MICROPROCESSOR CONTROLLED VARIABLE ACOUSTICS IN HOBART

Alex Burd and Laurence Haslam

Sandy Brown Associates, London
Sandy Brown Associates, Edinburgh

1. SUMMARY

This paper provides a brief description of the variable acoustic treatment installed in the Production Studio at the new Hobart Radio Studios of the Australian Broadcasting Corporation. A unique part of the design is the microprocessor control which independently adjusts each of the 24 absorbers and allows repositioning of the absorbers to any one of up to 100 pre-set arrangements. A VDU displays a complete representation of all absorbers on a single screen and includes text entered by the user to identify each set up.

In commissioning tests, reverberation times in the studio were able to be varied from 0.6 to 1.4 seconds over the range 250 to 4000 Hz whilst maintaining a uniform and high quality acoustic result.

Subjective appraisal with two groups of musicians confirmed the flexibility and acoustic appeal of the studio for a diverse range of recording requirements.

2. INTRODUCTION

The Australian Broadcasting Corporation began construction of the new Radio Broadcasting Centre in Hobart in September 1985. Initial design work for the project included two Production Studios, but cost cutting measures be taken early in 1985 resulted in only one studio being constructed, which had to satisfy the diverse needs of music, speech and drama. Sandy Brown Associates were approached to prepare a design which would allow the greatest possible range of acoustic conditions to be achieved with the minimum possible physical effort, whilst preserving conditions in the studio which would make it an acoustically comfortable and responsive performance space for musicians and actors.

Variable acoustics have been tried by most broadcasting organisations at one time or another. They usually fail in practice because they do not provide a worthwhile range of acoustic conditions or they take so much time and effort to change from one condition to another that the variation is seldom exploited. It was therefore with some trepidation that Sandy Brown Associates undertook this venture.

A design concept originally researched by the IRT was considered to be the approach which offered the best hopes of satisfying the aims. the absorbers were envisaged as an acoustically resistive membrane moved by an electric motor and drive shaft/roller over a backing of different depths. The fabric was to be supported and driven by roller chains over sprocketed guides. State-of-the-art sensing techniques together with computer control suggested the possibility of a considerable degree of remote control and pre-programming. The control system was proposed to be a proprietary microprocessor which would store any pre-selected combination of absorber positions. These conditions could then be recalled and the absorbers caused to move to the required position.

At the outset it was clear that ease of use together with user friendliness would be the key factors in the continuing success of the variable absorber concept. The controller should allow the studio engineer to manipulate the absorbers from the control room, using a keyboard and visual display which is a direct representation of the studio walls and ceiling depicting the location of the membrane in each absorber unit.

Any single absorber or any combination of absorbers can be moved any number of steps with a minimum number of keystrokes. Once a desired acoustic treatment has been achieved, the settings of the absorbers can be saved for later recall. To reset the studio to a previously saved setting required four keystrokes. Alternatively, the user may browse through all settings to recall the required condition.

Design was completed by December 1986 and the Department of Administrative Services, Construction Group, in Hobart implemented the design by separate Contracts for the various parts of the acoustic fitout and the mechanical and electrical system.

3. ACOUSTIC AND MECHANICAL DESIGN AND CONSTUCTION

A large number of fabrics were tested initially to determine their flow resistance. From this range six fabrics were selected and small samples were tested in an impedance tube to find their normal incidence absorption coefficient. Finally two fabrics, a cotton velour and a cotton/viscose/flax (linen) repp, were tested in full scale measurements in a reverberation room. The individual test results were promising but an even more effective result was obtained by a combination of the two fabrics. When stretched over a 200mm airspace, a very strong peak of absorption resulted at 200 Hz, as would be expected from a resistive membrane over such an airspace. With a combination of three different airspace depths the absorption could be spread over a much wider frequency range while the backing panels could also provide additional low frequency absorption from the panel vibration in combination with the closed airspace behind them.

On the basis of the reverberation room test results it was predicted that, using 24 variable absorbers covering a total surface of almost 140 sq.m., a variation of the reverberation time of 0.6 to 1.2 seconds would be achieved in this 100 sq.m. (600 cu.m.) production studio.

While it is obviously important to design the absorbers so that they are efficient in the absorbing configuration, it is equally important to minimise the absorption in the non-absorptive configuration. this is achieved by moving the fabric behind the backing box through as narrow a slot as is practicable. A cross section of the variable acoustic absorber (VAA) is shown in Figure 1 and the disposition of absorbers and controllers in Figure 2. Considerable care was taken to ensure that the backing boxes would not cause flutter echoes in the studio even when very non-uniform combinations of absorbers were selected. The full depth boxes are positioned at high level in the studio where the excitation of flutters is unlikely to occur while the lower level backing panels are all angled. A small area of Quadratic Residue Diffusers was incorporated into the room design to provide further diffusion of the sound field. Additional low frequency absorption was incorporated on the ceiling, the amount being selected after empty room reverberation time measurements had been made to determine the absorptive effect of the backing box. Further fixed absorbers could have been added on the walls as a final tuning measure.

