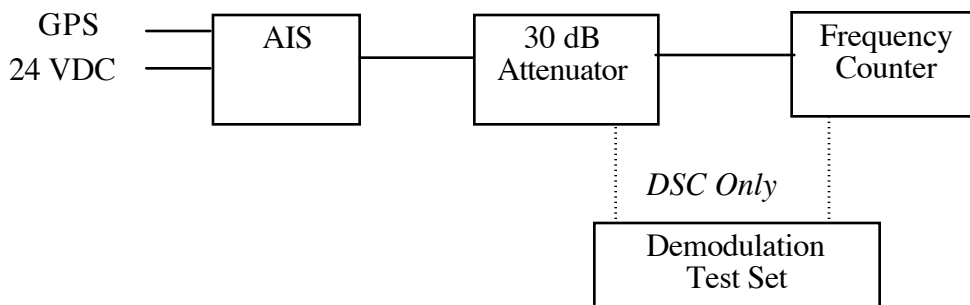
TDMA Frequencies: 156.025, 157.4125, 160.6375, 162.025 MHz

Specification: ± 0.5 kHz Normal Operation

DSC Frequencies: 156.025, 157.4125, 160.6375, 162.025 MHz

Specification: ± 0.5 kHz Normal Operation

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to 24-VDC power and GPS antenna; attach 30-dB attenuator to VHF port.
- b. Verify frequency counter and AIS operation.
 - i. Frequency counter is connected to 30-dB attenuator.
 - ii. AIS channels are selected from front panel.
 - iii. Frequency counter requires warm-up period.
- c. Verify AIS frequency with non-contact probe and spectrum analyzer.
- d. Operate EUT at first selected channel with no modulation.
- e. Record frequency displayed on counter.
 - i. Repeat for each TDMA channel – settings are 1060, 1228, 2260 & 2088.
- f. Perform state error and rate tests on DSC channel 70 using demodulated output.
 - i. Demodulation is connected between 30 dB and counter.
 - ii. States B & Y are D21 and D13 on AIS front panel.
 - iii. Use Marconi to demodulate for state error.
 - iv. Use second AIS (AIS TE) and LeCroy for rate test demodulation.



Block Diagram of Frequency Test

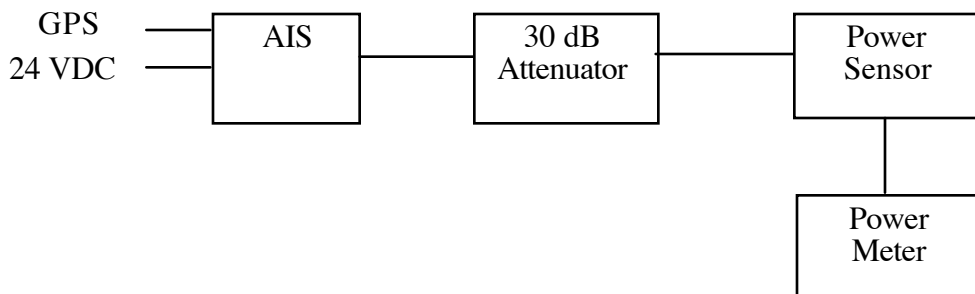
VI. Measurement Procedures for AIS Physical Tests Cont'd:

2. Carrier Power.

High Specification: 40.96 ± 1.5 dBm (12.5W +5.1W/-3.1W) Normal Operation

Low Specification: 33.01 ± 1.5 dBm (2W +.8W/-.6W) Normal Operation

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to 24-VDC power and GPS antenna; attach 30-dB attenuator to VHF port.
- b. Verify power meter/sensor and AIS operation.
 - i. Power sensor is connected to 30-dB attenuator.
 - ii. AIS power levels are selected from front panel.
 - iii. Power meter requires zeroing and calibration each time.
- c. Verify AIS frequency with non-contact probe and spectrum analyzer.
- d. Operate EUT at high power unmodulated.
- e. Record level displayed on meter.
- f. Repeat for low power.



