

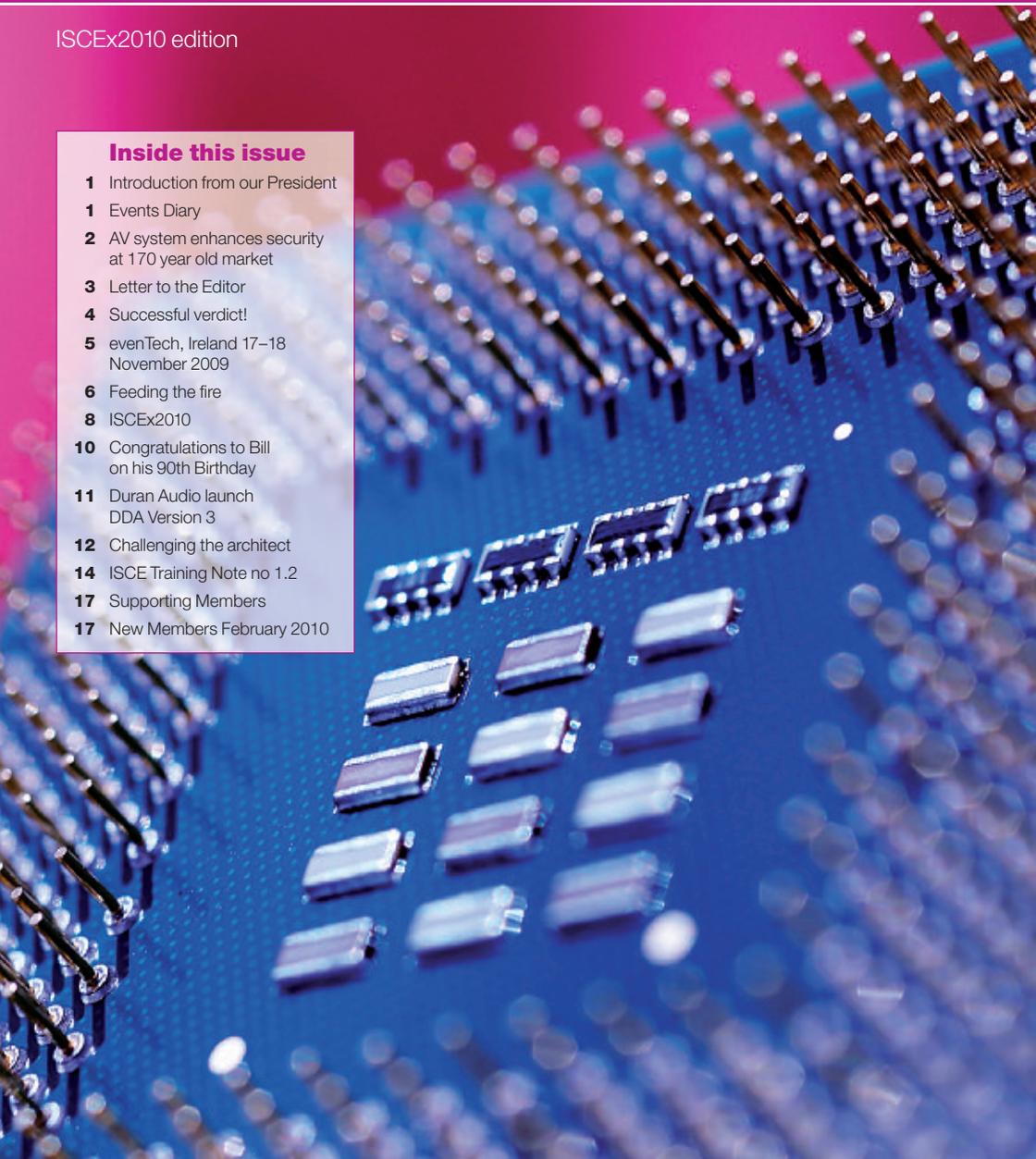
The magazine of the
Institute of Sound and
Communications Engineers
February 2010

ISCE

ISCEx2010 edition

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Introduction from our President

Terry Baldwin *ComplnstSCE*



The road to hell is paved with good intentions! Last month I announced it was my intention to visit all supporting members over the next three years, which is my term of office.

Then came the snow. Twice I have had to cancel

visits to a number of companies and to those, I apologise.

Don't count your chickens, I will be back, but the United Kingdom has taught me not to rush into things. I'm leaving it now until the spring when you'll see me chugging into your drive waving the document that says 'How best can we help!'

A couple of you have asked if I would visit them on a given date for anniversary reasons. "We're 15 years old on the whatever day, come and share a drink with us." You know me. Not one to shy away from a command. Don't particularly like the 'share a drink' bit, but I'm sure we'll overcome. If you fit into that category, please let me know and I will endeavour to call in.

Progress is being made regarding Certification and Training and the next meeting is being held in early February. Again, this had to be re-arranged due to the weather. It is clear that many so-called engineers are out there commissioning equipment and are just not qualified. I trust that is not the case with any of our members. However, once complete, it should give

2010 Register of Members goes live

The 2010 Register is now on the ISCE website. It incorporates all the changes received before 31 January. Future updates will be made quarterly.

a level platform for us all to provide the opportunity for training and the gaining of certification to prove it.

