A short investigation in the old wall stirring method for reverberating chambers

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Abstract

One of the oldest theoretical methods of stirring a reverberating chamber, shifting a wall, has been simulated and compared with the now common stirring methods. Comtest has devised a way for the complex operation of shifting a wall of a shielded room and has a pending patent on it.

Wall stirring has a couple of advantages over the common rotational stirring. The main advantage is that there is no stirrer anymore that has to be placed away from the walls and so in effect is placed in the middle of the chamber. A stirred volume of 10 % can easily be achieved with only one stirrer, so only one actuator and maintaining a large working volume. The chamber is well shielded by building the moving wall inside the shielded box and no stirrer means less surface so a higher Q factor.

1 Introduction

Either the dimensions of the reverberating chamber are changed [1], or a large a-symmetrical metal plate (stirrer) in the RC is rotated to change the mode pattern (stirring) in the chamber. There are also other stirring methods like moving the source or to use two sources but the use of a metal rotating stirrer is the most common.

If the frequency difference between the modes is small enough, generally starting around mode number 100, the chamber can be used as an approximation for a RC. For positions not closer to the wall than $\lambda/4$ at the lowest usable frequency, the maximum field inside the RC is stochastically uniformly distributed. This has to be verified over the eight corners of the rectangular working volume by a calibration as described in the IEC 61000-4-21, after initial placement and after large modifications.

2 Method

The first reference to stirring a reverberating chamber by moving a wall is from 1992 [2] and it is more a simulation of a cavity with one varying dimension. Since then there has not been done much with the wall stirring concept despite its advantages. It is intuitive that moving a wall will have similar results in comparison with the traditional rotating stirrer but moving a wall is considered impractical.

The stirring method of this paper combines the best features from the two best know RC types. The standard reverberating chamber with one or more rotating stirrers is well shielded and has a fairly high repeatability. However a lot of working space inside the chamber is lost to the stirrer that has to be positioned out from the wall and a rotating asymmetrical stirrer is not the most effective for stirring. On the other side the tent design of F Leferink [1] is very space efficient and is well stirred but it lacks in repeatability and it cannot reach the commonly required high shielding effectiveness values.

Therefore this paper has another look at the most basic stirring method of all, shifting a wall. With this method there is no stirrer in the room, keeping a big working volume, while still being well shielded and repeatable.

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2.1 Modes and the Q factor

Different kind of stirring methods have different effects on the mode excitation in a RC, a couple of them will be discussed here. A normal rotating stirrer will, by its shape and position, excite a certain mode that can best exist in the cavity with that certain stirrer position and bandwidth from the Q factor. A different position can excite another mode while the frequency is not changed and the mode plot stays similar. Frequency stirring will shift the Q plot in frequency and so excited other modes. Wall stirring will change the frequency of the modes and therefore shift them left or right, exciting the mode that is the closest to the transmitted frequency. Some modes will be more effected than others and some will not be effected at all, like the fundamental mode as long as it is not the smallest wall that is stirred.

2.2 Wall stirring

Moving a wall is a more complex, but still possible, operation than rotating a stirrer but it has some big advantages. The main advantages is that by moving a wall there is not a stirrer in the middle of the room and so increasing the working volume. It is also much easier to achieve a big stirred volume, the percentage of volume the stirrer travels through.

In the equation below the chamber is stirred by moving on wall with the dimensions a*d a distance of y. It is clear that all f(x0x) modes are not effected at all by this stirring and the f(0x0) modes are effected the most, shifting the frequency in percentage the same as the stirred volume percentage. Meaning that it is possible for modes to shift up to 10 MHz at 100 MHz.

$$f_{res} = \frac{1}{2\pi\sqrt{\mu\epsilon}}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b \pm y}\right)^2 + \left(\frac{p\pi}{d}\right)^2} \tag{1}$$

where y is the average distance of the stirrer between the middle and extreme position.

