Electromagnetic Compatibility

Test Report

for the

SART 3

July, 2003

TITLE PAGE

TITLE	:	Electromagnetic Compatibility Test Report for the SART 3.
DOCUMENT NO	:	**9304-07-03**
SUMMARY	:	Test procedures and test results pertaining to a series of electromagnetic compatibility tests performed on the SART 3 manufactured by ACR SA, are presented.
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ELECTROMAGNETIC COMPATIBILITY TEST REPORT

FOR THE

SART 3

SCOPE

This document reports on the electromagnetic radiated emission and immunity tests that were performed on a SART 3 for ACR SA at the Electromagnetic Test facility of the Institute for Satellite and Software Applications (ISSA) during the period April to July, 2001.

The document details the test set-ups, procedures that were followed, the instrumentation that was utilized and the results that were obtained.

APPLICABLE DOCUMENTATION

IEC 945 : Maritime navigation and radio communication equipment and systems
General requirements
Methods of testing and required test results.

IEC-1000-4-3 : Electromagnetic compatibly – Part 4: Testing and measurement techniques – Section3: radiated, radio-frequency, electromagnetic field immunity test

TEST SPECIFICATION

The electromagnetic compatibility tests as listed in Table 1 below were performed in accordance with the procedures and limits as defined in the specifications listed in this table.

Table 1: EMC Tests performed as part of this test series.

TEST DESCRIPTION	SPECIFICATION
Radiated Susceptibility (80MHz to 1000MHz)	IEC 945 at severity level 3 as specified in IEC-1000-4-3
Radiated emissions: Magnetic Field (150kHz to 30MHz). Electric field (30MHz to 1GHz)	IEC 945

The following major deviations in the procedures specified in the abovementioned specifications should be noted:

Radiated Emission Test

CISPR 16-1 calls for the performance of the radiated emission test on an open area test site (OATS). The tests performed at ISSA were done inside the anechoic chamber on a 3 m test range using a turn-table and adjustable mast. The chamber at ISSA is a fully anechoic chamber and in order to simulate the OATS more effectively a ground plane consisting of continuous metal sheeting was placed inside the chamber. The size of the ground plane was equal to the ellipse specified in CISPR 16 for a 3m OATS.

TEST APPARATUS

As indicated in Table 2 below, the following major items of equipment were utilized to perform the abovementioned emission and susceptibility tests:

Table 2: Major Equipment List

EQUIPMENT	MODEL	SPECIFICATION
Anechoic Chamber		11,5m x 7,5m x 8,5m (h x w x l)
Electromagnetic Emission Test Control System	Rohde & Schwarz Model TS9985 with ES-K1 and TS9984 software systems	
Wooden turn table with wooden support table (for radiated emission test)		Manual operation. Diameter 1m. Height of wooden table above ground plane: 0.8m
Antenna Mast		Manual operation. Height variation: 1 to 4m.
EMI Test Receiver	Rohde & Schwarz Model ESH3	9 Hz to 30 MHz
EMI Test Receiver	Rohde & Schwarz Model ESVP	20MHz to 1300MHz
RF feed cable for emission tests	Serial no: HEL001	
Receive Antenna Bi-conical	Rohde & Schwarz Model HUF-Z2	20 to 200 MHz
Receive Antenna Log-Periodic	Rohde & Schwarz Model HUF-Z3	200 MHz to 1000 MHz
Active loop antenna	Emco 6302	9kHz to 30MHz.
Signal Generator	Rhode & Schwarz Model SMG	Range : .01MHz to 1GHz
Isotropic Field Probe	Holiday Model HI-4421G	Range : 10kHz to 1GHz

EQUIPMENT	MODEL	SPECIFICATION
Power Amplifier	Amplifier Research Model 1000A100M1	Range : 10kHz to 100MHz, 1000W
Power amplifier	Amplifier Research Model 1000W1000AM2	Range : 80MHz to 1000MHz, 1000W.
Tx Antenna Log-Periodic	Amplifier Research Model AT 1080AM1	80 to 1000MHz 2200W
Antenna Feed Cable	Serial No.: Rus 1034.6414-W10	

RADIATED SUSCEPTIBILITY TEST

TEST SET-UP FOR THE RADIATED SUSCEPTIBILITY TEST

Refer to Figures 1to 5.

