The Design of Monitor Systems for Air Lyndhurst Studios.

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Introduction

The new studio complex at Lyndhurst Hall will contain four control rooms designed for a wide range of recording and mixing applications, from full surround film to digital multitrack mixing and mastering.

It was decided from the beginning to custom build the main monitor systems, partly because of the physical limitations of working in a listed building with restricted height, but mainly in order to develop a product which would solve all of the problems and pitfalls of large systems in relatively small rooms.

The main obstacles involved in loudspeaker system design are well documented and indeed form a significant proportion of the discussion of any audio fraternity. The inherent distortion of drive units, especially at high levels, the need for linear frequency response to within 1 or 2 dB between 20Hz and 20Khz and controlled directivity all conspire to make any monitor the least accurate part of the audio chain.

System Requirements

From the beginning of the project it was decided to use direct radiating drivers instead of horn loaded units as the inherent non linearities of such systems were deemed unacceptable. There was a general opinion that compression drivers had reached the limit of their performance possibilities and that the limit was not good enough.

After several years of experience with a combination of cone and dome drivers it was obvious that they offered the potential for high fidelity at high levels provided the units could be given sufficient sensitivity and power handling capacity. The rest would then be simply a question of control!

The parameters for the system were as follows;

Frequency Response: 20Hz to 20KHz, adjustable for room acoustic interface.

Total Harmonic Distortion: at least 50dB below a reference level of 90dB measured in free field conditions at 1 metre at any frequency.

Sound Level: 130dB Peak at 3 metres, two channels driven, without significant compression of music programme material.

Balance: The system must be judged neutral in that it should not exhibit any particular coloration of either speech or music material.

Time Domain: All effects of band pass delay, driver mis alignment and phase shift must be minimised by appropriate compensation.

Directivity: The system must not suffer significant beaming in any frequency band and the Directivty Index Q must not exceed a value which would impair the 90 degree forward coverage angle.

System Design

It became obvious that the only way to provide completely accurate control of the system would by using digital processing, due to the complex interaction between the drivers.
The decision to use a four way design with crossover frequencies of 200, 2K and 5.6K Hz. was not difficult and corresponded to the optimum band of each of the chosen drive units.
Each driver was tested to its limit and it was found necessary to modify each with ferrofluid damping and cooling, with the added advantage of increased sensitivity through flux concentration. A special fluid was designed for the 100mm diameter coils of the bass drivers by a specialist U.S. based company which gave the desired BL product for the LF section.
The most successful combination was found to be four 300mm bass drivers (or two 400mm in the space restricted main control rooms), two 150mm low mid units with 75mm voice coils, a custom built 54mm dome radiator and 28mm high frequency dome. This gave a response for each band within a 1dB envelope from 200Hz to 30KHz before combination. The LF section was tuned for a cut off of 20Hz but the final response shaping will be done in the digital domain as described later.
In order to achieve the desired sound level it was found necessary to use 5 amplifiers of 1300W peak power for each channel. Optimum results were obtained using units designed specifically for high headroom although the bass section did benefit from the higher current driving mono version.
The control system was required to give delay correction and response shaping to obtain a best fit between loudspeaker system and room. This will be achieved using a proprietary 20 bit digital crossover which at the time of writing is still under final test.
The initial results (using 20 bit converters at 48KHz) are so far beyond what was commercially viable even one year ago and so significantly more flexible than what is possible using analogue technology that there is no doubt that all the systems will eventually be digitally controlled.
The systems will have full AES/EBU interface which will make maximum use of the digital consoles currently under consideration.
Protection of the system will be effected by programmable digital limiters on each band and heat sensitive shunt resistors at key points on the driver impedance correction boards.
Although no system can be made completely 'idiot proof', this approach will protect all but the most determined head banger!
This short paper is merely intended as an introduction to what will be an exciting project but as with all speaker system designs the proof will be in the eating.

