BE-36

A VARIABLE VOLUME CAVITY EM NEAR FIELD SIMULATOR

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A variable volume cavity system capable of simulating complex electromagnetic fields by the simultaneous excitation of two independent cavity modes has been built and tested. As the physical dimensions of the cavity dictate the operating frequency of the device, in order to operate over a band of frequencies, the cavity must be capable of mechanically adjusting its physical configuration in accordance with operating frequency changes. A novel mechanical design allows the cavity to be adjustable in size over a wide extreme. The cavity is formed by four movable walls, a stationary back wall, and a sixth wall, called a plunger, which is cut to size and whose location determines the length of the cavity. A structural framework supports the plates. The four movable walls allow the cross-section of the cavity to be changed. They are positioned by the utilization of linear bearings, rack and pinion gears, shafting, and a chain-and-sprocket adjusting system. The plunger is attached to an all-thread bolt which is driven by an internally threaded handle mounted between two pillow blocks. Although there are no inherent size limitations to the mechanical design, a prototype system has been built in which the cavity cross-section can be adjusted from maximum dimensions of 24 in. x 24 in. to minimum dimensions of 6 in. x 6 in., while the length is adjustable from 4 ft. to 1 ft. This cavity system is of sufficient size to irradiate a variety of biological objects such as mice, cell samples, bacteria, and other microorganisms, as well as phantom scale models.

Summary

A Variable Volume Cavity EM Near Field Simulator

A large number of research projects are currently being conducted by various university, industrial, and governmental laboratories to assess and understand the effects of electromagnetic energy on biosystems. To perform these programs properly, it is necessary to simulate the complex electromagnetic fields generated by various transmitter equipment. For example, a phased array radar system is a widely used high-power electromagnetic radiating system. At any particular position near the antenna the resultant field will be a vector sum of the electric and magnetic fields emitted by each of the radiating elements, which are usually half-wave dipoles. The electric and magnetic fields associated with most arrays will be in space quadrature, however, the magnitude and phase relationship will vary, depending on the position in front of the array. Near fields will typically exhibit a standing-wave pattern whose periodicity is determined by element spacing and phasing.

Adequate simulation of these fields in a laboratory environment requires that the simulator system be capable of producing high-field strengths (kV/m) with various field impedances. In general, these criteria are extremely difficult to meet. The requirement of variable field impedance implies that the electric and magnetic fields emitted by the simulator must be independently controllable in both phase and magnitude. Even if the requirement of independently controllable electric and magnetic fields is disregarded, the use of standard gain horns or reflectors to develop kV/m field intensities would require impractically high transmitter power levels. If on the other hand very high-gain antenna systems were employed, their physical size would not be compatible with standard size anechoic enclosures.

Considering the above, it is felt that a resonant cavity system is a logical choice for the simulation of complex electromagnetic fields. The most obvious advantage of a cavity system is that it can provide a very efficient conversion of source power to high intensity fields. Less obvious is the fact that the generation of electric and magnetic fields that are independently controllable in phase and magnitude can be accomplished by the simultaneous excitation of two cavity modes. This allows the selection of virtually any value for the field impedance, including the plane wave case. The dual modes should be selected so that the exposure volume can be located at a position in the cavity where maximum electric field and zero magnetic field occurs for one mode, while the opposite conditions occur for the other mode. If reasonably uniform field conditions over the exposure volume are desired, then the exposure volume size must be much smaller than the distance between the nulls in the characteristic standing-wave pattern of the cavity field. Simulation of near-zone phased array fields may also necessitate the utilization of the nonuniformity of the cavity fields, since approximately the same nonuniformity within an exposure volume can be duplicated by the cavity fields. This case would require that the size of the exposure volume be almost as large as the period of the cavity standing-wave pattern. Other advantages of a cavity

system are: determinable fields in the exposure volume; no separate screen room or anechoic chamber requirements; no radiation hazards; and no interference problems.

The disadvantage of a resonant cavity is that when the frequency is changed, it must be physically retuned because the operating frequency and resonant modes are dictated by the physical dimensions of the cavity. Thus, in order for a cavity system to operate at a continuum of frequencies, it must be capable of mechanically adjusting its physical configuration in accordance with operating frequency changes. To that end, a mechanically adjustable cavity system has been built. Although there are no inherent limitations to the size of the cavity which may be constructed, a prototype system has been built in which the cavity cross-section can be adjusted from maximum cross-sectional dimensions of 24 in. x 24 in. to minimum dimensions of 6 in. x 6 in. The length is adjustable from 4 ft. to 1 ft. This cavity system is of sufficient size to irradiate a variety of biological objects such as mice, cell samples, bacteria, and other microorganisms, as well as phantom scale models.

The cavity is formed by four 24 in. x 48 in. movable walls, a stationary back wall, and a sixth wall, called a plunger, which is cut to size and can be detached from the structure allowing access to the interior of the cavity. All the walls are constructed out of 1/4-inch aluminum tooling plate. A structural framework supports the plates which form the cavity as well as the movable links and the other adjustable elements of the system. The four movable walls allow the cross-section of the cavity to be changed. They are positioned by the utilization of linear bearings, rack and pinion gears, shafting, and a chain-and-sprocket adjusting system. Cavity cross-section is varied by rotating a hand crank mounted on a shaft connected to the idler of the chain-and-sprocket system. The crank turns the drive shaft for each plate an equal amount, which through the linkage moves the walls equal distances. Thus, the cross-sectional shape (square or rectangular) stays the same, but the dimensions increase or decrease depending on which direction the crank handle is turned. The length of the cavity is controlled by the plunger, which is firmly attached to an all-thread bolt. The all-thread bolt is driven by an internally threaded handle that is mounted between two pillow blocks. Finger stock is attached to all movable surfaces in order to provide good electrical contact between the walls.

Cavity mode excitation and monitoring is achieved by positioning a short monopole and shielded half-loop arrangement at both ends of the cavity in such a manner that minimum coupling occurs between the loop and monopole at each end wall. TM mode excitation and monitoring is achieved by the monopole pair, while the loops are used to excite and monitor the TE modes. Shielded loops were used because a small loop may have electric field dependent currents associated with them. This could pose serious problems since the loop might excite the unwanted TM mode as well as the desired TE mode. Shielded half-loops with a gap at the center preclude this possibility.