The SART 3, also referred to hereinafter as the Equipment Under Test or EUT, was placed in the anechoic chamber on a wooden table of height 0.8m which had been positioned on the turntable approximately 5m from the rear of the anechoic chamber. The SART 3 was powered from its own internal battery.

The transmitting antenna used to generate the interference signal was mounted on a tripod and positioned immediately in front of the EUT at a separation distance of 3m from the SART as specified in Table 1.

The amplifiers driving the transmitting antennas were located in the control room adjacent to the anechoic chamber.

A battery powered isotropic field probe was placed on a support on the table top alongside the EUT. The output of the probe was fed from the anechoic chamber to the adjacent control room by means of a fibre optic cable. The cable passed through the wall of the anechoic chamber via a bulkhead connector.

The equipment provided by the client to monitor the functionality of the SART during performance of the radiated susceptibility test was placed in the shielded room alongside the anechoic chamber. A horn antenna was placed inside the chamber such that it could receive the pulsed outputs from the SART which were monitored on a spectrum analyser placed inside the shielded room adjacent to the anechoic chamber.

TEST PROCEDURE FOR THE RADIATED SUSCEPTIBILITY TEST

To perform the susceptibility test, the transmitting antenna and field-probes were positioned as described above. The monitoring equipment was initialized and the SART 3 placed in the standby condition.

The required interference field-strength (12V/m over the frequency range) was generated by observing the output from the field-probes and manually correcting the input power to the amplifiers until the required field-strength was achieved. The frequency would then be stepped to the next value until the complete frequency range applicable for the particular selection of amplifiers had been covered. In certain frequency bands the SART 3 was

also rotated along its vertical axis in order to evaluate its susceptibility in various orientations relative to the transmitting antenna.
The interference signal was amplitude modulated to a depth of 80% by the application of a 400Hz sine signal

The applicable step sizes and dwell times used for generation of the fields were as shown in Table 3.

Using the monitoring equipment supplied by the client, the output pulse from the EUT was continuously monitored during the application of the interference signal.

In order to allow a margin of safety, the interference field was set to 12V/m instead of 10V/m as defined in IEC 1000-4-3.

Table 3 : Parameters for the Radiated Susceptibility Test

Frequency	Antenna	Dwell Time (s)	Sep. Distance (m)	Step Size	Interference Field (V/m)	Modulation
80 – 100 MHz	Log -P	1	3	0,5 MHz	12	AM,80%, 400Hz sine
100 - 400MHz	Log -P	1	2	1 MHz	12	AM,80%, 400Hz sine
400 – 1000MHz	Log -P	1	2	2 MHz	12	AM,80%, 400Hz sine

RESULTS OF THE RADIATED SUSCEPTIBILITY TEST

Some instability, as indicated in Figure 4, was noticed during the Radiated Immunity test with the SART in the vertical position and the interference signal frequency between 199MHz and 230MHz and vertically polarised.

Figure 4 shows that the interference on the VCO is limited to a change in the start and stop frequency of some of the SART's sweeps. Figure 4 shows that some sweeps start at 9140 MHz and reach full amplitude at 9158 MHz and others start at 9152 MHz and reach full amplitude at 9170 MHz. The instability thus only appears at the band edges. The frequency band that every SART sweep covers is wider than the Radar Band of 9200 MHz to 9500 MHz. From Figure 4 it can be seen that the instability falls outside the Radar Band.

The result of a detailed investigation showed that the instability was caused by the battery interconnection cable that acts as an antenna and absorbs enough energy between 199 and 230 MHz to induce a marginal interference on the Voltage Controlled X-Band Oscillator of the SART. The frequency at which

this interference was most noticeable varied with the position and length of the battery interconnection cable within the SART.
By twisting the battery interconnection cable the inference could be reduced slightly as shown in figure 5. However in this case the frequency range over which the interference could be noticed was reduced from approximately 30 MHz to approximately 5 MHz.

It was thus concluded that the interference caused by a 12 V/m signal in the 200 to 230 MHz band that is vertically polarised, will not be noticed on any Radar that operates within the 9200 to 9500 MHz band, as the interference is limited to frequencies outside of this band. Furthermore if by chance a Radar is operating marginally outside of the 9200 to 9500 MHz band then the interference would still not be noticed as the persistence of a Radar screen is at least 500 ms, which means that enough SART sweeps would start and stop at the correct frequencies to adequately activate the Radar screen.