In order to determine final mechanical and acoustical requirements, a prototype absorber of half the full height was set up on site. The fabric mounting and drive was simplified to incorporate certain elements of sail technology. Thus the fabric was attached to a corded webbing along the edges, the cord running through guides. For stability and appearance the two fabrics forming the membrane were quilted together. Additional stiffening of the quilted fabric was by battens at 1200mm intervals; even so, it has proved difficult to ensure that the fabric is adequately stretched and runs with its leading edge truly horizontal.

The actual acoustic characteristics differ very little from the design proposals. The experimentally selected fabrics were retained together with the various depths of airspace in the backing boxes. Further samples of the absorbers were tested at the Australian National Building Technology Centre and the results agreed well with the initial experiments.

4. THE CONTROL SYSTEM (See Figure 3)

4.1 System Software

The software was written using macro assemblers to achieve the highest level of performance possible with the selected devices. Great care was taken with the user interface to ensure the shortest possible learning curve for operators.

The main control system software continually refreshes the video display and executes operator commands. Interrupt driven processes in the main control software handle timing and input/output (I/O) from the keyboard and communications circuits. The main control system communicates with the variable absorber controllers via a full duplex serial link.

Each variable absorber unit has its own processor which monitors and responds to data on the main communications interconnect, determines the shortest possible curtain movement to reach a destination location, drives the absorber motor units and senses the curtain location. The absorber software notifies the main control computer of the curtain location, allowing the video display to be updated.

The software includes a motor driver, driven by a mains frequency interrupt, which directly provides timing pulses to drive the SCR bridge connected motor control. The motors can be driven in either direction at variable speed and dynamically braked. Since one power supply drives three absorbers units, motor starts are staggered to minimise maximum current requirements. The absorber software also notifies the main system controller of any error condition detected in the electronics.

The hardware and software approach selected for the project resulted in a system with minimum installation and interconnection cost, and at the same time, providing high reliability and ease of support.

4.2 Colour Graphics Video Display
The display has been engineered to provide a complete representation of all 24 absorbers showing the current location and indicating the next destination location on a single screen. The relevant sections of the display are colour coded to match coloured keys on the keyboard. Video display brightness is controlled via a VIDEO key on the keyboard and the display is muted after 30 minutes of inactivity. Pressing any key restores the display to its original brightness. The colour video monitor is recessed into the ceiling of the control room immediately above the studio window.

4.3 Control Keyboard
The system keyboard contains 24 keys including a numeric keypad and specific function keys. The keyboard occupies a small section of the SSL studio desk.

4.4 Main Control Computer
The control computer selected is an STD buss system based on the Z80 microprocessor. Components include a Z80 microcomputer with battery-backed CMOS memory and a colour video control card. The video card was modified to allow for programmable brightness control. The control computer has two serial data ports; RS232C to communicate with the keyboard and an RS422 link communicating with the absorber control units. This 19" rack mounted device is located in a section of the studio equipment bay.

4.5 Absorber Control Units (ACU)
Each ACU mounted at strategic locations in the studio ceiling controls three absorbers. The ACU's were fabricated using a double sided PCB designed for the purpose. All connectors and power supply components are sited on the PCB, resulting in minimum wiring. Active components include three programmable single chip microcomputers and silicon controlled rectifier (SCR) based reversible variable speed DC motor driver capable of providing 8 amps drive current and dynamic motor braking. The overall design uses the power of the microcomputer to achieve minimum component count. The ACU software allows for parameters associated with the control of the absorbers to be modified or down-loaded from the main control computer; unknowns in the absorber can be corrected without removal or re-programming of the ACUs.

4.6 Optical Position Sensors
Adjustment of the absorbers requires that the position of the fabric membrane is known to within 20mm. this is achieved by the use of infrared optical sensors on each absorber to sense coded punched holes in the edge of the acoustic membranes. These devices use an array of 6 infrared light-emitting diodes and associated phototransistors. They were fabricated using two single sided PCBs mounted in custom designed housings machined from 1 cm perspex stock sections. The units and associated mounting hardware provide three axis adjustment for alignhment purposes.

