Institute of Acoustics

TV HOLOGRAPHY IN SOUND REPRODUCTION

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INTRODUCTION

The technique of TV-holography or Electronic Speckle Pattern Interferometry is briefly discussed and its application to the vibration behaviour of loud-speakers and sound systems is examined.

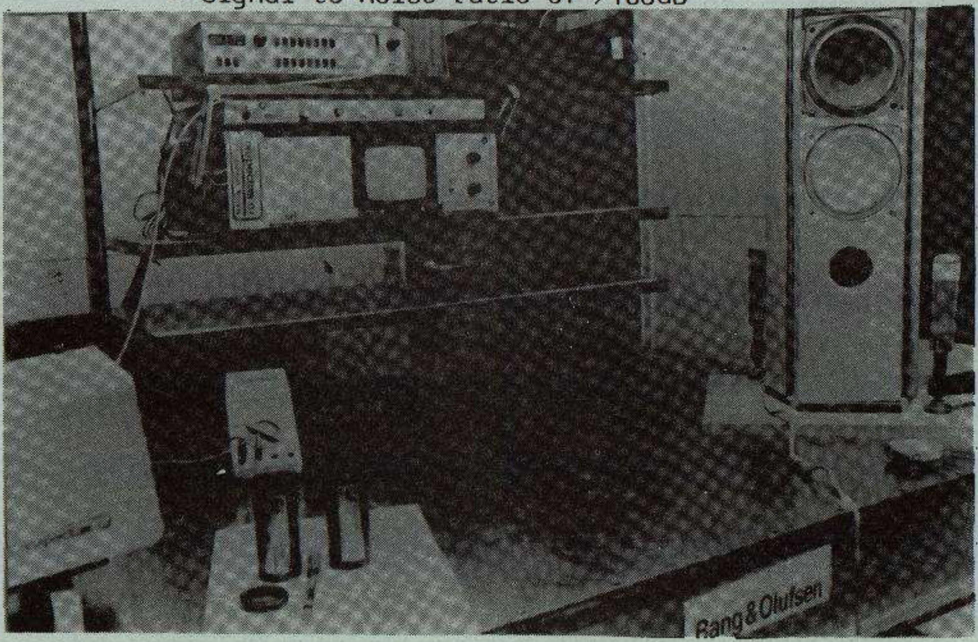
The practical application of this technique in the development of loudspeakers and their cabinets is illustrated by examples of typical results.

TV HOLOGRAPHY

The principles of Electronic Speckle Pattern Interferometry were first out-lined in the early 70's. One of the leading groups which started in those early days is based at the NTH in Trondheim, Norway. The instrument which has been used to perform the measurements documented here is the RETRA 1000 -developed by the NTH group and the CONSPECTUM company.

The principle is extremely straightforward and can be considered as a real-time video based system. Many previous papers have been written on the theory of TV holography, we therefore propose only to highlight the advantages of this technique:

- real time presentation
- full field measurement
- reduced sensitivity to environmental vibration
- can obtain phase information
- sensitive to vibration amplitudes of less than 50nm
- non-contacting
- signal to noise ratio of >180dB



LOUDSPEAKER CONES

By simple surface treatment it is possible to observe a loudspeaker drive unit using TV-holography. By using sinusoidal excitation it is possible to sweep through the frequency range and very quickly detect any flaws in the construction of the drive unit. For example, it is important to be able to visualise the linear working range of the drive unit and, more importantly, how the unit behaves when it starts to break up.

Using phase modulation techniques it is also possible to examine the phase relationships between particular anti-nodes. From such an analysis it is, for example, possible to identify the difference between travelling waves and standing waves, and to calculate the nett volume movement of the diaphragm.

Experienced operators can often assign particular phenomena appearing on the TV screen with anomalies in the frequency response of the unit.

Because the technique measures the full-field vibration amplitude (which is in the direction of the holographic sensor unit) it is possible to measure other parameters which are of great interest to the development engineer.

Firstly, the principal axis of the vibration. At any frequency of interest where there is a fringe pattern, by moving the HSU to look at the cone from a different angle it is possible to find that angle at which the vibration amplitude of a particular anti-node is a maximum. That then, is the principal axis of displacement at that point.

Increasingly, the use of modal and finite element analysis is being employed in the design of cones (and indeed cabinets). The only way in which such computer packages can save time in the long-run is by improving the models upon which they work. This can in part be achieved by TV holography. Testing products real-time and being able to identify modes, frequencies, and Q-factors helps tremendously in closing the loop. Experiments such as diaphragm mass versus frequency versus mode shapes can very quickly be performed and that data then fed back to the computer model.

LOUDSPEAKER CABINETS

As important as the drive units themselves is the cabinet in which they are mounted. The cabinet is generally responsible for a considerable number of the problems associated with a poor sounding loudspeaker system. Traditionally these cabinets have been treated with damping materials and stiffened using empirical methods. Such an approach will often take a considerable amount of time and still may not produce the optimum result. Many designers are also interested in moving away from the traditional high density chipboard boxes to more exotic geometries made from modern, lightweight, mass-produceable, low cost plastics.