As such, the interference signal does not affect the functionality of the SART and the SART can thus be considered as being immune to the radiated interference.

RADIATED SUSCEPTIBILITY TEST CONCLUSION

Although some degree of susceptibility is evident when the SART is subjected to the radiated immunity test as specified in IEC 945, the basic functionality of the SART as explained above is not affected.

It can thus be concluded that, in its modified form, i.e. with the battery cables twisted, the SART 3 complies with the requirements for immunity to radiated interference over the frequency range of 80MHz to 1000MHz as specified in IEC 945.

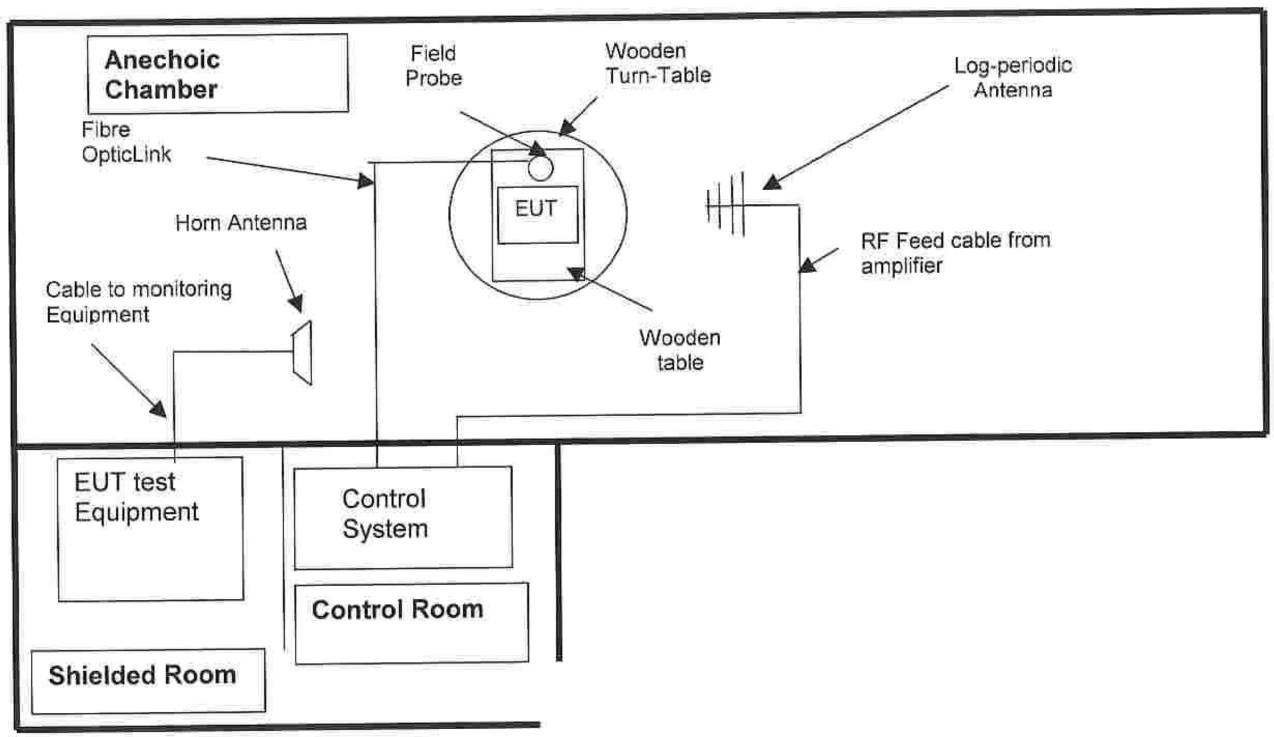


Figure 1: Schematic of the test set-up for the radiated susceptibility test

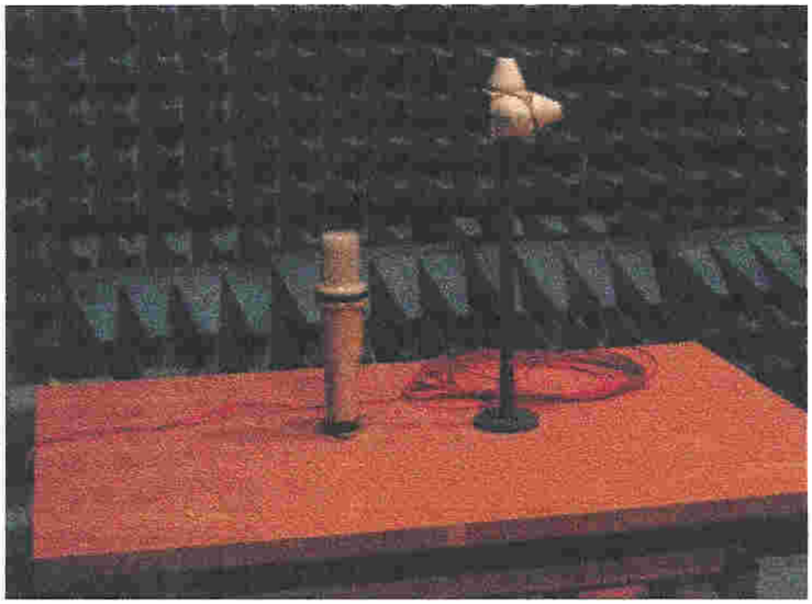


Figure 2: SART 3 positioned on wooden turntable with isotropic Field Probe for immunity testing.

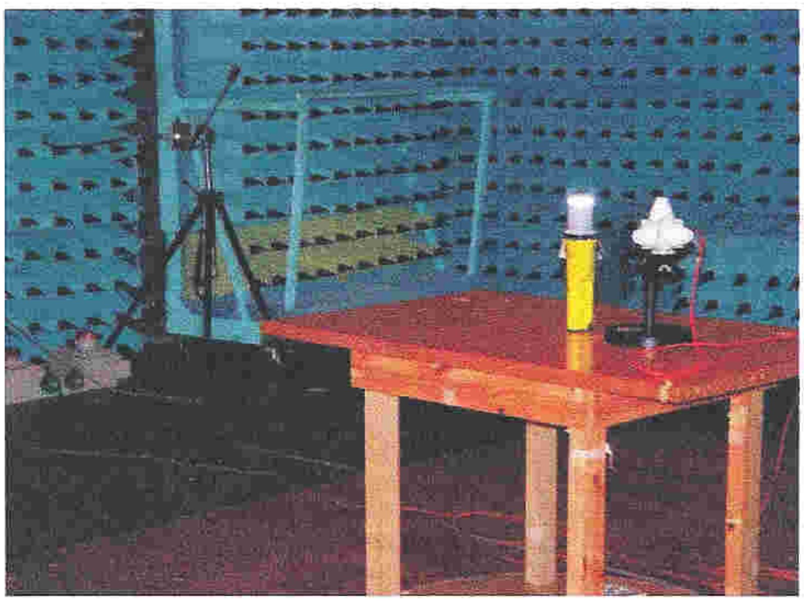


Figure 3: Positioning of the horn antenna to monitor the pulse from the SART 3.

