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SPECIALISED TEST EQUIPMENT FOR AMBISONIC SOUND SYSTEMS

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1. INTRODUCTION

As with all complex systems, a large Ambisonic rig can take a considerable amount of time to set up and debug. This paper examines the scale of the problem, looks at some of the difficulties that experience in the field has shown are likely to crop up and suggests that a single test unit designed to spot this set of common problems is far better than an ad hoc collection of off-the-shelf test gear.

2 ASSESSMENT OF THE SCALE OF THE PROBLEM

Whilst setting up Ambisonic systems does not in essence present any truly novel problems, it is never the less true that the number of variables involved - and hence the number of things that can go wrong - is significantly larger than is encountered in conventional stereo systems. Taking the case of a stereo system with 2 input channels, 2 amplifiers, 2 speaker lines and 2 speakers (fig 1a) we can say that there are 8 possible components which could give trouble. The total number of combinations of fault conditions in any system of n components is given by

$$\sum_{r=0}^{r=n} {}^{n}C_{r}$$

where the combination ${}^{n}C_{r}$

is given by; $\frac{n!}{(n-r)!r!}$

Fig 1a Stereo System

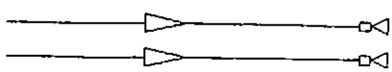
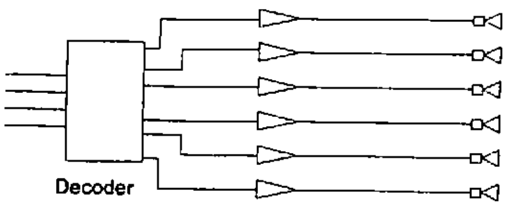


Fig 1b B Format System



So, for the stereo case of fig 1a with 8 possible fault sources there are 263 different ways it can go wrong. For a bare minimum periphonic system, if the amps are integrated with the decoder as a single 'black box' the total number of separate fault sources is 23, giving over 8 million different fault combinations! Although a significant number of these combinations involve 'self cancelling' faults such as double polarity changes and despite that fact with skill, knowledge and the appropriate successive approximation type of fault finding approach the task can be made manageable, anything which might make it easier would be of great assistance.
Although normal test gear can, of course, be pressed into use, by designing a unit with judicious choice of functions we can greatly ease the task of setting up an Ambisonic system. In order to design a unit for this purpose it is necessary to examine the processes involved in setting up Ambisonic systems. These can be divided into objective and subjective processes. We will only consider here the setting up of periphonic systems using programmable decoders such as reported elsewhere in these proceedings.

3. NECESSARY CRITERIA FOR CORRECT SYSTEM FUNCTION

3.1. Objective Criteria to be Met.

3.1.1Accurate measurement of actual Loudspeaker position.

3.1.2.Output channel (Amplifier & Loudspeaker) sound levels and polarities.

3.1.3.Amplitude and polarity of individual B Format components at each decoder output.

3.1.4.Consistent unit to unit loudspeaker behaviour.

3.1.5.Correct decoder output to output channel assignment.

3.2. Subjective Criteria

3.2.1. Image Quality.

4. FAULT FINDING

4.1
Taking the subjective category first, there is currently no practical way of measuring this, other than by ear. It should be stressed, however, that it is important to provide a means of distinguishing between poor images caused by system faults and those inherent in the nature of the sound being projected. We are all familiar with the problems of locating which phone is ringing when several similar ones are present, especially if they have electronic sounders.
The same sort of problem occurs with many other sounds. It is all too easy to blame poor localisation on system faults when the problem is actually the sound itself. This can most easily be avoided by providing a means for sending the sound to only one speaker at a time and alternating that with a panned sound reproduce Ambisonically at a location near, but not at, the solo speaker location. If both methods produce poorly localised sound, it can be assumed that the problem is inherent in either the sound source or the acoustic space, both of which are usually out of the control of the engineer setting up the system.
If there is a relatively good image during single speaker reproduction, then the problem is in the Ambisonic system itself. The quality of image generated by a properly set up Ambisonic system makes it

very easy to spot when something is wrong. It is, however, difficult to identify the exact nature of the fault aurally.