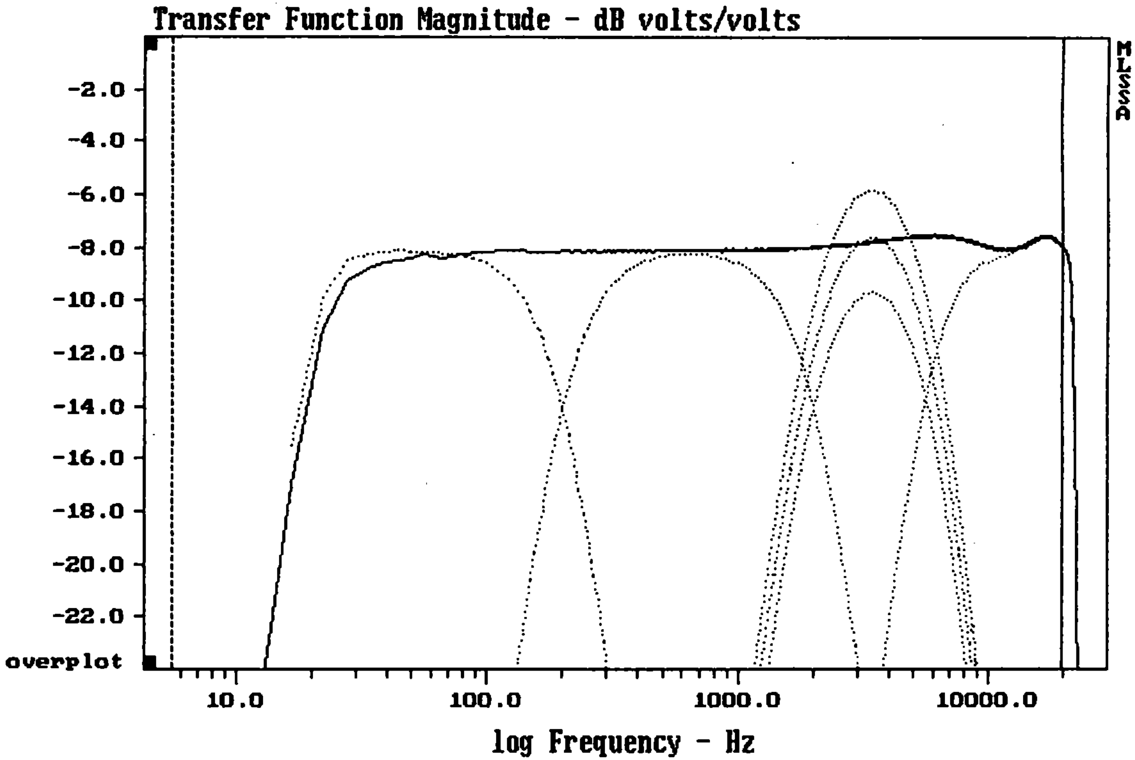
Special thanks is due to the following for work on this project;

Mark Thorup, Dynaudio AS
Dave Harries, AIR London

Illustrations

1. Bandpass criterion for digital filters, wiith combined response.
2. Impulse response of each band showing group delay effects.
3. Effects of filter slopes and roll over on Step Function reponse.
4. Digital delay correction of mid band filter to fit LF delay.
5. Investigation of LF port tuning with MLSSA ETF plot.

All measurement taken from MLSSA measurements with 30KHz bandwidth and 90 KHz sampling frequency and 2^15 impulse length to remove aliasing effects from the results.