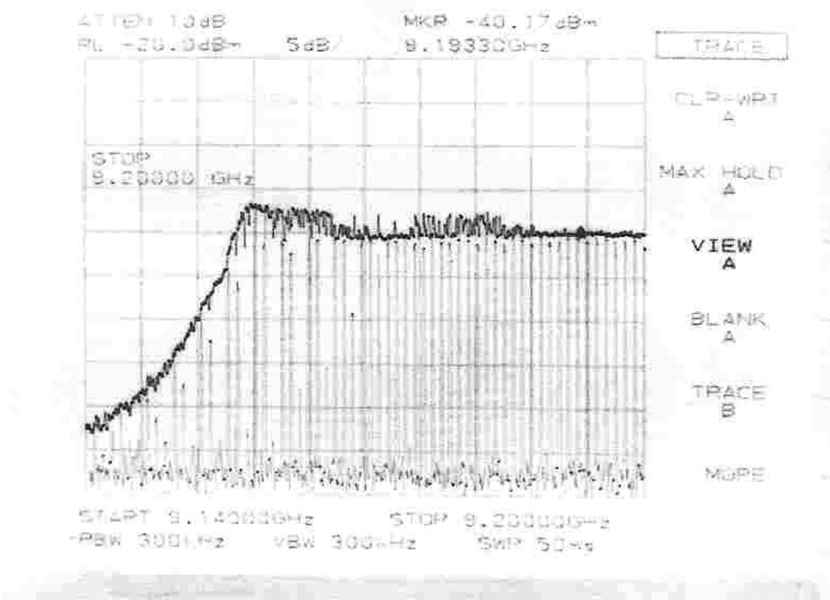
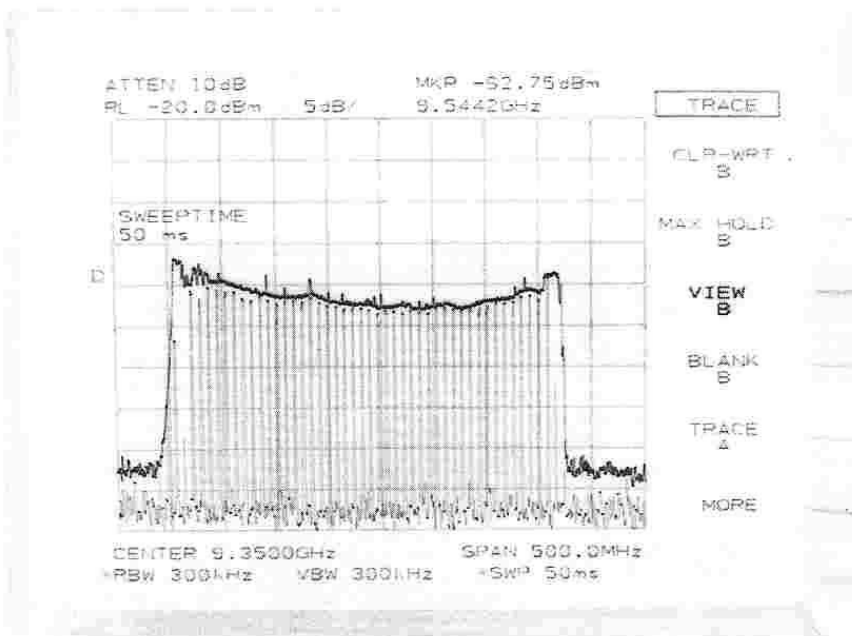


Figure 4: Output pulse from SART 3 before modification



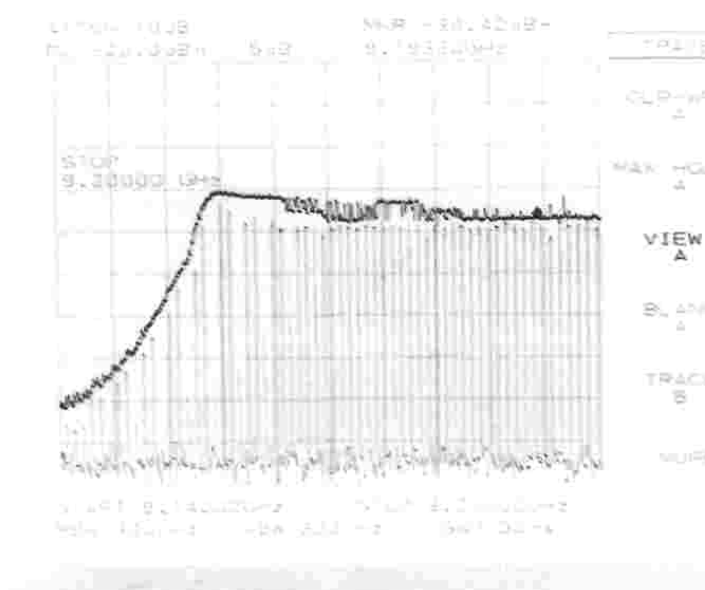


Figure 5: Output pulse from SART 3 after modification

RADIATED EMISSION TESTS

RADIATED EMISSION TEST-SET-UP

Refer to Figure 6.

In order to simulate the measurement conditions as specified in IEC 945 more effectively in the anechoic chamber, a ground plane consisting of continuous metal sheeting was positioned on the floor of the chamber. The ground plane was bonded to the common earth of the anechoic chamber by means of metal braiding straps. The size of the ground plane was equal to the ellipse specified in CISPR 16 for a 3m OATS.

A wooden turn-table was positioned at the one focus of the ellipse and an adjustable mast positioned at the other focus producing a separation distance of 3m.