Comtest's stirring method, which is being patented, comprises of a standard rectangular shielded room to reach the high shielding effectiveness required by many of our customers. A metal structure is hinged from the ceiling on one side of the room and pushed back and forward by a linear actuator. The stirrer will partially be build from lightweight honeycomb material to prevent pressure differences between the two sides of the stirrer.

3 Model

The wall stirring method is investigated with FEKO simulation software. FEKO is a good tool for estimating chamber performance although the simulation times are still long but the results can be fairly accurate [3, 4].

The simulated chamber has a size of 6 x 4 x 3 m, is stirred at the 4 x 3 m wall and the stirred volume is 10 %. The 60th mode is at 143 MHz and the 100th mode is at 169 MHz. The simulated models can be seen in Figure 1 and it includes the wall stirrer as a part of the wall and a transmit antenna. The working volume is highlighted in the middle of the room. The shielded box on the other side of the stirrer is not simulated because the simulation provides a perfect seal between te stirrer and the walls.

The simulations are done on a single pc with the MLFMM method, double precision. The walls are infinitely conductive because this saves simulation time and it is proven [4] that it does not change the results because the absorption of the antennas is far greater than the wall losses. The wall structure has been calculated with the combined field method to reduce the amount of computing time as well because the fast multi pole method converges faster with this method.

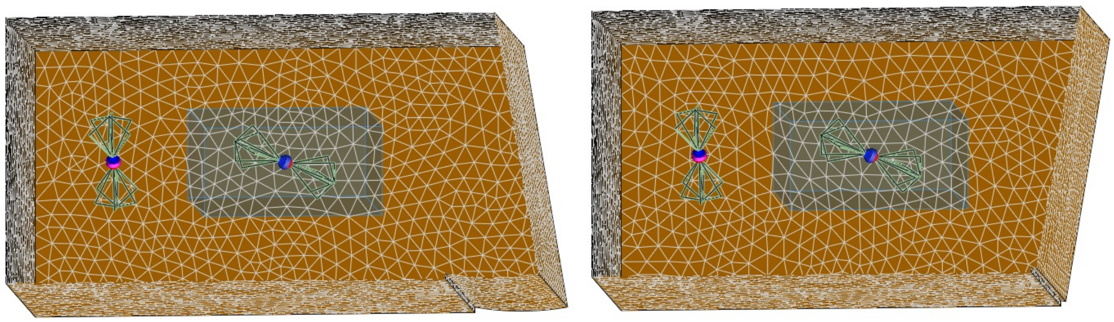

Figure 1: Simulated room with stirrer in minimum and maximum position

4 Simulation

As a performance measurement the mode stepped calibration of the IEC 61000-4-21 is used. This section will discuss the results of the simulations done on wall stirring so far. Due to the long simulation times and the desired spectral accuracy the picture is not yet completed.

The model is calibrated as described in IEC 61000-4-21 with 18 stirrer positions and with a couple of differences. The normal 8 positions are taken but the receive antenna is kept at a constant position because the time constraints prevent us from simulating it at eight different positions, which would require eight different simulation in stead of one. The frequency steps are also chosen a lot closer together so the problem frequencies can be better determined and not missed. It is already proven that the standard deviations at one frequency can differ a lot from the deviations 1 MHz higher [5].

Figure 2 represents the calibration results of two models, one traditional chamber with a rotating stirrer and one stirred by a moving wall. Both have the same dimensions, stirred volume and working volume. During simulation is was noted that the transmit antenna of the wall stirred chamber was experiencing a large mismatch, the average field level in the chamber was in the order of a factor 2 lower compared to the rotational stirrer. Both chambers had two antennas incorporated as the only loss mechanisms and infinitely conducting walls. For a rotating stirrer there is a guidance on how to place and aim the antenna. This is of no help for the wall stirred chamber so the best position still has to be determined. The wall stirred chamber was simulated with a different transmit antenna position and behaved totally different and noticeably better but still not optimal, the mismatch is still larger than the rotational stirred chamber.

