

SOUND SYSTEM DESIGN AND THE DIGITAL DOMAIN

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1 INTRODUCTION

Some 14 years after the first stadium sound system design using digital signal processing and fibre optic cable for signal distribution at Wembley stadium, the ability to design in anything but the digital domain is all but gone. However, the problem remains one of knowledge and experience. There are still a lot of Luddites who would never operate a digital mixing desk. There are some who still say that that digital equipment cannot be used in a life safety application, other say that it does not comply with Standards. Is there any truth in these allegations? This paper sets out to de-mystify digital system design and provide answers to those allegations.

2 THE BACKGROUND

The compact disc (CD) was probably the most important breakthrough in the world of audio. It was not a variation on a theme like the compact cassette, it was a true pioneering development. The fact that it was taken up with such great enthusiasm by the public made the prices drop to levels which were affordable. The term "CD quality" was coined and for the first time it was common for the general public to be provided with high quality and come to expect it as a norm, rather than a rich man's preserve.

Alongside the audio CD there was the CD ROM which was a digital recording of computer data. The two mediums were exactly the same in terms of their method of recording, it was just the data protocols which were different. Like so much in the world of electronics, the computer industry was driving a different industry and the latter was trying to stay independent. As we now realise, convergence between IT, audio and video is not only sensible, it was inevitable from the start.

Nevertheless, even today, there are those who refuse to accept it for what it is, a mature and stable medium. There are those who cannot understand the advantages because to really work with digital, one has to look at it from a slightly different viewpoint.

3 ROCK N ROLL

Back in 1990 the old Wembley stadium was fitted out with a sound system of professional grade with digital signal processing and fibre optic signal distribution to 12 rack locations around the building. It was the first 'house' sound system to be used by pop concert sound engineers as augmentation of the stage sound system.

3.1 The Analogue Mindset

Many of those same sound engineers are the very ones who refuse to use digital mixing consoles even today. Indeed, the console manufacturers went to great lengths to emulate analogue desks with their (literally) thousands of knobs and switches, just to make the engineer feel at home. The

engineers would refuse to use a desk if they could not find the mid-high EQ level knob on channel 95 whether blindfolded or not.

3.2 The Digital Mindset

The digital way of doing it is that the mid-high EQ level is the same knob for all channels. One merely has to select channel 95 first. But wait! Why do you need to know that it is channel 95? Whereas in analogue you plugged it up and annotated it with a marker pen, in digital one plugs it up and types in "Kylie vocals" or "Hi Hat", you then assign it to a sub-group, and possibly a song cue address. That way, during rehearsal, you have selected only the channels you need for that song, grouped up the drum kit and back line accordingly, and that leaves you with about 4 faders to control, each of which has got a name above the fader.

On the next song, the arrangement is different, but again you only have to operate the faders which are important. If something happens and you need to get something to the front, you hit 'open' and the screen will show you the names of the channels, you select (touchscreen?) the one you want and hit 'solo'. Now you have one channel's worth of all the control you need and it is right next to where you are standing, whereas in analogue it could be right up the other end of 4 metre long desk.

Also, the monitor mixer has all the same channels as the FOH mixer, all the same facilities, there are no splitters to worry about, the method of using it is different because it is the monitor mix, but should the need ever arise, the FOH mixer could be switched to control the monitor mix (albeit temporarily) and vice versa.

4 RADIO AND TV

These days, the radio station doesn't just have a mixer, it has a touchscreen. The touchscreen is 'scheduled' to change source, complete with ducking fading and cutting, so that it becomes an intuitive control surface which the DJ can use without having to have a producer.

In fact, the only time faders may be used is when the live sources are the microphone for the DJ, the co-presenter and any guests or discussion panel, but even these can be configured as an automatic mix.

It is not just the mixing and control which is in the digital domain. The 'records' the adverts, the trailers, and just about every other form of non-live source is stored on hard disk. The aforementioned scheduler is merely selecting a filename in a computer.

The same applies in television for some shows, and especially the transmission controller. However, the TV studio is more akin to the stage application where the scenes are set up previously and brought in as cues.

Again, in TV whereas the video tape machines used to "roll", now the pictures are stored on hard disc and can be called up by any studio or edit suite.

Broadcast stations today are more of a high speed computer network than anything else. To achieve that speed, the connection medium is usually fibre optic.

5 DIGITAL SIGNAL PROCESSORS

5.1 Thinking Digital

In analogue terms a circuit might consist of a microphone, going into a bass roll-off filter, then into some sort of mixing or routing, then into a room equaliser and then off into a crossover before going out to the amplifiers and loudspeaker units. To a DSP, all this equalisation boils down to two EQ parameters, one for each output.

On the other hand, a multi-delay system may seem to need a lot of RAM to produce, but in DSP it can be optimised by blocks of delay in series.

5.2 Different Network Configurations

In permanent installations there are many variations on the theme of DSPs. Some systems are centralised and the amount of DSP required is physically plugged into the mother board, rather like loading up RAM in a computer (but more expensive). Other systems have DSP engine not only in their own box, but also in the hubs on the network. This DSP can be utilised either directly by the local connection or across the network, so effectively you are sending a bunch of signals over the network, processing them and sending them back to where they started to be used at the output stages.

6 THE INTEGRITY OF SOUND SYSTEMS

We were recently asked to help a client in Canary Wharf to find the real source of the failure of the Voice Alarm (VA) system to broadcast an intelligible live announcement.

6.1 When is a Voice Alarm System Compliant?

The client repeated the mantra from the Fire Detection and Alarm company the the fact that messages generated using the digital sound store were intelligible meant that the system was compliant with the Standards and hence there was no reason why the building could not be occupied.