The EUT, was placed in the anechoic chamber on a wooden table of height 0.8m which had been positioned on the turn-table.

The EUT was powered from its own internal battery supply.

In order to measure the electric E-Field radiated from the EUT at frequencies above 30MHz, a receiving antenna was placed on the mast at a distance of 3m from the EUT. The output from the antenna was then fed via a low loss RF cable to the EMI receiver located in the adjoining control room and from there to the computer system located in the control room.

The antennas as indicated below were used to cover the required frequency range:

Receiving Antenna	Frequency Range
Bi-conical	30 MHz to 200 MHz
Log-periodic	200 MHz to 1000 MHz
Active Loop Antenna	9kHz to 30MHz

RADIATED EMISSION TEST PROCEDURE

Measurements were taken of the radiated electric field over the frequency range of 30 MHz to 1 GHz using the test set-up described above.

The EUT was placed in both the standby and transmit modes for the measurement of the radiated emission.

Initially complete scans of the radiated electric field emission from the EUT over the frequency bands 30 MHz to 200 MHz and 200 MHz to 1000 MHz were produced with the antenna height set at 1.54m.

The abovementioned measurements were performed using a peak detector and only in the areas where the emission limits were exceeded or were close to the limits, the measurements were repeated using a quasi-peak (QP) detector.

Where the emission levels were close to the limits, the maximum level of emission at this frequency was determined by rotating the turn-table and varying the height of the antenna.

Graphical outputs were produced indicating both the applicable emission limits as specified in IEC 945 and the actual measured levels of emission as a function of frequency.

This procedure was repeated for both the vertical and horizontal polarization cases by rotating the antenna.

The receiver bandwidths for the measurements were set at 120kHz in accordance with the requirements as specified in IEC 945.

For the measurement of the radiated magnetic field in the frequency range of 9KHz to 30MHz, the magnetic loop antenna was positioned on the mast at a height of 1,0m. The receiver bandwidth was set in accordance with the requirements as specified in IEC 945.

Graphical outputs were produced indicating both the applicable emission limits as specified in IEC 945 and the actual measured levels of emission as a function of frequency.

RADIATED EMISSION TEST RESULTS

The tests performed and the results obtained during the test series are tabulated in Table 4 below while the graphical printouts of the emission levels versus frequency appear in Annexure A.
The results from two units designated SART 3 are SART 3B are indicated. The two units are identical in design and construction and were both tested in order to verify production repeatability.

As indicated in Table 4 and in the graphical outputs in Annexure A, the levels of emission from the EUT's comply with the limits as defined in IEC 945.

Table 4: Summary of the tests performed during the radiated emission tests

Test	Frequency Band	Test Configuration	Result / Comments
1	30 MHz to 200 MHz	SART 3 EUT on and in standby mode. Horizontally polarized bi-conical antenna. Antenna height = 1.54m Separation = 3m Pk detector	Emission levels within specification limits.
2	110 MHz to 190MHz	SART 3 EUT on and in standby mode. Horizontally polarized bi-conical antenna. Antenna height = 1.54m Separation = 3m Pk detector	Emission levels within specification limits
3	30 MHz to 200 MHz	SART 3 EUT on and in transmit mode. Horizontally polarized bi-conical antenna. Antenna height = 1.54m Separation = 3m Pk detector	Emission levels within specification limits.
4	30 MHz to 200 MHz	SART 3 EUT on and in standby mode. Vertically polarized bi-conical antenna. Antenna height = 1.54m Separation = 3m Pk detector	Emission levels within specification limits.
5	200 MHz to 1000 MHz	SART 3 EUT on and in standby mode. Horizontally polarized Log-P antenna. Antenna height = 1.54m Separation = 3m Pk detector	Emission levels within specification limits.
6	200 MHz to 1000 MHz	SART 3 EUT on and in transmit mode. Vertically polarized bi-conical antenna. Antenna height = 1.54m Separation = 3m Pk detector	Emission levels within specification limits.