4.2. Objective Fault Finding.
As indicated above, the ears are often the best means of telling when something is wrong but instrumentation is almost essential for finding out what it is. Experience has taught us that there are two common problems which are difficult, or at least time consuming, to track down. These are polarity errors in one of the output channels and the loss of a B format component.

4.2.1 Polarity Errors. Errors in the polarity of an output channel are particularly disruptive for centralised listeners and are very difficult to locate in rigs with large numbers of speakers. The technique of simply swapping the polarity of one speaker, as is normal practise in stereo systems, is impractical since there may be more than one channel in error. It is therefore necessary to provide electronic means for checking output channel polarity. If multi-unit speakers are being used. If at all possible, narrow band polarity, or 'polarity phase' should be checked in each individual unit pass band since it is not unknown for these to be wired inconsistently.

4.2.2 Output channel amplitude errors.
Within reasonable limits, and for larger rigs, amplitude errors are not as important as polarity errors, especially if the output level is lower than the average. This is a result of the fact that if a sufficiently large number of speakers are in use, lower output from one results in elements of the image near that speaker becoming a little more diffuse whilst high than average output levels 'pull' image components into the offending speaker, making it stand out and this is much more offensive.

4.2.3. Decoder performance. In order to test decoder operation, it is necessary to provide a source of known B-format signals with which to feed the decoder and a means of measuring each output of the decoder. Once again, both amplitude and polarity are important. If the B-format test signals are injected right at the start of the chain - all our Ambisonic control equipment is daisy chainable - it is possible to use this to check for the loss or misbehaviour of B-format components anywhere in the chain. This kind of fault is one of the most difficult faults to diagnose in a complex 3D sound image, unless you are already familiar with how it should sound. The ability to generate a known single sound source image is essential for both measurements and aural tests.

4.2.4. Loudspeaker Position Determination.This is usually accomplished with old fashioned tape measures, although we are looking into electronic means for measuring this. Although with large rigs, precise positioning is not important as in smaller ones, the problem of ensuring that you have entered the correct set of co-ordinates for each speaker increases. Until fully automated measurement systems come on line, the ability to turn on known individual speaker drive outputs, (as can be done with the York programmable Ambisonic decoders' software) so that a check can be carried out to see if the expected speaker produces sound is essential.

5. AMBISONIC TEST BOX.

With all the above to do, the amount of test gear, leads etc. that have to be carried is not insignificant. Furthermore, the chances of errors in test proceedures when using ad-hoc collections of test equipment increase. In order to address these problems, we have designed a unified test box (fig 2) which provides most of these functions.