CURSOR: y = -79.5587 x = 19747.6468 (3559)

digital bandpass filters M4 AIR STUDIOS

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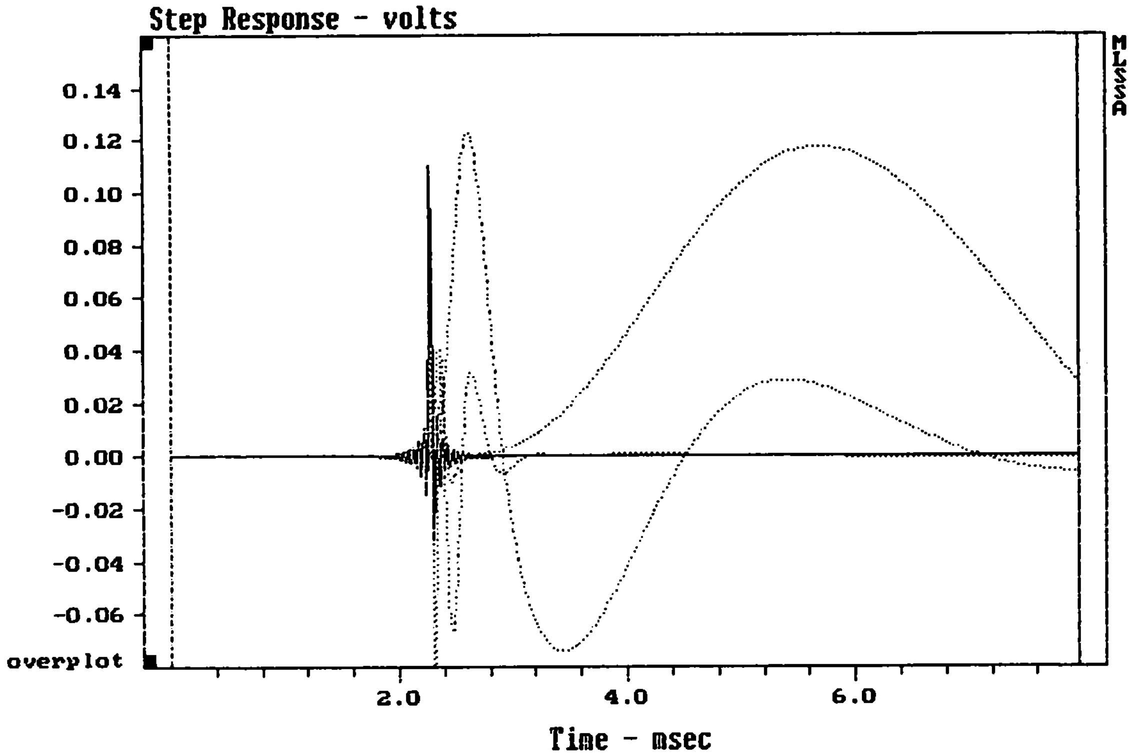
MLSSA: Frequency Domain



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Digital filter group delays ref. to 20K Impulse.