Block Diagram of Carrier Power Test

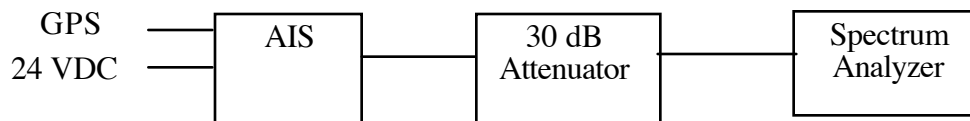
VI. Measurement Procedures for AIS Physical Tests Cont'd:

3. Modulation Spectrum.

25kHz Envelope: 0dB $\pm$ 10kHz, decrease -25dBc to -70dBc from $\pm$ 10kHz to $\pm$ 25kHz

12.5kHz Envelope: 0dB $\pm$ 2.5kHz, decrease 0dBc to -60dBc from $\pm$ 2.5kHz to $\pm$ 12.5kHz

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to 24-VDC power and GPS antenna; attach 30-dB attenuator to VHF port.
- b. Verify analyzer and AIS operation.
 - i. Spectrum analyzer is connected to 30-dB attenuator.
 - ii. AIS test signals 1, 2 & 3 per 61993-2, para 10.4 are selected from front panel.
 - iii. Spectrum analyzer requires warm-up period.
- c. Verify AIS test signal on spectrum analyzer.
- d. Operate EUT at first selected test signal with standard modulation.
- e. Record frequency spectrum displayed on analyzer.
- f. Repeat for each TDMA and DSC test signal.



Block Diagram of Modulation Spectrum Test

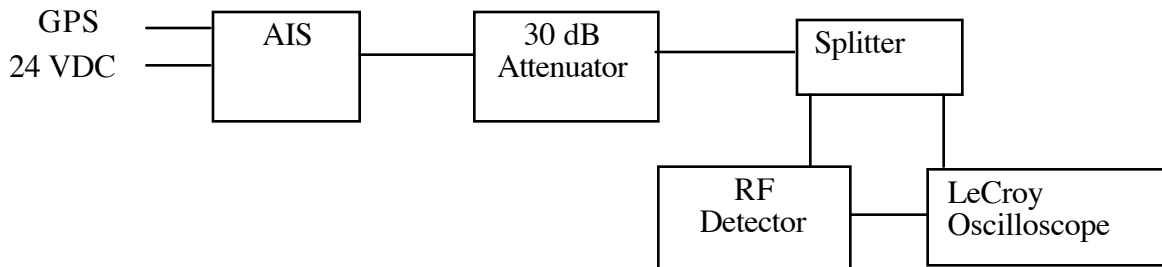
VI. Measurement Procedures for AIS Physical Tests Cont'd:

4. Attack/Release Time.

Attack Specification: 80% power at 1ms

Release Specification: 50 dB below power at 1ms

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to 24-VDC power and GPS antenna; attach 30-dB attenuator to VHF port.
- b. Verify oscilloscope and AIS operation.
 - i. Power splitter input is connected to 30-dB attenuator.
 - ii. Oscilloscope is connected to splitter and triggers on RF detector.
 - iii. RF detector uses other splitter output.
- c. Verify system sensitivity is 30 dB down and trigger on leading edge.
- d. Operate EUT with standard modulation.
- e. Record rise time (attack) transient displayed on oscilloscope.
- f. Repeat for falling edge (release time).



Block Diagram of Transmitter Attack/Release Time Test

VI. Measurement Procedures for AIS Physical Tests Cont'd:

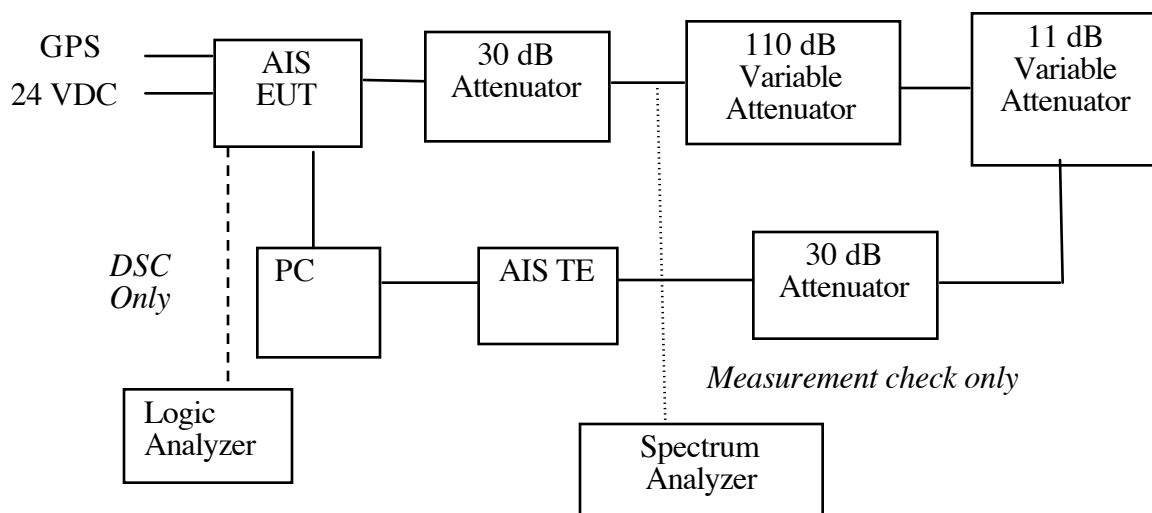
5. Sensitivity including Error at High Input.

