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MAKING A HEARING AID TESTER

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INTRODUCTION

Hearing aids are prescribed according to the degree and type of hearing loss a particular individual has and it is important that the performance of the hearing aid remains unchanged throughout its life if it is to continue to give the level of benefit it was intended. This is particularly so with hearing impaired children who depend a great deal on their hearing aids for education and speech development.

A hearing aid consists basically of a microphone, amplifier and output tranducer. The amplifier generally gives very little problem, but the microphone and output tranducer being electro-mechanical devices can often become faulty. The types of fault that tend to develop may not cause the hearing aid to cease working altogether but will change the performance of the aid in terms of acoustic gain, frequency response and output level. These changes in performance, if they occur, may not be noticed for a long period of time and would of course have a more serious affect on a child than an adult.

A survey of the performance of hearing aids in schools for the deaf and partially hearing units as long ago as 1968 [1] showed that only 50% of the aids tested actually worked correctly and other more recent surveys show that there has been little change in this situation.

One of the factors contributing to the high proportion of faulty hearing aids in schools is that many of the faults could not be detected by a simple listening test. Because of the lack of proper test facilities many of these faults went unnoticed for long periods of time.

The need for a simple, low cost means of testing hearing aids became apparent to the RNID many year ago. In 1975 we embarked on a project to design and produce a piece of equipment that could be used by Schools for the Deaf, hearing aid clinics and hearing aid dispensers.
Over the last 10 years this work has led to the development of four distinct systems. Two are stand-alone devices, and in 1980 we began the development of systems which attach to a microcomputer.The remainder of this paper will be a technical description of the devices, and our experience with attempting to obtain the commercial manufacture and distribution of the systems.

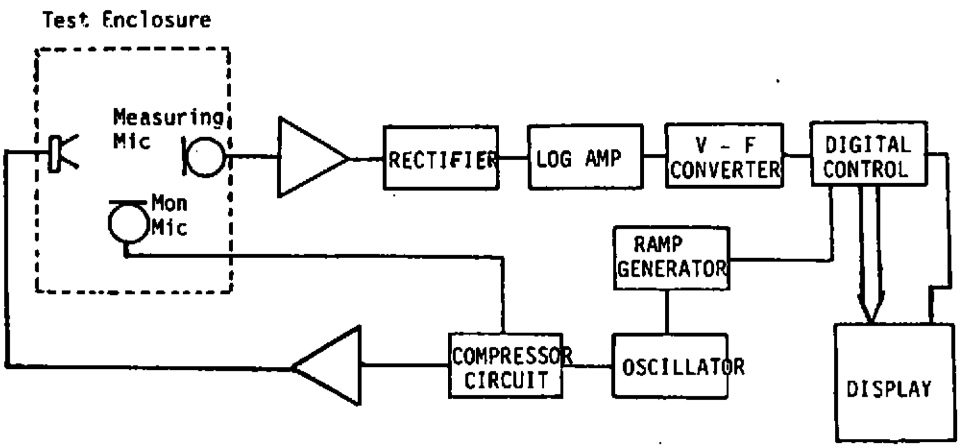
MAKING A HEARING AID TESTER

RNID I: FREQUENCY RESPONSE DISPLAY USING LED'S

For the equipment to be as easy to use as possible we considered that it would be necessary to actually display the frequency response of the hearing aid under test. This would have enabled comparison to be made with manufacturers' published curves or those from previous tests. Cathode ray tubes and printers were considered but were eventually excluded on the grounds of size, power supply requirements and cost. Since we were not designing a piece of equipment of high accuracy but simply to give a reasonably accurate indication of hearing aid performance it was decided to manufacture our own display using a matrix of light emitting diodes. The display was arranged in 8 vertical columns of 9 lights. Each column represented a narrow band of frequency and each light in a column a 5db step in sound pressure level.

The display was digitally controlled and interfaced to the analogue hearing aid measurement and test signal generation circuits. A block diagram of the system is shown in Figure 1.

Figure 1. RNID I system with LED display



The hearing aid under test was placed into a small wooden test enclosure where a sinusiodal test signal was produced. This signal was produced by a voltage controlled oscillator and swept at constant rate over the frequency range 200Hz to 5KHZ. The overall sound level of the signal could be manually set by the user to 60, 70 or 90 dB SPL. The sound pressure level in the test enclosure was kept constant over the frequency range by means of a compressor microphone and feed back circuit arrangement.