This move represents enormous problems for the poor engineer who has to make this new enclosure "invisible".

Once again the use of a real-time full-field tool allows the engineer to quickly evaluate what modes are being excited and hence have a better understanding of how to approach the quietening process. Similarly, the real-time presentation allows the user to interact with the test box. The nett result will therefore be an optimally designed cabinet produced in a fraction of the time traditionally required.

CROSSOVER NETWORKS

These pcb's suffer in two ways from vibration. The first is the excitation caused by sitting inside the loudspeaker and being vibrated. The second is the vibration caused by the components on the board being excited. Most engineers are probably familiar with the noise produced by coil windings on the large inductors used in such networks.

These mechanisms present two potential problems to the successful designer. First is the subtle nuances of sound quality which are caused by the network acting as a sound source. The second is, perhaps, more ominous, fatigue. If the pcb is mounted and designed in such a way as to be particularly sensitive to frequencies predominant in the music programme, then excessive vibration will ultimately lead to component leads breaking, tracks breaking, or worst of all the so-called dry joint. Such a reliability problem could involve considerable service costs and change a successful product into a corporate disaster.

Once again the TV holography system can be employed to examine the pcb for any such faults, explore appropriate mounting arrangements and eliminate such difficult problems at source.

OTHER PRODUCTS

So far we have looked at the loudspeaker only and how TV holography can be applied to their development and refinement.

Other items in the sound reproduction chain can also be examined using this technology:
- turntable platters
- headphones
- drive motor mounts
- TV cabinets
- tape recorder heads

and so on.

For portable and in-car equipment it is also important to be able to examine the effects of external vibration on the components.

Again on the subject of in-car entertainment, it is important for the car manufacturers to be able to understand precisely how the sound sources in the car are going to behave and how they are going to affect the body panels.

Practical Examples

LOUDSPEAKER

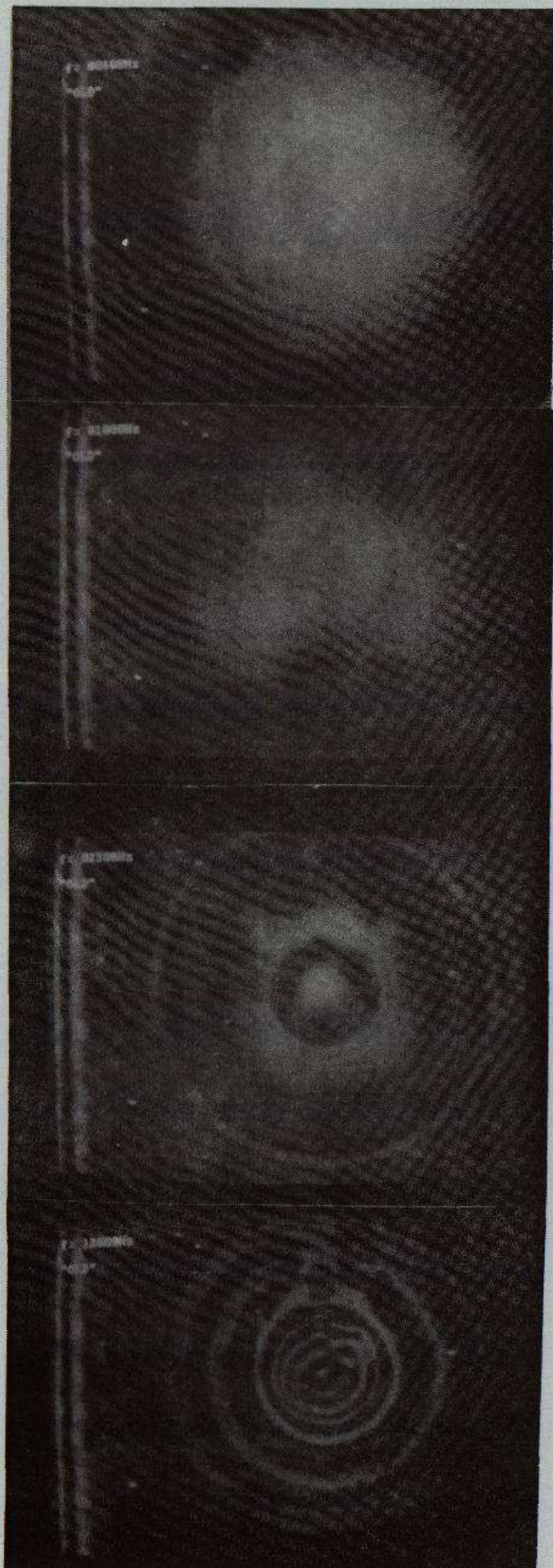
The following series of photographs show the comparison between two 5 inch drive units. The pictures are speckle - averaged with the automatic speckle noise reduction system built into the RETRA. The "new" drive unit had an improved frequency response of the "old" one and so, it would be expected, would be that chosen for the design. The holographic measurements show however that the "new" unit has a poorer mechanical behaviour then the "old" one.