25 kHz Specification: -107 dBm @ 20% PER Normal Operation

12.5 kHz Specification: -98 dBm @ 20% PER Normal Operation

DSC Specification: -107 dBm @ 0.01 BER Normal Operation

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to 24-VDC power and GPS antenna; attach 30-dB attenuator to VHF port.
- b. Verify PC and AIS operation.
 - i. Second AIS (AIS TE) is used as a signal generator.
 - ii. Variable attenuators are set to provide -107 dBm at EUT (25 kHz).
 - iii. Spectrum analyzer verifies correct signal level.
- c. Operate AIS TE with standard modulation at 156.025 MHz.
- d. Operate AIS EUT with standard modulation at 156.025 MHz.
- e. Run sensitivity software program on PC.
 - i. Software determines TDMA packet error rate.
- f. Repeat step e. for 162.025 MHz.
- g. Set variable attenuators to provide -98 dBm (12.5 kHz).
- h. Repeat step e. for 157.4125 MHz and 160.6375 MHz.
- i. Repeat step e. with attenuators to provide -77 dBm and -7 dBm.
 - i. Use 10-dB power attenuator for error at high input.
- j. Repeat steps a. – i. for DSC: 156.525 MHz, 156.5265 MHz and 156.5235 MHz.
 - i. Logic analyzer used for DSC measurements.



Block Diagram of Receiver Sensitivity Test

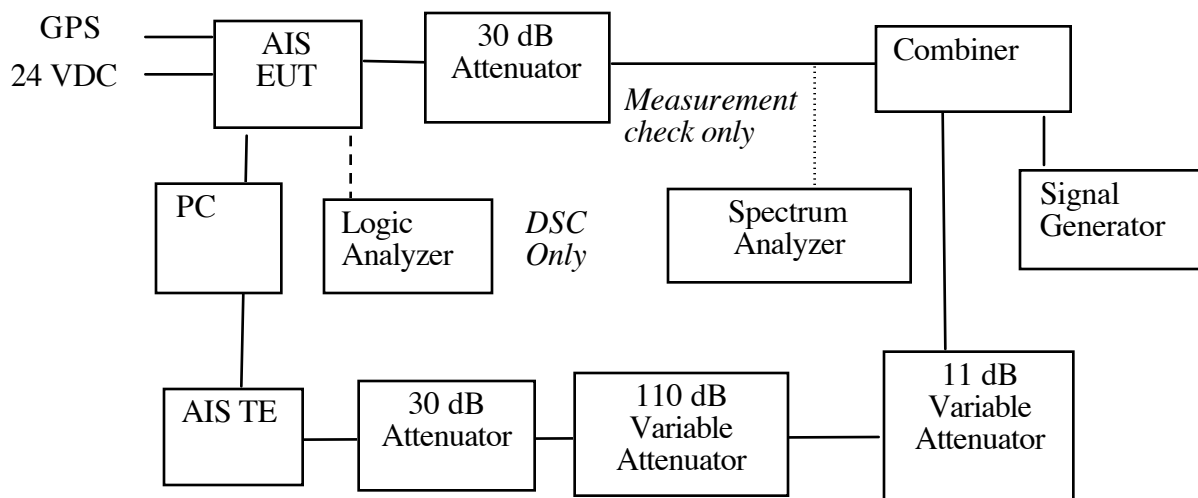
VI. Measurement Procedures for AIS Physical Tests Cont'd:

6. Co-Channel Rejection.

25 kHz Specification: -10 dB to 0 dB

12.5 kHz Specification: -18 dB to 0 dB

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to PC, 24-VDC power, GPS antenna, and 30-dB attenuator.
- b. Verify PC and AIS operation.
 - i. Second AIS (AIS TE) is used as signal generator A.
 - ii. Variable attenuators are set to provide -104 dBm at EUT (25 kHz).
 - iii. Signal generator B set to provide -104 to EUT (0-dBm result) at same channel as AIS.
 - iv. Spectrum analyzer verifies correct signal level.
- c. Operate AIS TE with standard modulation at default channel and test signal 1.
- d. Operate EUT with standard modulation at default channel and test signal 1.
- e. Run co-channel software program on PC.
 - i. Software determines packet error rate from messages.
 - ii. Proceed as in IEC 61993 para. 15.3.4 steps a. – i. if PER >20%.
- f. Repeat step e. for test signal 2.
- g. Repeat step a. - f. with signal generator B set to frequencies of $\pm 12\%$ of channel separation.
- h. Set variable attenuators to provide -95 dBm (12.5 kHz) and repeat steps b. –g.
- i. Repeat steps a. – d. for DSC; generator provides -112-dBm FM modulated at 400 Hz/3kHz.
 - i. Logic analyzer used for DSC measurements.



Block Diagram of Receiver Co-Channel Test

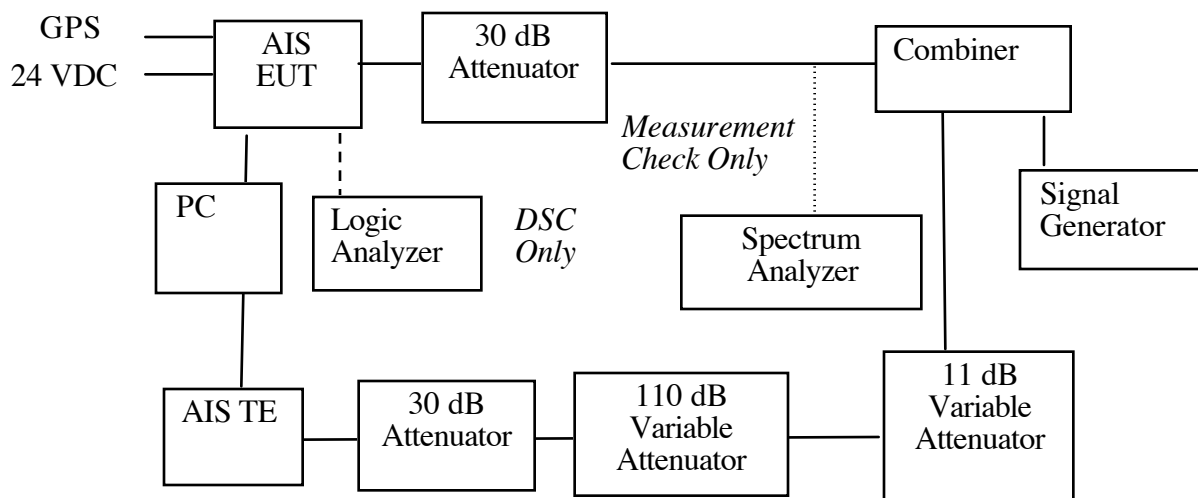
VI. Measurement Procedures for AIS Physical Tests Cont'd:

7. Adjacent Channel Selectivity.

25 kHz Specification: 70 dB Normal Operation

12.5 kHz Specification: 50 dB Normal Operation

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to PC, 24-VDC power, GPS antenna, and 30-dB attenuator.
- b. Verify PC and AIS operation.
 - i. Second AIS (AIS TE) is used as signal generator A.
 - ii. Variable attenuators are set to provide -104 dBm at EUT (25 kHz).
 - iii. Signal generator B set to provide -34 to EUT (70-dB result) at channel immediately above the AIS channel.
 - iv. Spectrum analyzer verifies correct signal level.
- c. Operate AIS TE and AIS EUT with standard modulation at default channel.
- d. Run adjacent-channel software program on PC.
 - i. Software determines packet error rate from messages.
 - ii. Proceed as in IEC 61993 para. 15.3.6 steps a. – k. if PER >20%.
- e. Repeat step d. for channel immediately below AIS channel.
- f. Repeat steps d. and e. for 12.5-kHz AIS channel.
 - i. Set variable attenuators to provide -95 dBm/-50 dBm.
- g. Repeat step a. – c. for DSC; Generator provides -34-dBm FM modulated at 400 Hz/3kHz.
 - i. Logic analyzer used for DSC measurements.