The hearing aid output was fed to a 2cc acoustic coupler fitted with a measuring microphone. The output from the mikrophone was amplified, fed through a rectifier and log circuit to a voltage to frequency converter. Each column of the display was controlled by its own decade counter. Each counter sampled the V-F output frequency at a specified time, with results being displayed by the appropriate LED column. The signal controlling the voltage-controlled tone generator also synchronised the decode counters, ensuring that the sampling of hearing aid output signal occurred at the correct frequencies. The base line of the display could be set to 85, 95 or 105db spl as required and with each light in a column representing 5db a step, measurement of the output SPL of the hearing aid at each of the eight frequencies could be obtained and the general shape of the frequency response observed. Maximum output level of the display was 145db spl, sufficient to cover all hearing aids. If a permanent record was required this could be manually traced on to a small paper chart. A switch for freezing the display in a static mode was provided for this purpose.

Although several samples of this hearing aid test system were made by the RNID and a patent taken out by the NRDC, it did not go into production as a suitable manufacturer could not be found. Considerable problems were experienced convincing manufacturers of the potential market.

RNID II: FIXED FREQUENCY TESTER

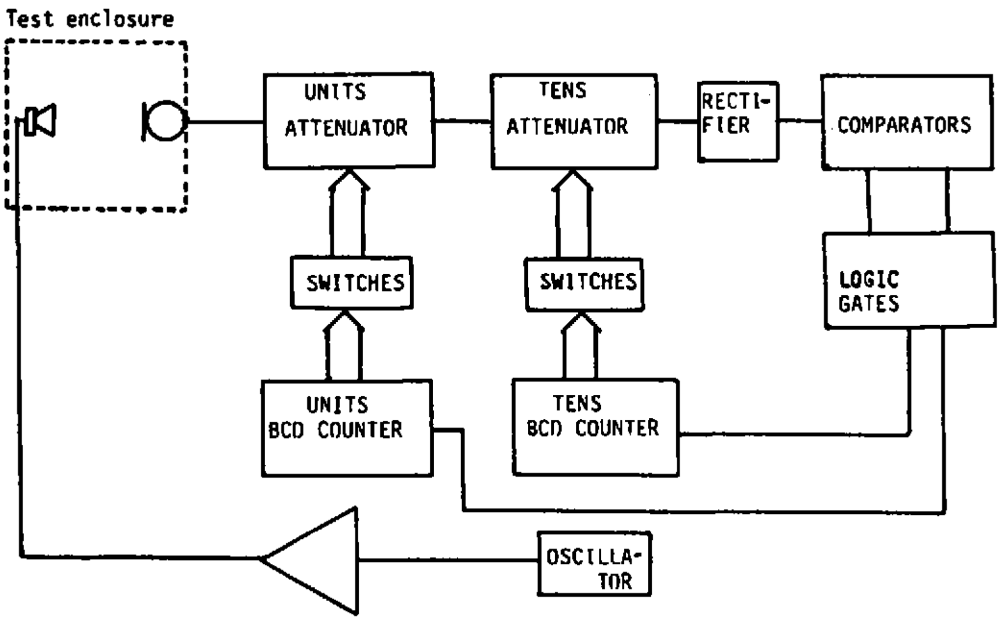
To attract a manufacturer it bacame clear we would have to simplif y the design of the tester to make production easier. A completely new design was produced but reluctantly we had to abandon the idea of displaying the complete hearing aid frequency response curve.

The new version of the tester had a conventional numeric display to give a read out of sound pressure level from the hearing aid, at any of nine frequencies.

The production of the nine test tones was by analogue circuits and the tones were presented to the aid under test through a loudspeaker in a small test enclosure. The frequency and sound pressure levels of tones were selectable by the user over the ranges 200 to 5KHZ and 60db to 90db spl respectively. As the test tone was not continuously swept over the range, compressor microphone and feedback circuits were not required to maintain a constant level of sound in the test enclosure. Rather, compensation to produce uniform SPL for the nine frequencies was built into the hardware. This did mean that the system was tailored to a particlar test enclosure. The compressor arrangement of RNID I allowed use with any reasonable output transducer, and so potentially the system could be used for more than just hearing aid testing. This versatility was another feature which had to be discarded to produce the simplified RNID II.

Figure 2 shows a simplified block diagram system. The output signal from the measuring microphone is amplified and fed through an attenuator chain to a RMS rectifier. The DC output of this stage is then fed to a comparator. If the signal voltage is lower or higher than the comparator voltage the appropriate gates cause the BCD counters to increment up or down as required.