Andy Scott and his noble committee are heading this one, so our thanks go to them.

Many members are flying off to Holland as I write. Integrated Systems Europe (ISE) 2010 takes place at the Amsterdam RAI, between 2-4 February 2010 and we are all hoping it will prove well worthwhile. It is very much an international exhibition, specialising in the integration of systems, both audio and visual. I'm certain that by the time this journal is published, the exhibition will be over, but it will give me the opportunity to précis the show in detail in our next edition.

Our own exhibition and seminar day, ISCEEx2010 is being held on 2 March in Watford and we are pleased to see so many existing and new exhibitors joining us this year. There is an excellent mix of seminars and I hope you have already booked your place.

It just leaves me to wish you all a belated greeting for the year ahead and trust that for all our members it will be a healthy one. ♦

Events Diary

2 March 2010
ISCEEx2010
Watford, UK

24-27 March 2010
Prolight & Sound
Germany

12-15 April 2010
NAB
USA

18-20 April 2010
PALME
United Arab Emirates

18-20 April 2010
PLASA Focus
Leeds, UK

21-23 May 2010
AES 128th Convention
London, UK

9-11 June 2010
InfoComm 10
USA

16-17 June 2010
ABTT 2010

10-14 September 2010
IBC2010
The Netherlands

12-15 September 2010
PLASA 2010
London, UK

4-7 October 2010
AES 129
USA

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AV system enhances security at 170 year old market

Customers at the 170 year old Granger Market in the centre of Newcastle upon Tyne will now be able to hear crisp security messages thanks to a state-of-the-art audio system installed by Blaydon Communications Ltd.

Managers at the Grade 1 listed building specified a system that would deliver a clear message to each individual aisle in the market, to the open Arcade section and to the whole market as required.

Since the building is listed, the Blaydon Communications team could not drill holes or alter the recently refurbished Victorian fixtures and fittings. To add to the pressure, the installation had to be completed during a single Sunday when the market was closed.

Blaydon Communications Director Paul Dougherty said: "Aside from the restrictions on working in a listed building the challenge with the Grainger Market was the huge void between the top of the stalls and the ribbed roof.

"We designed a system using TOA speaker systems that directs sound to the people in the market but does not 'excite' the air in the void above, which would cause distortion and reverberation.

"This resulted in clear reception for security messages in each aisle and in the open Arcade area. Now security staff can play digitally pre-recorded messages or communicate with shoppers in any section of the market."

The system allows security staff to address customers with health and safety or security announcements in a single aisle or throughout the market. In addition, there are recorded messages



Newcastle City Market Manager Heather Thurlaway,
Blaydon Communications Managing Director Paul Dougherty

reminding customers of the no smoking policy, a fire alarm drill, closing time and an evacuation message.

Market Manager Heather Thurlaway said: "It's great that we have the new sound system for our refurbished market. The old one was limping along and didn't work in some areas. Now our security staff can communicate with the whole market or just one aisle." ♦

Letter to the Editor: well done ISCE

Ref page 10–11 of September magazine

David Futers *MInstSCE*

As some of you may know, I come from the old school; starting my career with valves, building my first amplifier as a school project and then getting into the big stuff with KT66's. If you know what one of those is, you're like me, OLD.

I have always tried to keep up with the changes in technology and had to learn from magazines, *Wireless World*, a circuit for a mixer using a 741 op amp I remember so well and used as a theatre 8 channel mixer for many years without fault. Many other projects built on vero board using state-of-the-art components – well they were state-of-the-art in my days. Don't tell me you have never used a red spot transistor.

I never had the opportunity to attend a formal training course and there was no internet to glean information from. It was all learnt from books and magazines and of course, fellow sound engineers.

I always remember my days in theatres, when we struggled with feedback and wished every seat had headphones; too loud at the front, not loud enough in the back stalls. I wish I had been a theatre lighting guy and put a candle on the stage and everyone thinks he is a master. Put up a mic and everyone in the cast insists on standing on the other side of the stage, demanding you put the fader up until it screams.

I also received lots of help and advice from many in the trade, staff from Millbank, Harry Greenaway from TOA, Dave Chapman from Blaydon Comms and Signet, the list is endless and they all helped with advice freely. I survived, but would I have done so today in such an advanced market. I am not so sure, or at least not without taking more formal training.

It was great to see in the September issue on pages 10 and 11, the training courses being run by the ISCE, teaching the new breed of sound engineers about the actual technology of the subject. Yes, we had heard about decibels and could talk about dB, but that was just to confuse the customer. How could they argue with someone who talked about dB things. It was even nice to see one of our local engineers participating. Yes, he knows who he is.



I remember my time well in the trade and I do hope that I did a decent job, but I am sure that with more technical training I would have been able to do much better. I did, eventually, get some training by taking an Open University degree and I would recommend that to any of our aspiring engineers as another route to get technical qualifications.