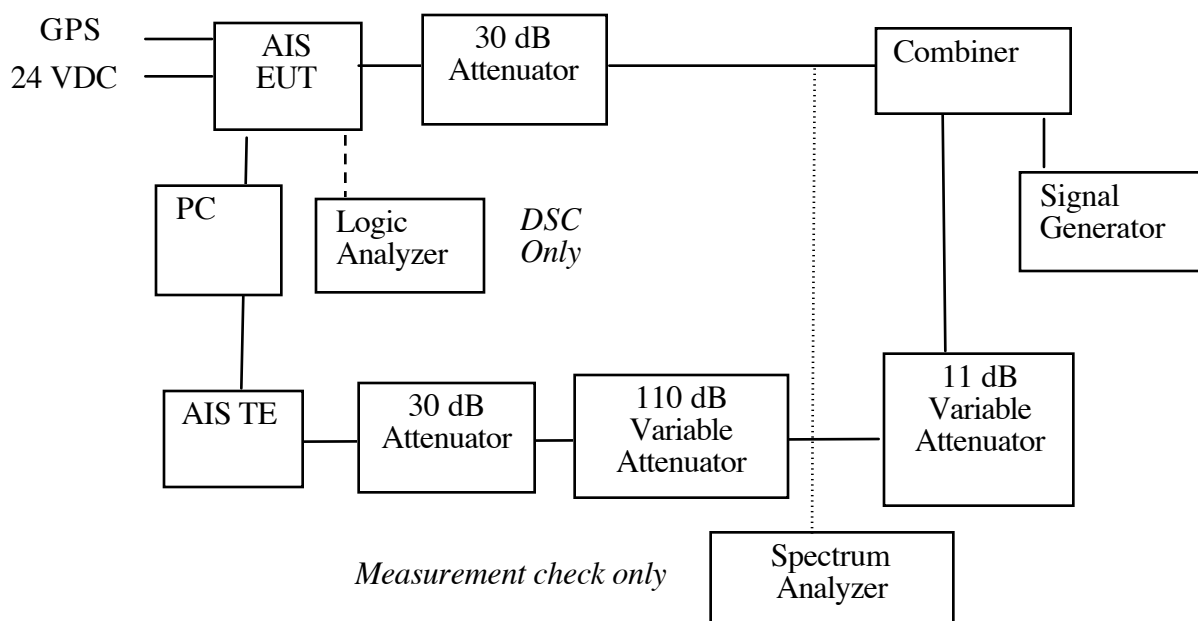
Block Diagram of Receiver Adjacent-Channel Test

VI. Measurement Procedures for AIS Physical Tests Cont'd:

8. Spurious Rejection.

Specification: 70 dB Normal Operation

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to PC, 24-VDC power, GPS antenna, and 30-dB attenuator.
- b. Verify PC and AIS operation.
 - i. Second AIS (AIS TE) is used as signal generator A.
 - ii. Variable attenuators are set to provide -104 dBm at EUT (25 kHz).
 - iii. Signal generator B set to provide -27 dBm EUT, FM modulated 400 Hz/3kHz.
 - iv. Signal generator B set to provide sweeps to EUT per calculations in results (VIII-8).
 - v. Spectrum analyzer verifies correct signal levels.
- c. Operate AIS TE with standard modulation at default channel.
- d. Operate EUT with standard modulation at default channel.
- e. Run spurious-rejection software program on PC.
 - i. Software determines packet error rate from messages.
 - ii. Proceed as in IEC 61993 para. 15.3.8 steps a. – h. if PER >20%.
- f. Repeat step a – c. for DSC; generator provides -24-dBm unmodulated from 100kHz to 2GHz.
 - i. Logic analyzer used for DSC measurements.



