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# Design, Development & Performance Evaluation of an Anechoic Chamber for Microwave Antenna Studies

E J ZACHARIAH*, K VASUDEVAN, P A PRAVINKUMAR, P MOHANAN & K G NAIR

Department of Electronics, University of Cochin, Cochin 682 022

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The design, erection and evaluation procedures for a microwave anechoic chamber completed at Cochin University for antenna studies are presented. The chamber has an average reflectivity level of −32 dB at X-band frequencies, and it is comparable to international standards.

Antenna measurements and electromagnetic compatibility measurements require an environment free from external radio signal interference. Outdoor sites usually cause interference due to reflections from nearby objects and ground. Hence specially prepared indoor test ranges called anechoic chambers are used for conducting these experiments. An anechoic chamber is an artificially simulated free space environment in which RF propagation studies can be performed without any interaction from external sources. The design, development, and evaluation of a microwave anechoic chamber, recently completed in the Microwave Laboratory of the Cochin University, are described in this communication.

Microwave absorbing material is used to absorb electromagnetic energy in this frequency band. In the anechoic chamber described here, the absorber used is a polyurethane-foam-based one, with some microwave absorbing material dispersed inside. The material was cut into pyramidal or wedge shapes. The following types of material were employed in different portions of the chamber.

(i) Small pyramids of base 7.6 cm and height 15.2 cm were used on the ceiling, side walls, a major portion of the back wall, and a portion of the floor.

(ii) Larger pyramids of base 15.2 cm and height 45.7 cm were used on the central portion of the back wall from where reflections are most likely to occur.

(iii) Wedges of base width 10.2 cm and height 5.1 cm were used to cover the less important portions of the chamber, like the surfaces of the tapered section.

(iv) A layered flat sheet absorber having five layers and a total thickness of 15.2 cm was used on the walk-ways.

(v) A densely packed flat absorber of thickness 5.1 cm had been put beneath all of the above mentioned types to increase the total absorption.

Before stacking these material inside the chamber, their reflectivity was measured using the Arch[1] method. The small pyramids, with a 5.1 cm flat absorber at the back and a metallic sheet behind it, had a reflectivity of −35 dB. The wedge absorber had a slightly higher reflectivity. These values were considered adequate for the present application.

While taking the antenna measurements, the test antenna should be illuminated by a plane wave front[2]. For this, the minimum separation between the transmitting and the test antenna is $R = 2D^2/\lambda$ where $R$ is the separation between the antennas, $D$ the aperture diameter of the test antenna, and $\lambda$ the operating wavelength. The length of the chamber should be more than this, since the test antenna has to be put in the quiet-zone, which occurs at some distance from the chamber walls also. The length of this chamber was chosen to be 7.2 m. Hence the chamber has an effective propagation length of about 6 m. This corresponds to an antenna diameter of 30 cm in the X-band. This is the largest diameter of the antenna expected to be tested in this chamber.

Since the anechoic chamber is lined with pyramidal absorbers, the diffraction from the tips of the pyramids also have to be considered. The finger pitch of the pyramids determines the scattering by them. According to Green[3] the lowest frequency at which back-scattering can occur is

$$f_{min} = c/2s$$

where $s$ is the finger pitch and $c$ is the velocity of light. In this chamber, $s = 7.6$ cm, and the corresponding value of $f_{min}$ is 1.97 GHz. Hence specular reflection will occur only below this frequency.

*Present address: Atmospheric Sciences Division, Centre for Earth Science Studies, P B 2235, Trivandrum 695 010.

This chamber is designed to have a tapered geometry due to the following reasons. Firstly, the quantity of the absorbing material needed for a tapered chamber is much less than that required for a rectangular one. Secondly, in a tapered chamber, the image sources of the transmitter will be closer to the transmitter itself, thereby minimising the wavefront distortions in the quiet zone. Again, the tapered geometry straightens out the wavefront faster than a rectangular one[4]. Tapering starts at one end of the chamber and extends till the middle. In order to avoid interference from external signals, the chamber is given a metallic shielding. Thin aluminium sheets are used for the shielding.