AMBISONIC TEST EQUIPMENT

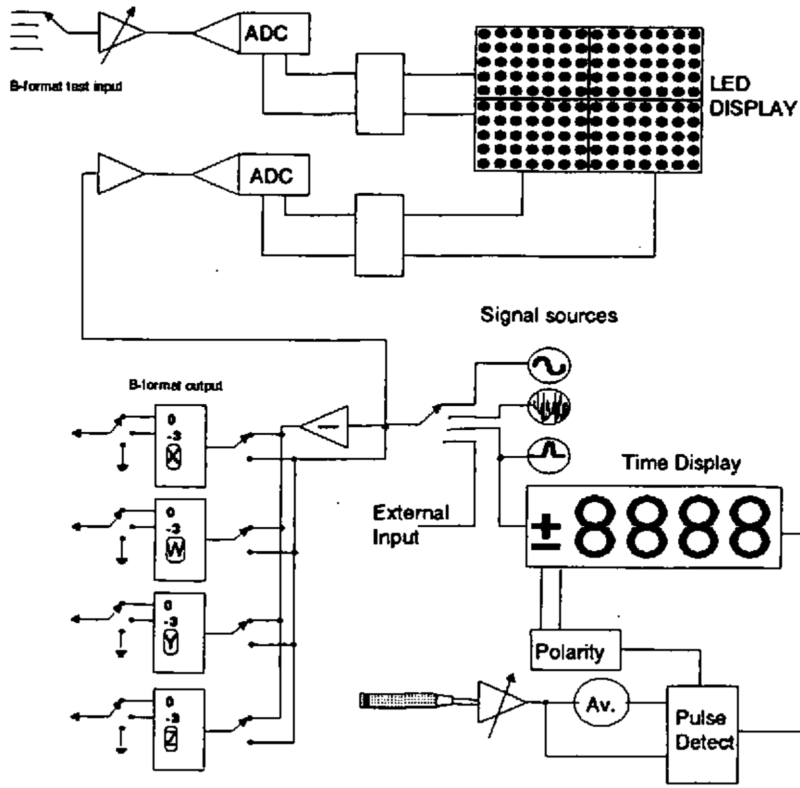


Fig 2

5.1 Test Functions.
The box has three main functional blocks. An LED dot matrix vectorscope style display, a versatile B format signal source, and a pulse generator based time measurement system.

5.1.1 Vectorscope. This is used for checking polarity of individual B format components, usually with respect to the omnidirectional, W, component. Since it is only necessary to see whether signals have the same or opposite polarity and that there are no gross errors in levels etc., a fairly coarse display proved satisfactory. Four 5 x 7 dot matrix displays are combined to form a 10 x 14 display panel. the incoming signals are digitised with high speed six bit ADC's which feed standard bar graph decoder drivers. One axis is always driven by the test signal, the other can be selected from one of four inputs which are allocated either to the four components of a B Format signal or to the outputs on a decoder. A fifth input is provided so that a test probe may be used.

5.1.2 Signal Source. The B format signal source has the signals for all four channels switch selectable, both for polarity and for levels of 0, -3dB and off. Thus, all of the horizontal cardinal points can be generated plus due up/due down (Table 1) and also all the test signal combinations to check out a UHJ encoder (Table 2). The test source can be either on the internal oscillator, an internal PSRB noise

Horizontal Position	Angle	X	Pol.	W	Pol.	Y	Pol.	Z
Due Front	0°	0	+	-3	+	off		off
Left Front	45°	-3	+	-3	+	-3	+	off
Due Left	90°	off		-3	+	0	+	off
Left Back	135°	-3	-	-3	+	-3	+	off
Due Back	180°	0	-	-3	+	off		off
Right Back	225°	-3	-	-3	+	-3	-	off
Due Right	270°	off		-3	+	0	-	off
Right Front	315°	-3	+	-3	+	-3	-	off

Table 1

B-format tests
levels in dB

Inputs			Outputs	
X	W	Y	Left	Right
x	-	-	-5.3	-5.3
-	x	-	+0.0	+0.0
-	-	x	-3.8	-3.8
x	x	-	+1.1	+1.1
x	-	x	-0.3	-0.3
-	x	x	+4.2	-7.1
x	x	x	+5.0	-5.8

Table 2

UHJ Encoder Tests

Inputs marked 'x' are fed 0 dBu, all others are off, output levels in dBu

generator, the internal pulse generator or an external signal. Internal sources are set at OdBu.

5.1.3 Pulse Generator/Time Measurement System. This consists of a unipolar pulse generator which feeds out through the B format output connection and a microphone input amp/pulse detector. These in turn drive a counter chip driving an LCD display, which displays the delay time between pulse output and acoustic return to the microphone from the speaker under test. By placing the microphone in the nominal centre of the speaker rig, it is possible to detect any significant deviations from the spherical (or circular in a horizontal rig). The pulse detector is sensitive to both positive and negative edges and it stops the counter on which ever arrives first. Input level controls and a slow averaging detector feeding the reference input of the detector reduce false triggering. Additional logic detects which edge triggers the detector, giving an indication of polarity, although this is somewhat unreliable for centrally mounted measurement microphones. For phase checking, it is better to take the microphone right up to the speaker. On large rigs it makes it a lot easier if a radio mic is used, but beware of diversity receivers since they can introduce polarity anomalies when switching from one receiver to another. Judicious positioning of the microphone close to each driver in a multidriver speaker system can provide some of the functions of a narrow band polarity phase detection system without the cost.

6. CONCLUSIONS

Large Ambisonic speaker rigs are complex to set up, but by intergrating frequently used test functions in one package, the task can be considerably eased.