5. PERFORMANCE AND COMMISSIONING

The construction and installation of the absorbers and decorative masking panels were completed in February 1988. Reverberation time measurements were first made with the absorbers fully exposed and fully retracted to define the limiting values of the system. The results plotted in Figure 4 showed that the absorber construction was as effective as predicted in the absorptive condition, and the remanent absorption in the retracted condition had been very effectively minimised.

It was considered that the 1.7 second peak RT at 2 kHz was unnecessarily long for a studio of this volume, and that the characteristic would be improved if the curve could be flatter over a wider frequency range. This was acheived by using about 16 sq.m. of the double fabric stretched over some of the areas of flat reflective panels.

Commissioning continued by selecting absorber configurations which adjusted the studio RT in 0.2 second steps with the most uniform distribution of absorption. Measurements confirmed that diffuse conditions had been achieved because the reverberation times were satisfyingly uniform both at floor level and at a number of high level microphone positions. In general, octave band measurements were used to calibrate the absorber arrangements but for each configuration a single one-third octave band measurement was also made; this single position measurement is reproduced in Figure 5 for each reverberation time.

Drama users frequently require a studio to be designed so that actors can move from a dead acoustic (outdoor acoustic) into a more reverberant space. In a fixed treatment studio the two halves of the studio are separated by heavy curtains and have the mid and high frequency absorption concentrated in the dead end of the studio; it is very difficult to achieve any significant separation at low frequencies and the low frequency absorption is therefore distributed throughout the entire studio.

It is straightforward in the Hobart Production Studio to arrange that all the variable absorbers at one end are exposed and all the absorbers at the opposite end are retracted. Carpet squares are laid on the floor at the dead end and the studio is subdivided by 2 metre high screens having efficient absorbing material on one face and a hard reflective surface on the other.

Subjectively the dead end of the studio has a slightly dead feel but the separation from the live end is not really sufficient to maintain the illusion.

6. SUBJECTIVE EVALUATION AND CONCLUSION

Initial subjective evaluation of the studio acoustics with various noise and impulsive sources confirmed that a consistent sound quality with an adequate degree of diffusion existed in the studio.

A string trio from the Tasmanian Symphony Orchestra played for a time in the studio. The reverberation time was set to 1.2 seconds initially and reduced to 1.0 seconds during the performance. For both settings the acoustic result was of high quality, the difference being a matter of recording preference to obtain the required result. It was notable that the players felt comfortable in both conditions and that microphones did not need to be moved to restore a suitable balance after the setting had been altered.

Test recordings were also made with a jazz quartet in the studio. In this instance tests were begun with a low reverberation time, 0.6 seconds, and the reverberation time was gradually raised. However, this performance requirement was found to be best served by the dead acoustic condition. As with the string trio, the players found the studio an acoustically comfortable performance space for all reverberation time settings.

In studios with a fixed reverberation time, excessive reverberation can only be reduced relative to the direct sound by placing the microphones closer to the sound source. Suitable artificial reverberation at the appropriate level can then be electronically introduced. This process is often time consuming, and frequently does not produce a suitable sound quality from the close microphone arrangement. The variable acoustic studio offers the advantage of the natural acoustic and balance of instruments and instrumental sound that are obtained from more normal microphone distances. In the limited tests conducted thus far, this was found to be the case.

The variable acoustic design and the associated control system exceeded the design expectations and will satisfy the requirements of the majority of the users. Drama will require some additional provision of acoustic isolation to achieve satisfactory live end/dead end operation.

The internal appearance of the studio is pleasing and it has the potential to be a very exciting performing environment.

ACKNOWLEDGEMENT

The Australian Broadcasting Corporation for permission to publish this paper.

DASOG (Peter Dolan, Kevin Combey, Dick Smith and others) for all the development work that has gone into implementing the desing.

Computer Switch (Grant Pearce and John Russell) for creating an interesting and easy-to-use control system and for their contribution to the writing of this paper.

Pearu Terts for assistance in carrying out measurements and useful discussions during the commissioning tests.