5 Conclusion

Stirring a reverberating chamber by moving a wall is a viable stirring method. The construction of a moving wall is more complex than building an asymmetrical rotating stirrer but it will increase the usable area of the reverberating chamber by a significant amount. It is also possible to achieve a high amount of stirred volume (> 10 %) with the use of only one actuator and without a big concessions to the working volume inside the chamber. The author acknoledges that this is just the top of the iceberg for this stirring method and that a lot of research still has to be done on this to explore all of its possibilities. Future field of interest include building the chamber and characterizing it, optimizing working volume and stirred volume and characterizing the higher frequencies.

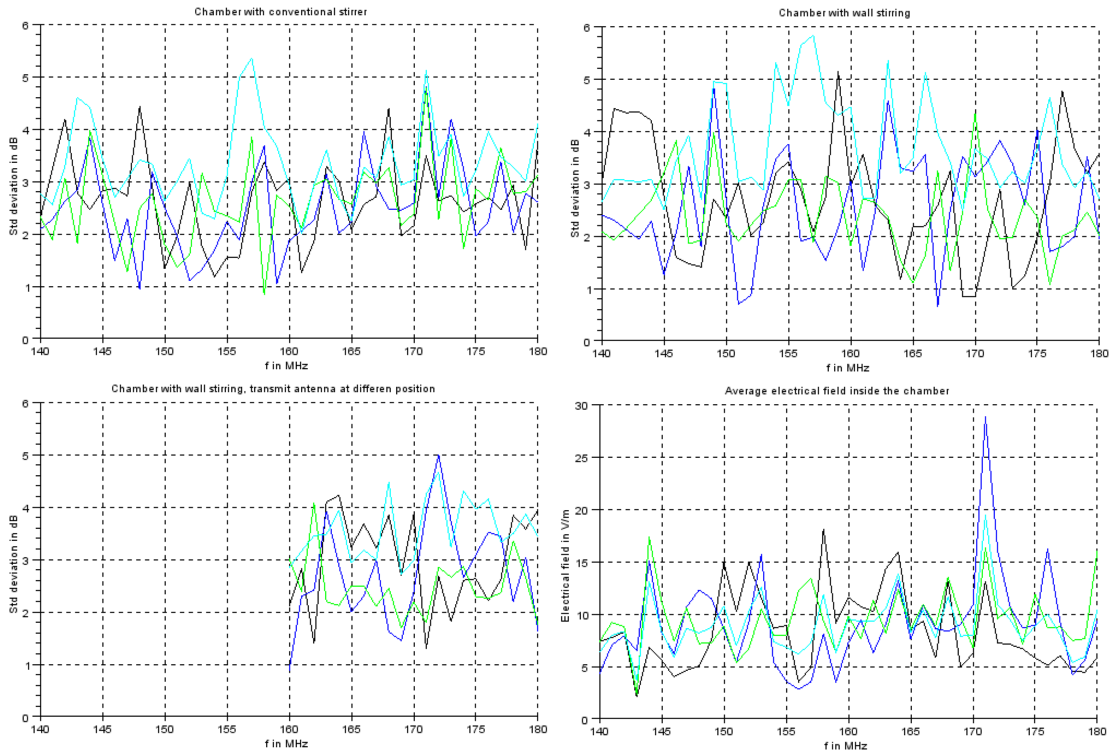

Figure 2: (clockwise) Standard deviation of a chamber with conventional stirrer, a wall stirred chamber, average electrical field inside the chamber with 1 W, standard deviation of a wall stirred chamber with a differently place transmit antenna.

6 Note for the reviewer

I know that the frequency ranges of the simulations are too short at the moment and I'll increase the span for the final paper. I've chosen to simulate more different setups and had some problems so I was not able to finish the simulations in time for this preliminary paper. But the pc is still simulating at this moment and the graphs will be complete for the final paper.

References

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