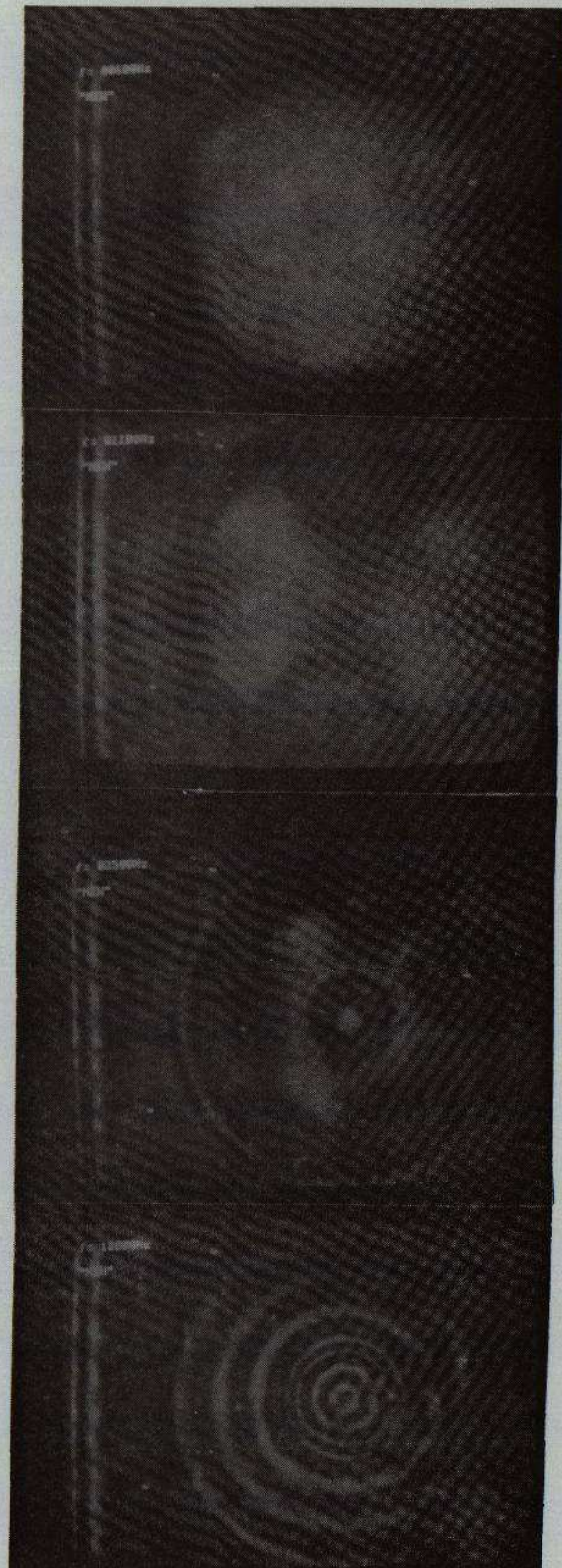
At 200Hz both units are in their piston region. At 600Hz "old" is still behaving as a piston but "new" is showing some break-up at the edges. As the frequency continues to increase both units start to break up.

"Old" shows a fairly smooth series of break-up modes whilst "new" at 1100Hz has a strong symmetrical feature with two areas one at the top and one at the bottom moving in phase with each other.

At still higher frequencies both units exhibit similar behaviour and at 12kHz both produce quite spectacular fringe patterns.

Based on this holographic information, the 'new' unit was rejected and the development continued using the 'old' design of drive unit.





CAR BODY

The photograph shows a car door which is being excited by a loudspeaker.

This particular behaviour was exhibited over quite a wide frequency range. Clearly visible at the bottom of the door are the door welds. At the weld points strong vibration/sound radiation is taking place.

Whilst such vibration may have little effect upon the listeners' enjoyment of the reproduced sound in that frequency range, it will have an unwanted effect on the car.

It is clear to see that any protracted excitation of the door in this frequency range - either by the music programme or by the vibration associated with driving the car - will have an adverse effect in weakening the lower weld seam.

It is interesting to reflect that this effect can be regularly seen on older cars and is often highlighted by accompanying rust problems.

CONCLUSIONS

A real-time full-field holographic technique can be used to look at the vibration modes of many of the components which make up the sound reproduction chain. The technology can also be used to evaluate the effects of that sound system on its environment. Quick, simple set up and operation procedures allow the engineer to reduce testing time, enhance existing test methods and thereby reduce the development costs of new pieces of equipment.

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