MICROPROCESSOR CONTROLLED VARIABLE ACOUSTICS IN HOBART

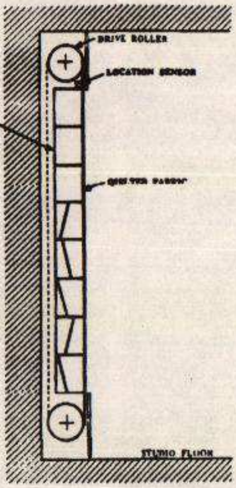

FIG 1 Variable Absorber Section

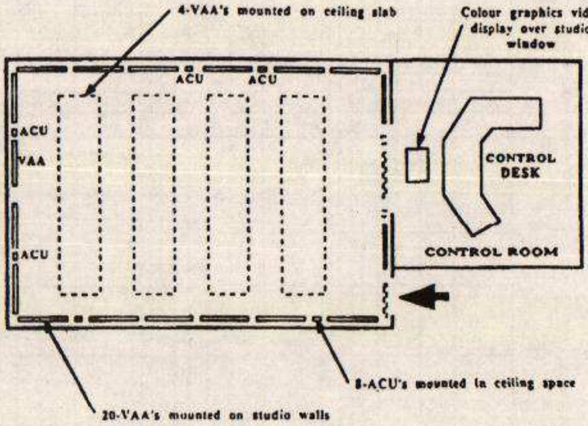

FIG 2 Studio Plan
VAA variable absorber
ACU - absorber control unit

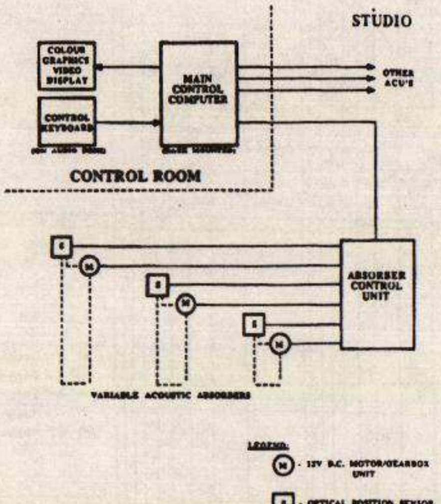

FIG 3 Block Diagram of Control System

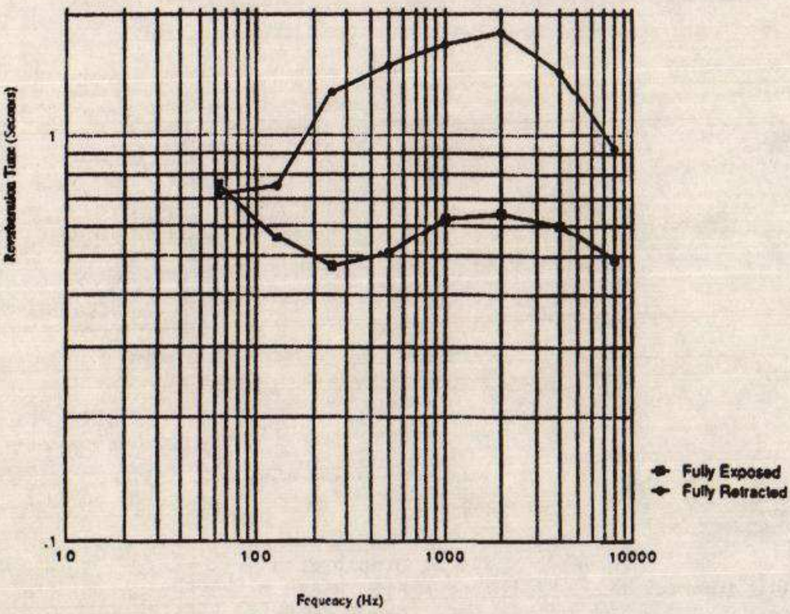

FIG 4 Initial Reverberation Times

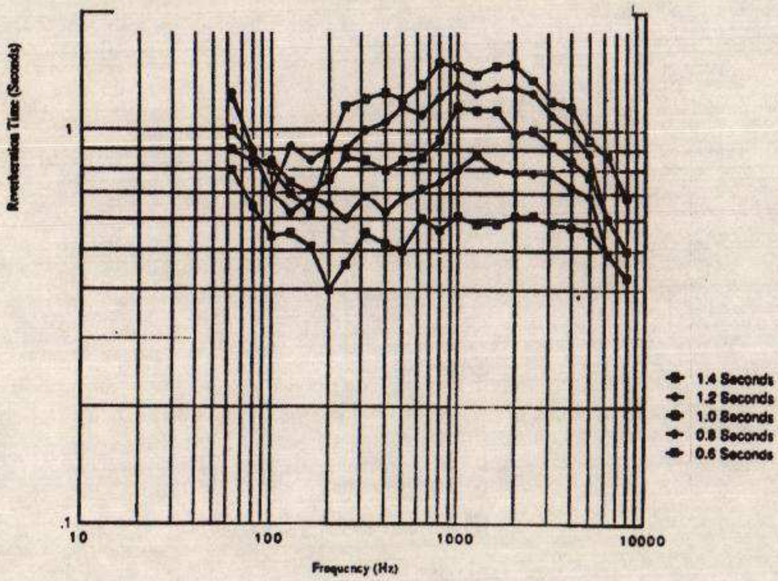

FIG 5 Programmed Reverberation times after commissioning