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IMPROVED INTEGRITY MONITORING IN DIGITAL SOUND SYSTEMS

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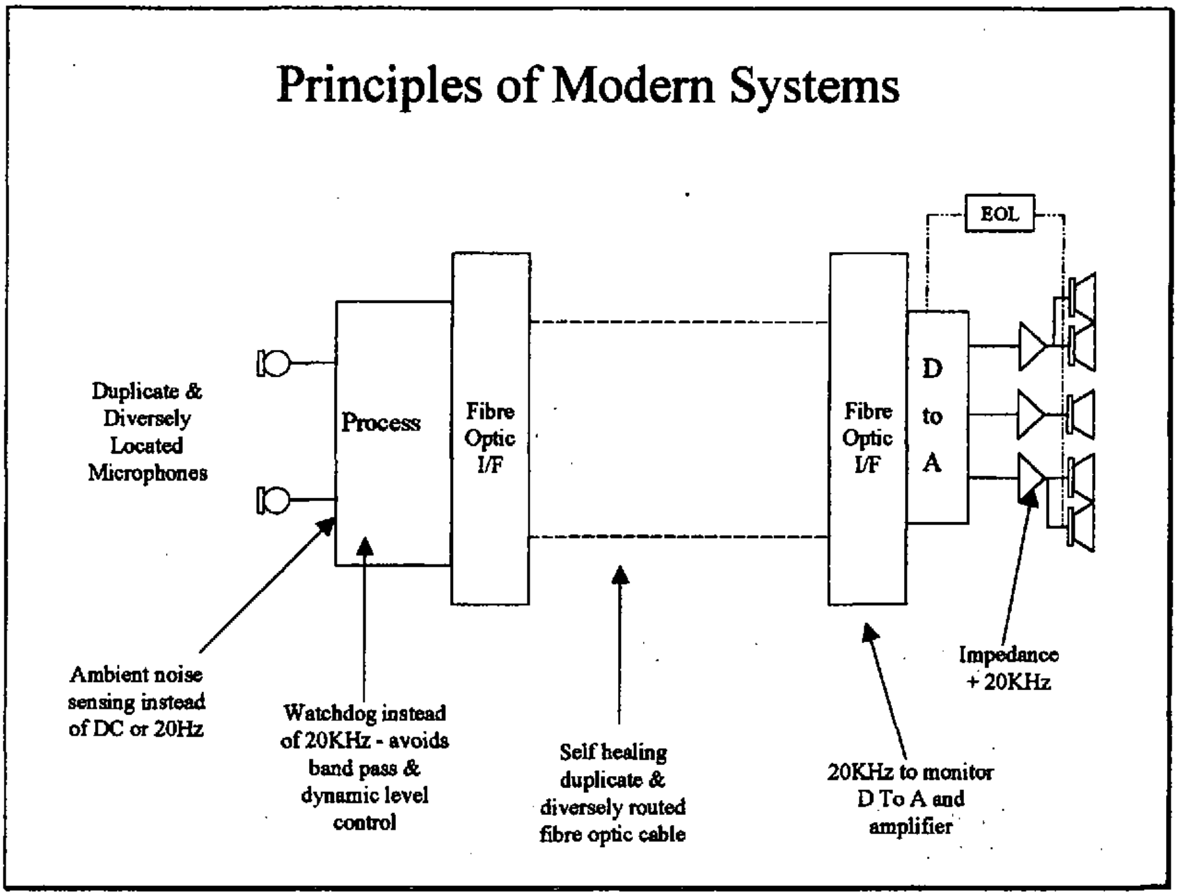
1. INTRODUCTION

The requirement to monitor the integrity of life safety systems was first brought into the Standards in BS5839 in 1980, and more specifically monitoring of sound systems in BS7443 in 1991.

The degree of monitoring and what methods are acceptable is extremely woolly and undefined for the most part in BS5839. Some may consider that the schematic diagram in BS7443 speaks better than a thousand words. Certainly the unnecessary prescriptiveness of parts of BS5839 Part 8 and BS60849 in 1999 show that Standards must be as future-proof as possible and yet not be trade protectionist.



2. MICROPHONE MONITORING

Traditionally the integrity of the capsule of the microphone was monitored either by a 20Hz tone (which was subsequently filtered out) or by a d.c. offset; neither of these approaches is flawed, provided that the engineering is designed properly.

By locating the detector circuitry within the signal processing equipment ("Control and Indicating" equipment as described by BS5839 Part 4) the integrity of the microphone cable is also monitored.