The anechoic chamber was constructed inside a large room of length 9.1 m and breadth 7.3 m. A portion of this rectangular room, 7.2 m × 3.6 m, was separated using wooden boards and framework for the anechoic chamber. The tapered portion begins with a slope of 25° at exactly the middle of the chamber. Aluminium sheets were nailed over the wooden framework for the shield. Over this aluminium shield, water resistant, 12-mm thick, plywood boards were fixed and the absorber was attached over these using commercial adhesives. Since the maximum reflection may occur from the centre of the back wall, this region was covered with larger pyramids. The tapered portion was covered with wedges and walkways with flat-layered absorber.

At the cubical end of the chamber there is a door to provide entry into the chamber. The tapered portion ends in another small terminal box. The interior of the portion is also covered with wedge-type absorber. The transmitting antenna is kept at the apex of the tapered portion. Fig. 1 shows a sketch of the anechoic chamber. A view of the different portions of the chamber is shown in Fig. 2.

The antenna positioner placed inside the chamber is the major instrument used in the chamber. The positioner consists of a platform which can rotate at a uniform rate of 1 rpm.

The control unit for the antenna turn-table, the transmitter, and the measuring and recording instruments are located inside the control room, adjacent to the chamber. The main features of the control panel are the following.

(i) ON OFF switch for the motor; (ii) forward reverse control for the turn-table; (iii) direction of rotation indicator; (iv) position indicator; (v) signal level monitor; and (vi) limit switch control.

The measuring instruments like the VSWR meter, power meter, pattern recorder, etc. are kept in the control room.

The quality of the microwave anechoic chamber depends on the reflectivity levels in the quiet zone. The

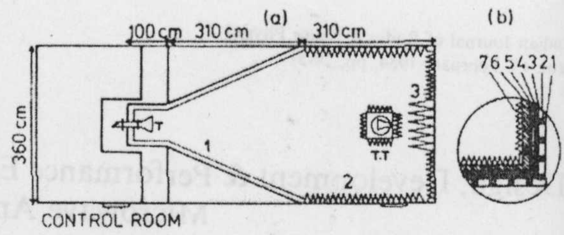


Fig. 1—(a) Construction of the anechoic chamber (T, transmitter; T.T, turn-table; 1, wedge absorber; 2, small pyramids; and 3, large pyramids), and (b) structure of the walls [1, outer plywood lining; 2, wooden structure; 3, plywood lining; 4, aluminium sheet (shield); 5, water resistant plywood lining; 6, flat absorber; and 7, pyramids]

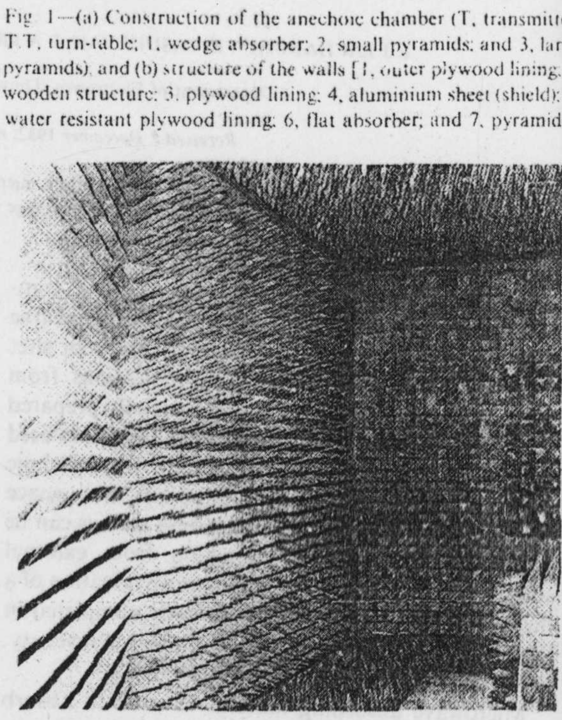

Fig. 2—Interior view of the anechoic chamber (Wedge absorbers lined in the tapered portion, pyramidal absorbers in the cubical portion and on the turn-table frame, and layered-flat absorbers paved in walkways around the turn-table can be seen.)

quiet zone is the region inside the anechoic chamber, where the total reflection from the chamber walls are below the direct radiation by the transmitting antenna by a certain specified amount.

The chamber reflectivity is defined as the average reflectivity level measured in the quiet zone. The reflectivity of the chamber was measured using the technique[5–7] of pattern comparison.