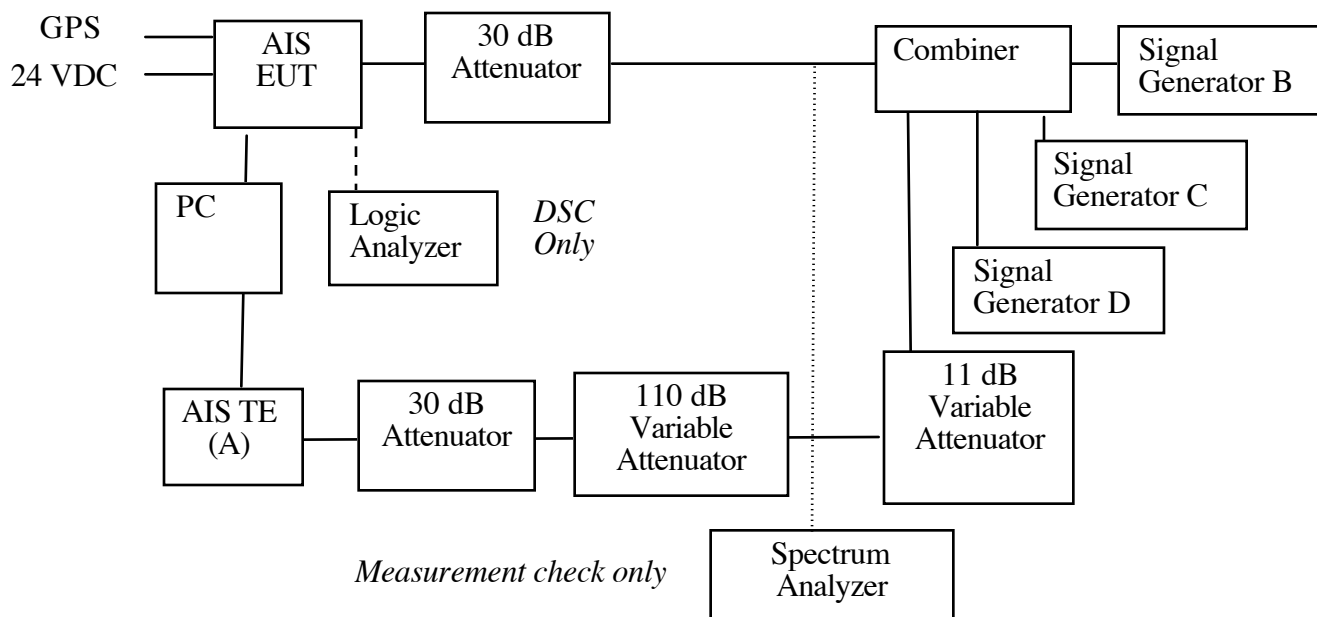
Block Diagram of Receiver Spurious Rejection Test

VI. Measurement Procedures for AIS Physical Tests Cont'd:

9. Intermodulation Rejection.

Specification: PER $\leq 20\%$ Normal Operation

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to PC, 24-VDC power, GPS antenna, and 30-dB attenuator.
- b. Verify PC and AIS operation.
 - i. Second AIS (AIS TE) is used as an intentional signal generator (A).
 - ii. Variable attenuators are set to provide -101 dBm at 156.025 MHz.
 - iii. Signal generator B provides -27 dBm at 156.525 MHz, FM modulated at 400 Hz/3kHz.
 - iv. Signal generator C provides -27 dBm at 157.025, unmodulated.
 - v. Signal Generator D set to -15 dBm at 161.750 unmodulated.
 - vi. Spectrum analyzer verifies correct signal levels.
- c. Record generator levels necessary for correct signal at EUT.
- d. Operate EUT with standard modulation at selected (A) channel.
- e. Run intermodulation software program on PC.
 - i. Software determines packet error rate from messages.
- f. Repeat e. for A = 162.025 MHz, B = 161.525 MHz, C= 161.025 MHz, and D 156.300 MHz.
- g. Repeat b. through f. for DSC:
 - i. A= -104 dBm, test signal 1, B = -39 dBm, nominal ± 50 kHz, and C= -39 dBm, modulated at 400 Hz/ ± 3 kHz, nominal ± 100 kHz.



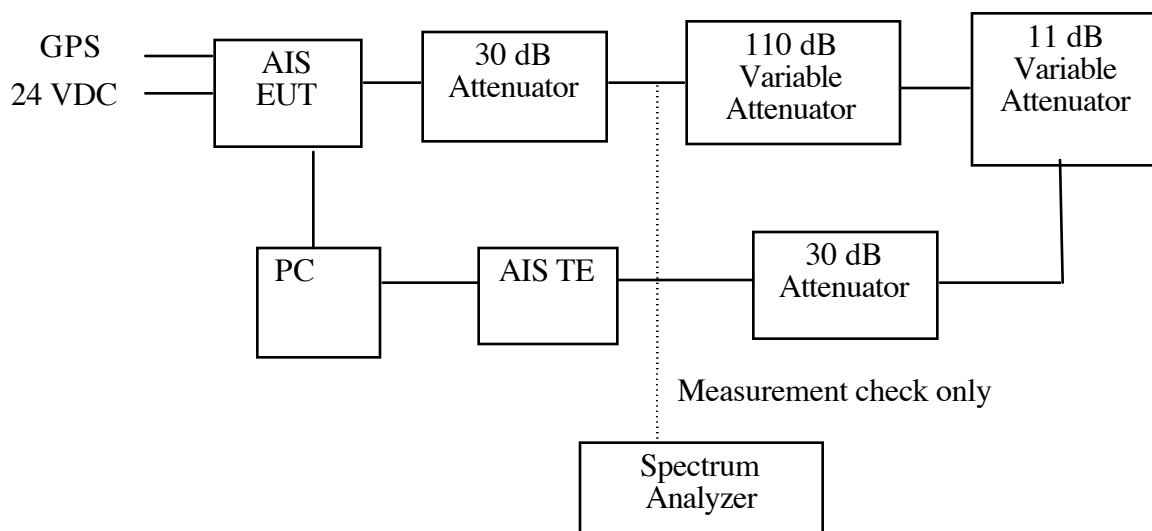
Block Diagram of Receiver Intermodulation Test