Figure 2. RNID II system, single frequency numeric display



When the counters increment the attenuator values change in 1 dB steps either up or down as appropriate until the signal voltage equals the comparator voltage. The number of increments clocked by the two counters is shown on the display as a measurement of hearing output.

The range of this sytem was 100db ie. 49db to 149db spl, suitable for the most powerful hearing aids.

Being a digitally controlled system with a conventional display it was more stable and generally more accurate than the previous analogue version.

Six samples of this second system were produced. Four went into Blue Peter Audiology vans, and remained in use for more than five years. A manufacturer did take up the design (on the strength of the Blue Peter order) but discontinued manufacture after producing two more systems. The device was relatively expensive for a very small company, which needed orders in hand to fund production. But effective sales required systems in hand, so the orders did not materialise.

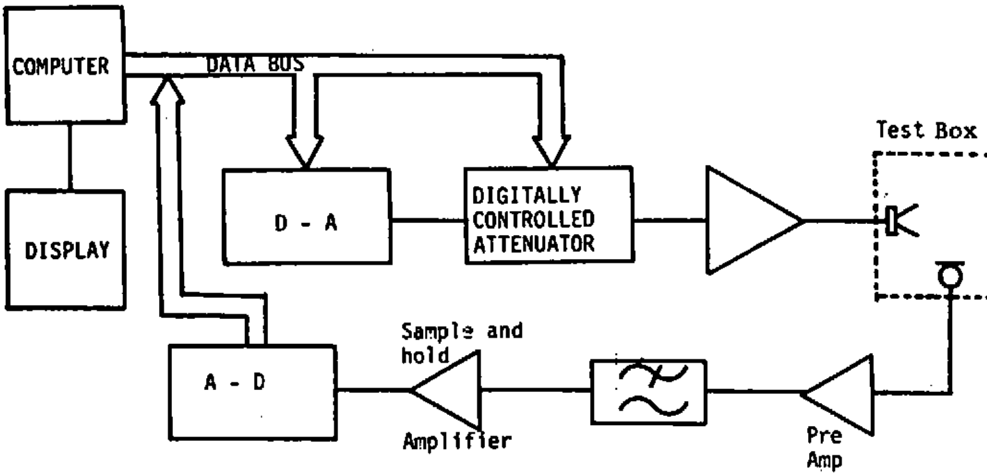
RNID III: MICROCOMPUTER-BASED ALL-DIGITAL SYSTEM

In 1980 the RNID began to use microprocessors in their designs, beginning with a computer-based speech display. The speech display proved the value of attaching a special device (consisting mainly of analogue circuitry for audio processing) onto a commercially-available microcomputer. This approach was simpler than building an entire instrument, whether or not a microprocessor was incorporated.

It was decided in the design of RNID III to aim for generality, to build as few limitations into the device as possible. Hence an all-digital approach was used: the signals were produced by digital-to-analogue (D-A) conversion. The response was brought back into the computer by A-D conversion, where signal averaging and filtering were performed, and finally calculation of RMS power. The block diagram is shown in Figure 3. Use of a microcomputer brought a large increase in capability. A frequency response for 36 frequencies was measured and displayed on the computer monitor. The memory and graphics of the computer allowed much more detail to be observed than for previous systems. Multiple traces could be displayed, to directly compare effects of changes in input or controls. Also results could now be printed, or saved on discette for statistical analysis.

The Apple II computer was used, as it was at that time the cheapest available system with good graphics. The hardware was produced on a single board, fitting inside the Apple. Thus all that was required externally were leads to a test enclosure and pickup. This system was taken up by a manufacturer and a printed-circuit board was produced. Several prototype systems were sold during licensing negotiations, but ultimately discussions between the company, the RNID and British Technology Group (who had supported the RNID development) foundered and no further systems were produced.

Figure 3. RNID III all-digital microcomputer test system



During licensing discussions the UK experienced a major change in educational policy, and virtually all schools acquired a microcomputer, with 85% buying the Acorn BBC product. A conversion box to attach the Apple hearing aid tester card to the BBC was built, and software rewritten.

The main problem with RNID III was that generality was bought at the price of speed. It was in principle very powerful, capable of everything from hearing aid testing to evoked response audiometry. In practice, it took six minutes to measure a frequency response. This was a major drawback.