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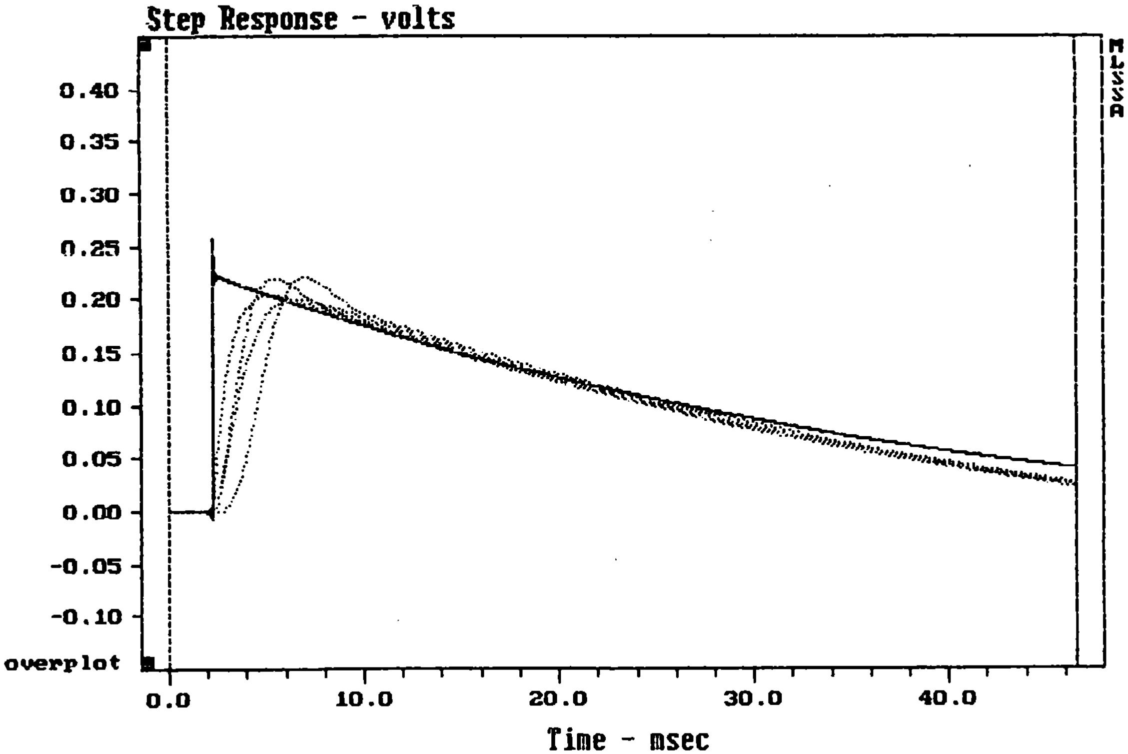
MLSSA: Time Domain



CURSOR: y = 0.0223028 x = 46.5850 (4235)