The fact that the reason why the Client had realised that his 5 year old system was faulty was that 18 months ago (after September 11th.) they decided that they should practice for emergencies other than fire, and that no pre-recorded messages were really suitable, so they had to be live announcements. It was then that they realised than the system was faulty, and to date no-one had come up with a solution.

The "compliance" in the true sense of the word must be questioned under these circumstances. Indeed it just serves to highlight that a system which is ONLY used in emergencies, rather than every day, is actually very likely to be deficient when required. In fact, as proven many times, systems are certified as compliant by the installers when they have actually never worked, let alone complied. There are many excuses for this scenario, including not being allowed to test, or being thrown off site because the building is late and the client wants beneficial use etc., but in reality it begs the question 'what is the point of the Standard when there are no policemen?'.

Recent attempts to improve the relevant Standards for Voice Alarm such that it is performance based rather than product based have met with great resistance. The concept which should be adopted is that the equipment which is readily available and used across the spectrum of the whole audio industry in huge quantities is likely to have a known MTBF, or at least an industry accepted reputation, and that a performance based standard will allow this, and new technology, to be used PROVIDED that the system designer uses reasonable skill and care.

The resistance to this approach stems from people who are involved in manufacture. They manufacture to product Standards. The result is an old technology base which is over-priced, produced in low volumes, often over-engineered in the areas which are not critical, and even so, installed in a manner which does not work properly, if at all. This is a cottage industry using the Standards for trade protection. The result is the scenario described here i.e.: life safety compromised by a cottage industry with Standards bigots.

6.2 Day and Night

It transpired that the tests carried out at night showed that the live broadcasts were *generally* (but not totally) intelligible. However, the monthly daytime tests (during operational hours) was almost completely unintelligible.

It was allegedly a combination of distortion and a Norman Collier comedy act of intermittent signals.

So why the difference between day and night?

6.3 Configuration

The system was divided into 5 equipment locations, one (grandly titled) Fire Control and Command centre containing the routing selection, the microphone and the fault monitoring display, and four sets of equipment racks spread amongst the 20 or so floors of this high rise building. Each of the equipment rack sets comprised amplifiers, a set of digital sound stores, a token ring network decoder, and a network hub. This means that the selection of which message is broadcast, and to which amplifier channel(s) is controlled by a "processor". Now BE5839-8 states that in the event of the failure of a "processor", it should be by-passed. Now the original meaning of this clause was that the "processor" was a PLC which controlled only routing and therefore having by-passed it, the system should be able to broadcast an 'all call'.

In this system, the live announcement was also carried on the token ring network. Now if that audio signal was distorted and intermittent, one has to question the integrity of the control system which was required to carry out routing and signal initiation. The fact that a digital network could not be by-passed meant that it was non-compliant.

So lets now consider this token ring network. How is it configured? It is carried on fireproof copper cables which are not screened, and the cable itself is not actually designed to carry digital signals. The fact that low speed data may be fairly tolerant of its transmission medium is not the same thing as a high density audio signal over such a network medium.

It is then discovered that due to the steel construction of the building, it is difficult to get PMRs (Private Mobile Radio – walkie-talkies) or mobile phones to work. As a result, a leaky feeder aerial system has been installed up adjacent risers to the VA network cables. Also, mobile phone repeater access points are also installed.

So, when considering what is the difference between night and day? The answer (or at least part of it) is RF spectrum traffic!!

6.4 The Cure

It is not the forte of a cottage industry to design systems for performance standards. Whilst all the indicators are the colour required by the Standards, the control panel is huge and custom built, the wiring was neat and tidy at one time in its life, the circuit boards have no indication as to what they do, what connections are for, and there is nothing in the O&M manuals which gives the slightest hint of what it does or how it does it. This is a 'professional' system for life safety which doubtless cost a

fortune, it is fault monitored to the nth degree, runs from batteries when the mains fails (one hopes) and yet it produces a fault indication when the huge front panel is opened because one of the switches strains against the next door equipment. Compliant? Why bother when it is unintelligible.

The solution is as follows: Firstly, eliminate the front end faults and check for distortion in the analogue domain. This means taking the telephone handset (which serves as the microphone for the live announcements) and making sure that it bridges correctly into the pre-amp feeding the A to D converter, and that it (via a compressor/limiter if necessary) does not overload the A to D converter.

Having established an intelligible signal in the analogue domain, any further distortion and the interference can be attributed to the digital domain. The copper cables can be bypassed by means of fibre optic cables and off the shelf boxes to convert fibre to Ethernet (on copper) and Ethernet to token ring, thus leaving the original system immune from interference.

It is too early to say if the medicine worked, but it just goes to show that it is not necessarily digital or fibre optics which are "non-compliant" as some in the fire industry would say, but the cottage industry which diverts good engineering practice into potentially fatally flawed system design.

The systems which we designed for buildings as far back as 1990 used fibre optics and digital, and these were used in life safety applications, but crucially, they were used operationally every day and therefore everyone could hear for themselves that the result was intelligible. The other big difference was that these designs used equipment which was on the open market, for which there were published and available circuit and equipment manuals. These, together with some decent system schematics made the systems serviceable by any competent engineer.

7 CONCLUSION

Sound system design is like most professions, in the hands of bigots and Luddites, the result is of dubious quality and demonstrably poor value for money. The appeasement of these people by using analogue layouts with digital innards is wrong because it again costs too much and does not address the advantages of thinking with a mindset of digital signals. The answer is to embrace the digital domain, both in terms of audio signals and computer networks. So much so, that the convergence of these two technologies has already happened. It is unavoidable therefore that those who do not embrace it will be left behind. The next concept to embrace is the totally digital communication networks for vision as well as sound, because that too arrived some time ago.