Test	Frequency Band	Test Configuration	Result / Comments
7	200 MHz to 1000 MHz	SART 3 EUT on and in standby mode. Vertically polarized bi-conical antenna. Antenna height = 1.54m Separation = 3m Pk detector	Emission levels within specification limits.
8	400 MHz to 1000 MHz	SART 3B EUT on and in standby mode. Vertically polarized Log-P antenna. Antenna height = 1.54m Separation = 3m Pk detector	Emission levels within specification limits.
9	400 MHz to 1000 MHz	SART 3 EUT on and in transmit mode. Horizontally polarized Log-P antenna. Antenna height = 1.54m Separation = 3m Pk detector	Emission levels within specification limits.
10	9kHz to 30MHz (H-Field)	SART 3 EUT on and standby mode. Active Loop antenna. Antenna height = 1. m Separation = 3m	Emission levels within specification limits.
11	9kHz to 30MHz (H-Field)	SART 3 EUT on and transmit mode. Active Loop antenna. Antenna height = 1. m Separation = 3m	Emission levels within specification limits.
12	9kHz to 30MHz (H-Field)	SART 3B EUT on and transmit mode. Active Loop antenna. Antenna height = 1. m Separation = 3m	Emission levels within specification limits.

RADIATED EMISSION TEST CONCLUSION

The SART 3 conforms to the requirements for radiated electric and magnetic field emission as specified in IEC 945.

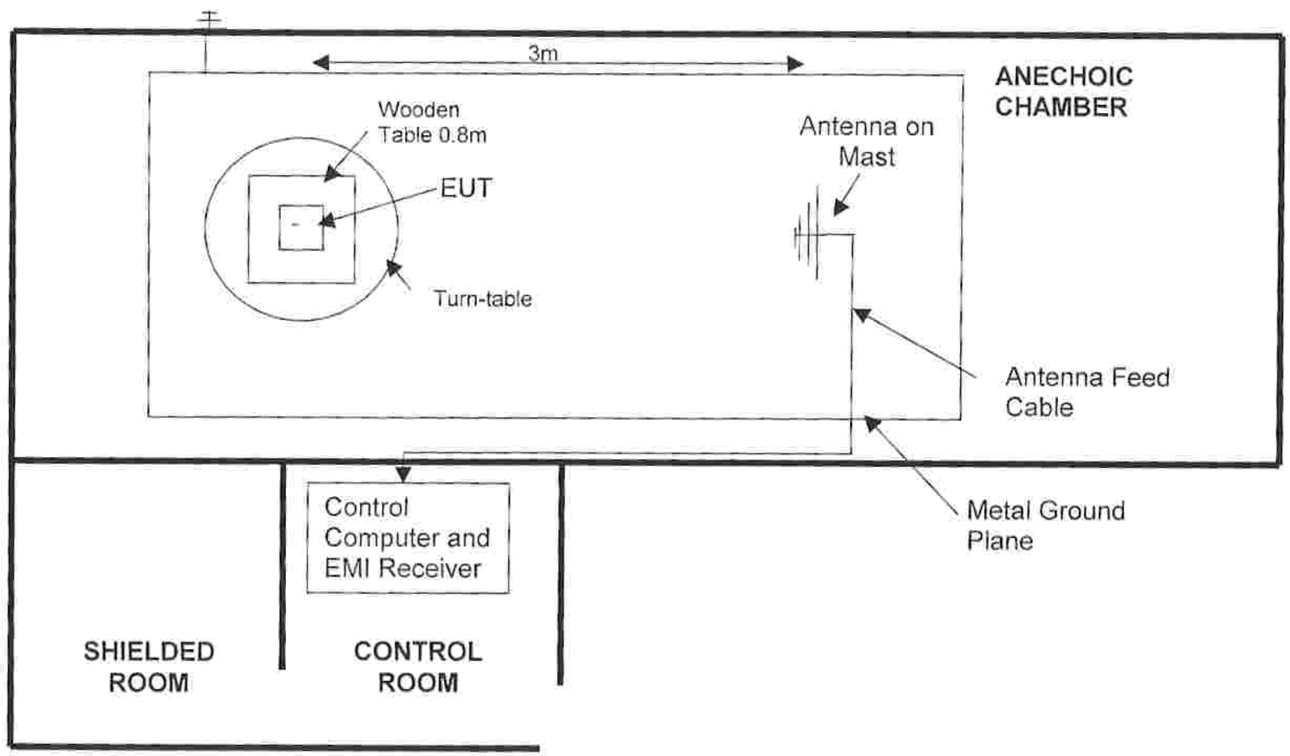


Figure 6: Schematic of the test set-up for the radiated emission