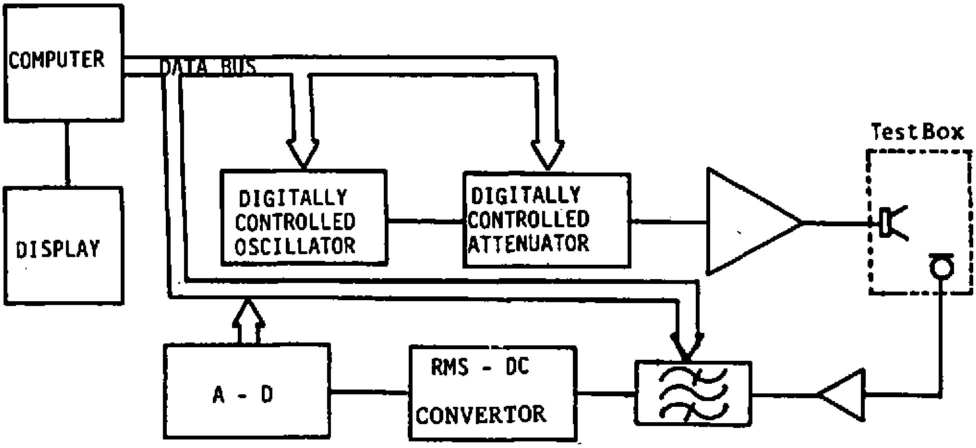
At this point Cirrus became aware of the RNID project, and began to work together on a new version.

RNID IV: COMPUTER PLUS ANALOGUE CIRCUITS

The work on the RNID III unit led to the decision to choose a new technique for a production instrument. Firstly, the BBC computer was chosen for all further development. The BBC had comprehensive input/output facilities and was almost universally available in British schools. Furthermore, if a dedicated unit was required, the circuit functions of the BBC could be duplicated using commercially available hardware. Finally, the huge amount of available software for the BBC together with the powerful BASIC interpreter built in, made the BBC an obvious choice.

The second major change was the use of analogue signal generation, filtering and power measurement (Figure 4). Switched-capacitor filter chips were used as a digitally-controlled oscillator and bandpass filter. This arrangement ensured that the filter would not be mistuned from the frequency being tested. Power was measured (after suitable digitally controlled gain/attenuation) in an RMS-to-DC convertor. Operation was now much less computer intensive, and the speed was increased by a factor of 60. The sacrifice was generality of signal generation, and no signal averaging.

Figure 4. RNID IV system with microcomputer control of analogue signal generation and measurement circuits



RNID and Cirrus both required that any unit should meet the relevant standards and be within the budget of the potential users. Cirrus wished to have a unit which had such accessories and options as would appeal to the largest commercial market. This appeal could be enhanced by careful use of colour graphics for display, together with a menu driven approach which would lend itself to easy translation to languages other than English.

The basic mechanical unit contains the power amplifier, chamber and microphone while a further unit contains all the drive circuitry attached to the computer. The first five prototypes were made using a case exactly matching the BBC computer. The acoustic chamber was moulded from fibre glass to be a pleasing and yet practical shape.

The chamber had a reasonable isolation, but no real attempt was made to achieve high levels of attenuation as this was not perceived as a user requirement, particularly as the size and weight of a unit having really good attenuation would significantly increase the cost, and limit portability.

The actual performance of the latest unit is still being evaluated, in particular with respect to international requirements. Comments have been received from Australia and New Zealand and it is hoped that all significant comments will be received before the intended production date of Winter 1986.

The design of the new unit encountered unusual problems. Firstly the communication problems of a joint design with the partners 400km apart cannot be underestimated. Secondly technical problems relating to the signal generation became apparent during the design. The original switched-capacitor oscillator is adequate for testing acoustic devices, but not for the electrical testing of electronic circuitry as the clocking frequency of the synthesised sine wave can well be in the pass band. A further unit has been developed for pure sine generation.

A final problem is the choice of computer. The original BBC-B is not available worldwide, reducing commercial prospects for the unit. Also it is no longer being produced. The replacement Master series is software but not fully hardware compatible.

The inevitable conclusion is that choosing a particular computer, however attractive in specification, leads to risks in terms of availability and that choosing a system which can run on many processors would have been a better choice.

CONCLUSIONS

The availability of inexpensive microcomputers has a significant influence on acoustic testing. The computer can generate frequencies, control level, select the receiver gain and finally read and plot the results. Having done all this, the data can be filed, processed or even corrected all by software. All of this can be used by someone not totally skilled in acoustics. Thus to a large extent the accurate test and calibration of relatively complex hearing aids can be made a routine and automatic task.

REFERENCES

[1] Data available from Technical Dept, RNID.