In the pattern comparison method, two identical pyramidal horns of known gain are taken. The chamber is illuminated by the transmitting antenna located along the major axis of the chamber at the tapered end. The receiving antenna is mounted on the turn-table, at the centre of the design quiet zone. The radiation pattern of the antenna is plotted and this is used as the reference pattern. The receiver is moved to a new position along the axis through a distance of 15 cm. The radiation pattern is plotted at this position. This pattern is superimposed over the reference

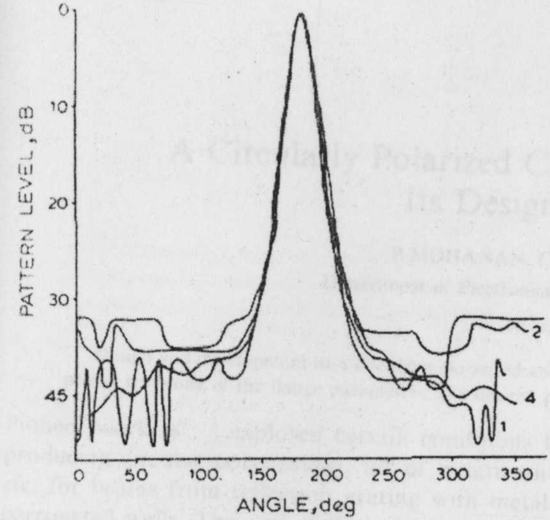


Fig. 3—Radiation patterns recorded for the pattern comparison method of evaluation (1, reference pattern; 2, 15 cm off-centre; 3, 30 cm off-centre; and 4, 45 cm off-centre)

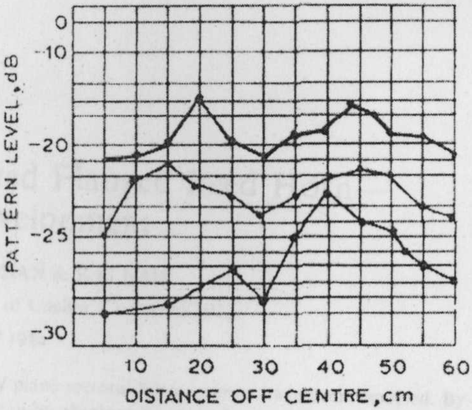


Fig. 4—Deviation at each reference-pattern level with radial distance between chamber centre and test point

pattern, so that the peaks coincide. This is repeated at different positions along the transverse and longitudinal directions from the centre of the quiet zone.

Fig. 3 shows some of the patterns recorded by the above method. The difference between the patterns, at specified pattern levels, say −15 dB, −20 dB, −25 dB, etc., below the mainlobe peak are noted and plotted as a function of the distance from the centre of the quiet zone. Fig. 4 shows this deviation curve. The peak-to-peak excursion of this deviation curve is noted at each pattern level. The chamber reflectivity can be then determined from standard curves supplied by Buckley[6]. The average reflectivity of this chamber determined by this method has been found to be −32 dB at X-band frequencies.

Another important chamber characteristic to be determined is the termination VSWR. The termination VSWR of anechoic chambers should be very small. Hence the conventional method of measuring the VSWR with a slotted section cannot be adopted, since the mismatch introduced by the probe in the slotted section itself is of the order of the chamber mismatch. Therefore, for measuring VSWR the moving termination technique[6,8] is employed. The measured value of the termination VSWR was found to be less than 1.05.

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## References


1 Stephen Galagan, *Microwaves* (*USA*), 9 (1970) 47.
2 *Test procedure for antennas* (IEEE Press, New York), 1965.
3 Green H E, *Electr Eng Trans* (*Australia*), (1977) 18.
4 Stephen Galagan, *Microwaves* (*USA*), 9 (1970) 44.
5 Stephen Galagan, *Microwaves* (*USA*), 9 (1970) 69.
6 Buckley E F, *Microwave J* (*USA*), 6 (1963) 69.
7 Zachariah E J, *Corrugated flange technique for beam shaping of sectoral electromagnetic horn antennas*, Ph D thesis, Cochin University, Cochin, 1981.
8 Montgomery C G, *Techniques of microwave measurements* (McGraw Hill Book Company, New York), 1949.