In digital systems, a chain of signal processing parallel to the audio path can be incorporated which monitors the background noise at very low levels and thus the integrity is being checked.

It is not to say that this could not be achieved by analogue equipment or by a stand-alone noise gate, but when it is a cheap addition to a DSP programme it becomes a financial benefit as well.

3. MONITORING SIGNAL PROCESSING

Traditionally there was little more than a 2 band tone control and possibly a bass roll-off filter in analogue life safety sound systems and the quality of sound was dubious. Since the imposition of objective intelligibility measurement methods, the system designer now needs to be a lot more than a seller of black boxes.

Processing in the form of graphic equalisers, delay line, automatic level controllers, dynamic notch filters (feedback controllers) were rarely included because of the need to modify a mains powered standard product to work off 24v. The fact that nowadays UPS is cost effective means that all the expense of 24v circuitry can be done away with.

Nevertheless, the signal processing and amplification were traditionally monitored by a 20kHz signal. The tone detectors had a window of about 15% tolerance. This meant that dynamic processors like automatic level controllers could not be used, or were excluded from the monitoring process.

Other types of signal processing caused problems at the tone detector, such as a crossover for a 3 way loudspeaker system where the mid band would not pass the 20kHz – what is the point of monitoring the H.F. if the voice region is handled by the M.F.. However not many sound designs had this problem since there was rarely a 2 way loudspeaker used, let alone a 3 way!

The programmable DSP has a checksum watchdog programme which closes a contact in the event of failure thus the signal processing is monitored. The A to D converter is automatically checked by the noise sensing part of the signal processing used for microphone integrity monitoring (as previously described) and also programmed to appear as normally open contacts and/or direct connection to the fault monitoring computer.

The integrity of the D to A has to be monitored. Probably the easiest way is to inject a 20kHz tone just prior to the D to A and then monitor it either inside or after the amplifier.

4. MONITORING DISTRIBUTED SYSTEMS

In large buildings it may be necessary or preferable to distribute the amplifiers to be closer to the loudspeakers they serve.

In analogue terms, this would be at line level and the cable would need to be protected from fire and mechanical damage by means of conduit or trunking, thus adding cost.

In digital terms, the use of twisted pair copper cable would have the same disadvantage as analogue. However the use of fibre optic cable has the great advantage of being inherently fire proof and immune to interference.

In order to avoid a single point of failure, the fibre optic cables would be duplicated and diversely routed. The hubs at any central location would also be duplicated.

The use of a transmission protocol sufficiently close to a computer protocol means that the equipment is not too expensive and has proven reliability. This applies to the Cobranet protocol from Peavey which is close to Ethernet.

Other DSP manufacturers such as BSS Soundweb and Klotz Vadis have designed their hardware for fibre optic connection since they prefer to use bespoke protocols.

In either case, spare fibre cores can be usefully employed to run the fault monitoring network and/or control network which are standard computer based applications.

5. MONITORING AMPLIFIERS

Traditionally, the designer of amplifiers for constant voltage loudspeaker systems was more concerned with running off 24v d.c. rails so as to have a direct maintained secondary power source in the form of trickle charged batteries. Thus the expense of the charging circuitry and the limitation of headroom due to the relatively low voltage of the rails. Often the latter limitation manifested itself in form of inconsistent output power over the complete spectrum – something which the system designer was often blissfully unaware – thus producing a system which could hardly be considered to reproduce music (sometimes referred to as "Musak").

So if one releases the designer from the shackles of 24v rails by using a UPS (which is, after all, just trickle charged batteries inverted up to a.c. mains voltage) then the spectrum of design principles is enlarged. In the case of a system designer, the range of products is increased and the costs tumble.

However, one facet which the designer of any amplifier must take into account, is the ability of the amplifier design to handle the reactance of a loudspeaker circuit wired in MICC (mineral insulated copper cable).

So if the system designer opts for the cheaper "bare" amplifier, how is the amplifier to be monitored? The 20kHz tone used for the D to A converter surveillance is a valid form of monitoring the amplifier.

However, amplifier manufacturers have been designing monitoring circuits to run over standard computer protocols so that the user can check all sorts of parameters and also control basic functions. Some even have a small DSP built in so that it can handle some signal processing.

The application of interest here is that overheating is a latent problem and it can be flagged early as a "non-critical" fault, especially if the sound system is being used solely as a voice alarm system where it is in quiescent mode for 99% of its life.