VI. Measurement Procedures for AIS Physical Tests Cont'd:

10. T/R Switching Time.

Specification: -107 dBm @ 20% PER Normal Operation

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to PC, 24-VDC power, GPS antenna, and 30-dB attenuator.
- b. Verify PC and AIS operation.
 - i. Second AIS (AIS TE) is used as a signal generator.
 - ii. Variable attenuators are set to provide -107 dBm at EUT (25 kHz).
 - iii. Spectrum analyzer verifies correct signal level.
- c. Operate AIS TE with standard modulation at 156.025 MHz.
- d. Operate EUT with standard modulation at 156.025 MHz.
- e. Verify operation in the slot at default settings and perform sensitivity.
- f. Run sensitivity software program on PC.
 - i. Software determines packet error rate.



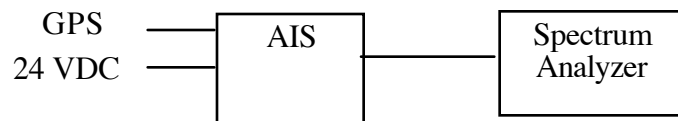
Block Diagram of T/R Switching Time Sensitivity Test

VI. Measurement Procedures for AIS Physical Tests Cont'd:**12. Conducted Spurious.**

Transmit Specification: -36 dBm from 150 kHz to 1 GHz, -30 dBm from 1 GHz to 2 GHz

Receive Specification: -57 dBm from 150 kHz to 1 GHz, -47 dBm from 1 GHz to 2 GHz

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to 24-VDC power and GPS antenna.
- b. Verify analyzer and AIS operation.
 - i. Spectrum analyzer is connected to VHF port.
 - ii. AIS test signals 1, 2 & 3 are selected from front panel.
 - iii. Spectrum analyzer requires warm-up period.
- c. Verify AIS test signal on spectrum analyzer.
- d. Operate EUT at first selected test signal with standard modulation.
- e. Record frequency spectrum displayed on analyzer.
 - i. Repeat for each TDMA and DSC test signal.



Block Diagram of Conducted Spurious Test

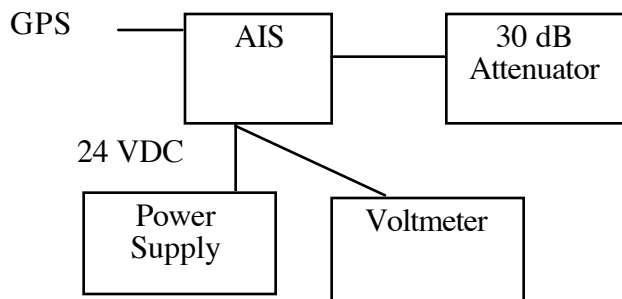
VI. Measurement Procedures for AIS Physical Tests Cont'd:**13. Power Supply.**

Overvoltage Specification: 40V Extreme Operation

Reverse Polarity: No Damage, Extreme Operation

Voltage Variation: 10.8-31.2 VDC, Extreme Operation

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to 24-VDC power, GPS antenna, and 30-dB attenuator.
- b. Verify AIS operation.
 - i. Power supply is increased to max and effects noted.
 - ii. Polarity is reversed and effects noted.
 - iii. Power supply is varied and effects noted.
- c. Voltage is verified with voltmeter.