Effects of 6,12,18 dB 200Hz filter ,But v Link

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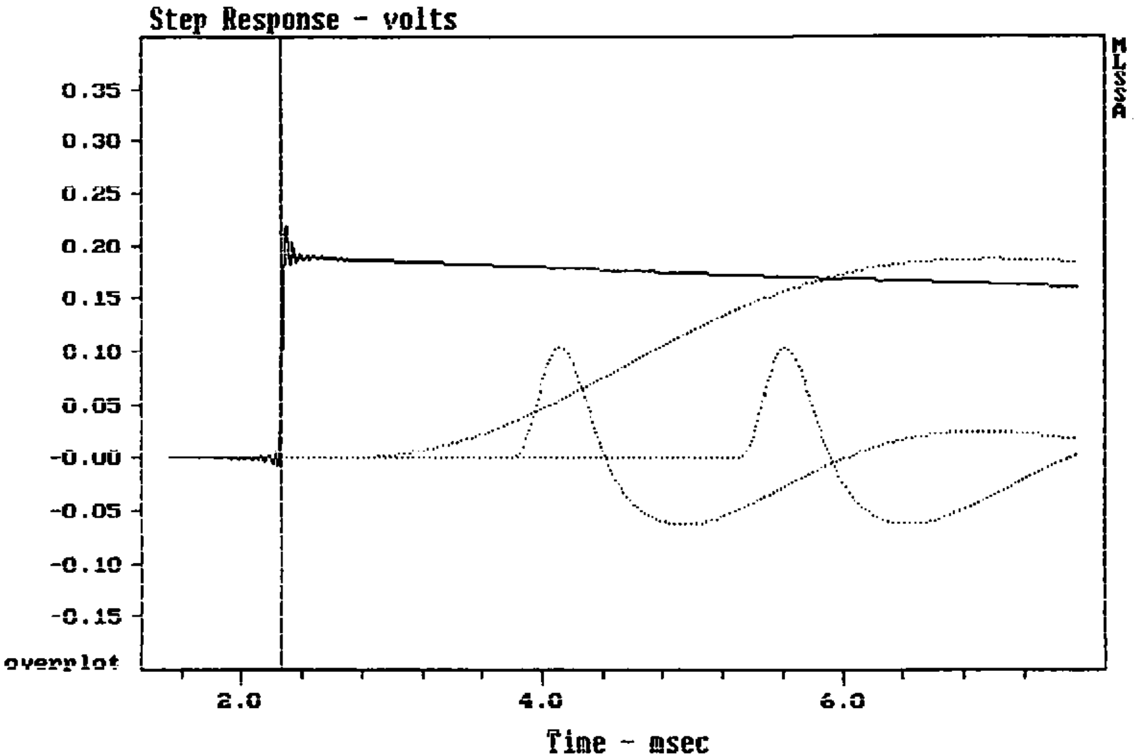
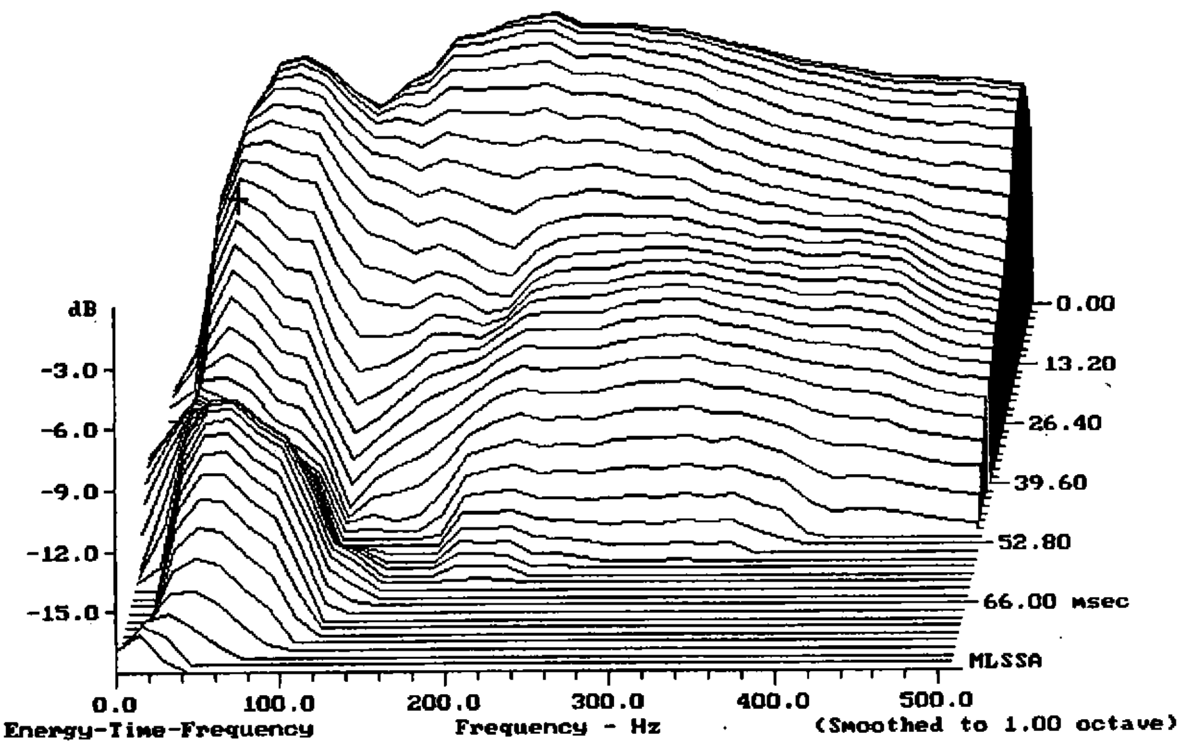
MLSSA: Time Domain



CURSOR: y = 2.65867e-006 x = 2.2660 (206)

digital delay of LF & LMF bandpass filters.

10-17-92 6:16 PM MLSSA: Time Domain



-4.99 dB, 44 Hz (3), 34.650 msec (21)

File: C:\MLS7\TOKYO8.TIM 9-3-92 4:44 AM

MLSSA: Waterfall