A system running at full power for ½ hour or 3 hours during an evacuation should not cause overheating if designed properly. There is evidence of poor planning where the batteries are mounted in the bottom of a rack, the amplifiers are stacked one on top of another with no ventilation strips, and then the racks are located in a sealed room. Thus the board temperature rises from 40^0 in quiescent to 55^0c under load and the amplifiers soon give out.

Perhaps a more interesting feature of "Intelligent" amplifiers is that they can monitor the impedance of the load. If that strays from the norm, it is likely that there is a fault. Like the tone detection method, the window is only about 15%. This translates into a single loudspeaker failure will be detected in a circuit of a maximum of 6 or 7 loudspeakers. Low impedance loads are, of course, much easier to detect with impedance monitoring, and the threshold of detection rises to a theoretical level of 1 in 16.

The great advantage of impedance monitoring is that it does not require the third core of the cable for the return signal as in "end of line" monitoring. This is a considerable cost saving in large buildings, and even more so when retrospectively converting an existing system into a life safety system as part of a refurbishment programme.

6. SUPPORT EQUIPMENT

The use of a UPS means that its status is usually available as an RS232 or RS485 signal which can be fed directly into the fault monitoring computer.

The Standards do not require the fault monitor computer or control computers and associated hardware to be monitored, although it is not particularly difficult to achieve. However there is a danger of a "who polices the police" syndrome of over-engineering.

The fault monitoring does not need to be a "computer" per se. There are still some good old fashioned relay driven types of "lamp and key" fault indicators out there.

However, recently, some products have emerged which serve as universal input devices which give a fault status output – either as a stand alone unit, or as a distributed system over a network. The reference above to "universal input" means that the fault status can appear as a closing contact (with or without voltage) or a data stream such as RS232, RS485 etc., or even more obscure protocols. These are then stripped of any unnecessary information and combined into a standard protocol which is then provided as light emitting indicators, alpha-numeric messages, text on a computer screen, messages from a digital sound store, or maybe just a very annoying siren.

Whatever the method of human interface, the result must be that the human is warned of a fault in the sound system, thus ensuring that the 3rd Guiding Principle of the Risk Assessment [1] is achieved – proving that for an acoustic input, there can be an acoustic output when required.