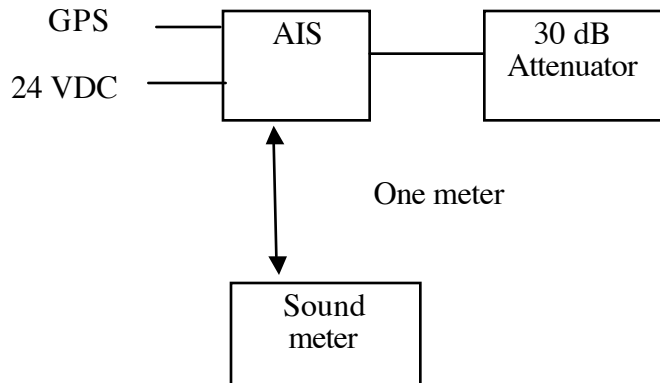


Block Diagram of Power Supply Test

VI. Measurement Procedures for AIS Physical Tests Cont'd:**14. Acoustic.**

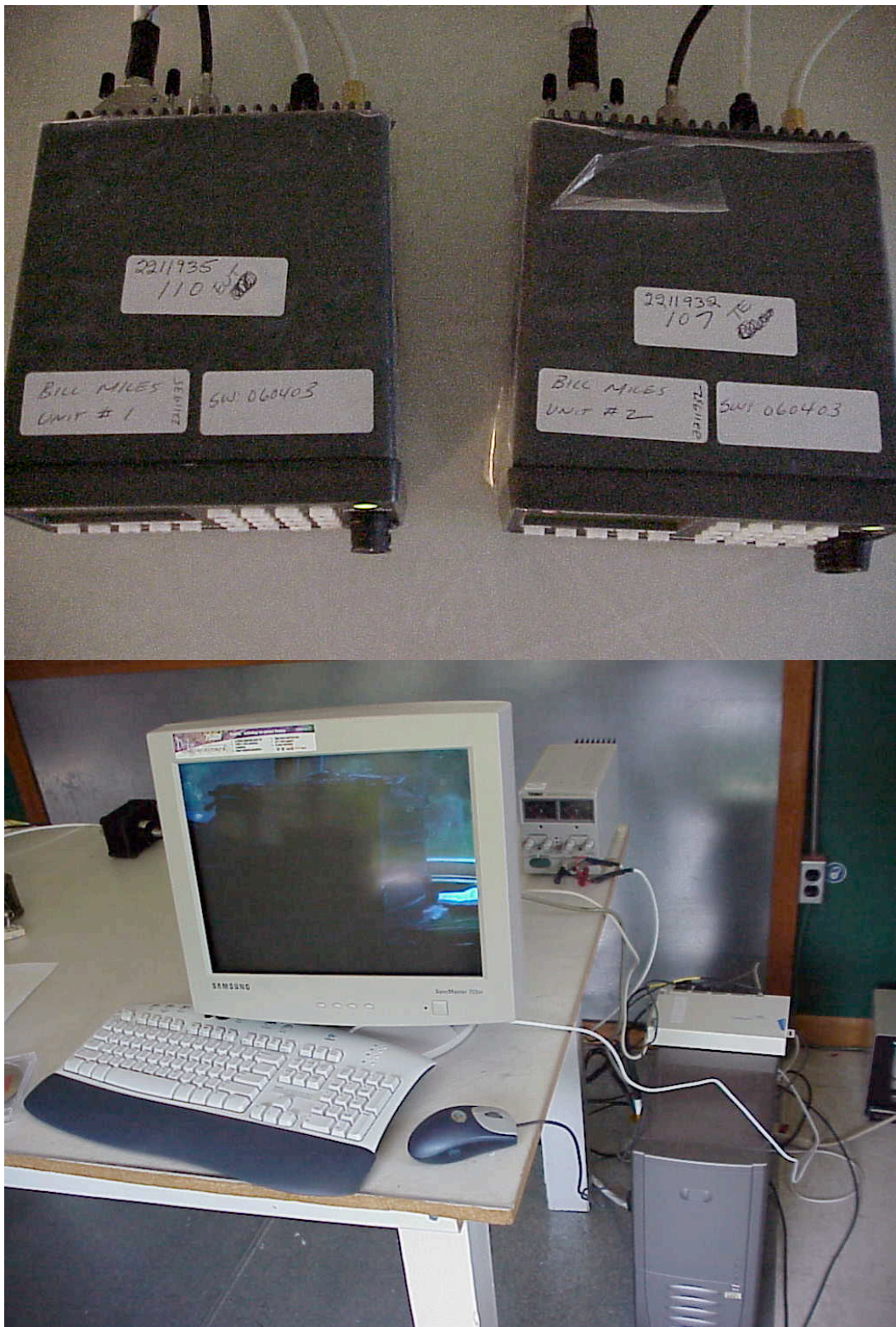
Specification: 60 dBA Normal Operation, No Alarms

- a. Set up EUT and test instrumentation in laboratory.
 - i. Connect AIS to 24-VDC power , GPS antenna, and 30-dB attenuator.
- b. Verify AIS and sound meter operation.
 - i. Sound meter is 1 meter away from each face.
 - ii. AIS operated normally.
- c. Values on sound meter are recorded.



Block Diagram of Acoustic Test

VII. Test Setup Photographs for AIS Physical Tests:



EUT and Support Equipment