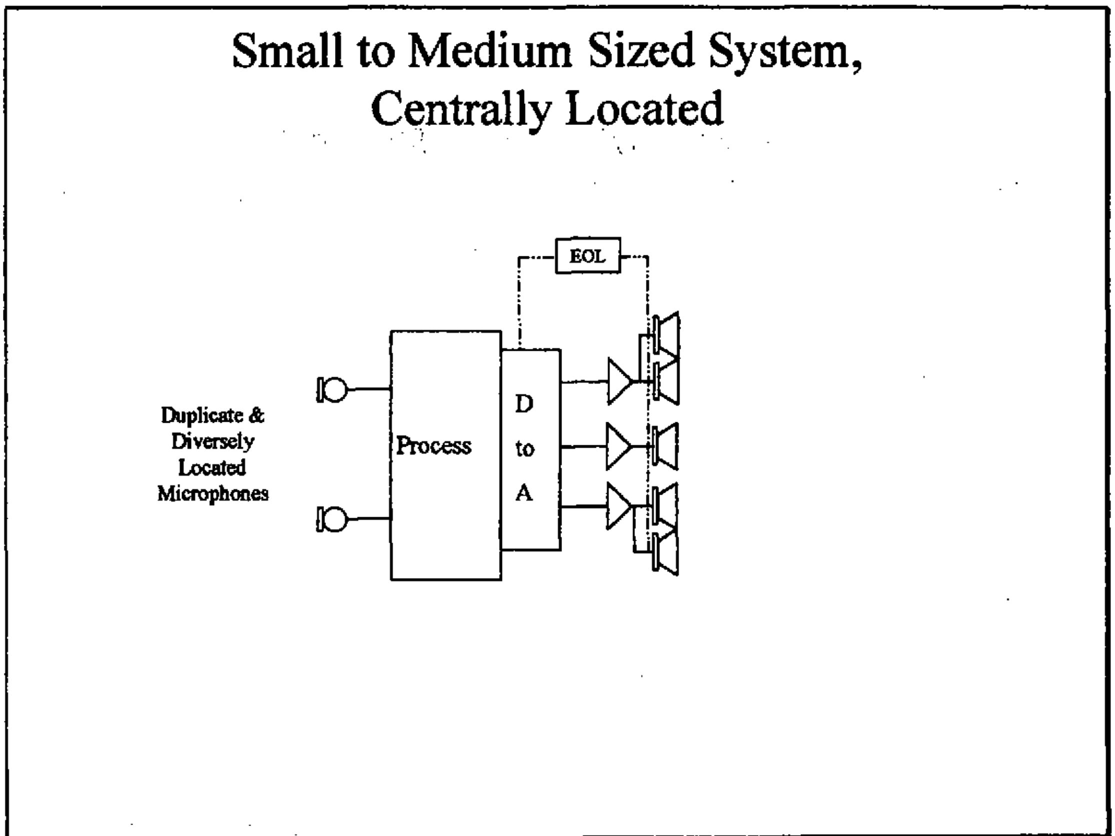
7. CONCLUSION

In conclusion it can be seen that digital sound systems, and intelligent amplifiers connected over fibre optic cables can achieve an improved level of integrity monitoring for the same (or may be lower) cost.

The degree of system monitoring is improved and the additional benefit is that it is quicker and easier to maintain.

8. REFERENCES

[1] S. P. Jones, *Sound Systems for Life Safety and the need for Risk Assessment*,. Proc IOA Vol 21 pt 8 1999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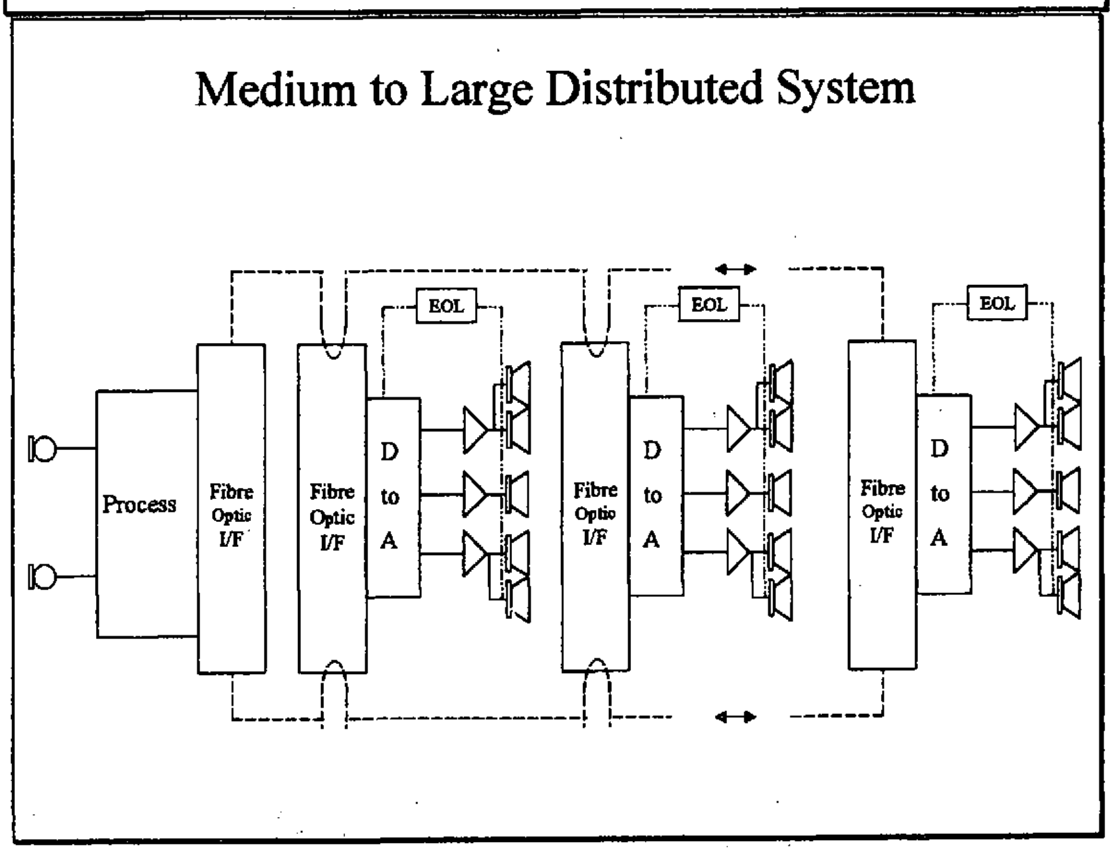
Medium to Large Distributed System
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