Well done ISCE. It has taken a number of years, but you have got there in the end. I do wish I had put more effort into the organisation than I have. Well, I have just paid my subs each year, but congratulations to the stalwarts for taking a sound acorn and growing it to a sound oak. The task is not completed but it is getting closer by every year that passes. ♦

Buying copies of BSI Standards

John Woodgate FInstSCE

Your County Council Library Service may have a facility for read-only access to most BSI standards (including BS ENs). If so, and you have or get a library ticket, you can read a standard, either at the library or on your own computer and see whether you want to buy it. On your own computer, you can only read, nothing else.

Successful verdict!

SigNET's integrity voice alarm brings order to Isleworth courts

SigNET's powerful Integrity voice alarm/public address system has been installed at a prestigious Crown Court building in the Borough of Hounslow in London as part of a multi-million pound expansion project.

The existing building in Isleworth has been extended to accommodate six new Crown Courts, a development which will increase custodial capacity and the infrastructure necessary for the courts to function. The ambitious project called for a complete overhaul of the life-safety equipment and SigNET's Integrity was approved for the site.

Integrity combines a voice alarm system with a high specification public address system and is incredibly flexible and is fully compliant with BS 5839 Part 8 and BS 7827.

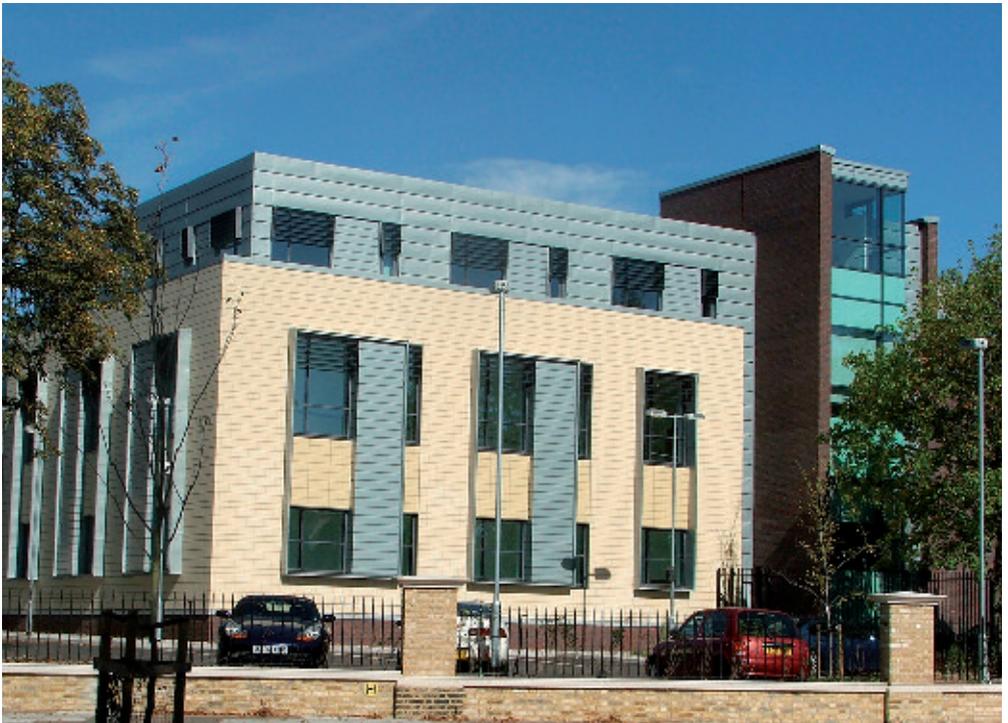
Mark Latawski, of Caldera Fire & Security, the BAFE SP203 accredited company that installed the system said: "The project involved the installation of a new fire

alarm system and a combined integrity voice alarm/public address system, within the existing Isleworth Crown Courts and a newly constructed ground to second floor extension.

"The installation took place over a 13-month period, leaving the existing manual conventional fire alarm system with bells and separate public address system functional throughout. We chose Integrity due the fact that it is a flexible yet a very powerful voice alarm."

A rotation of courts and facilities allowed the site to function continuously throughout the 'new build' and refurbishment programme. Mark said:

"Two thirds of the installation was carried out in a fully functioning Crown Court and our engineers maintained an excellent working relationship with our client, the builder and Her Majesty's Court Services, to bring the project to a highly successful conclusion for all parties." ♦



evenTech, Ireland 17–18 November 2009

Andy Tinsey *TechInstSCE*

It's early on a Monday morning. I'm at Holyhead Harbour and it's blowing a gale at around Force 9. The rain is nearly horizontal off the Irish Sea and I am waiting in my car to board a ferry to Dun Laoghaire. The wait gives me ample opportunity to reflect on the wisdom of volunteering to man the ISCE stand when I could have been enjoying a leisurely retirement at home. It had seemed a good idea back in April at Plasa Focus when Scattered Media offered us the stand!

After a rough crossing, I arrive in one piece at the exhibition centre. RDS is a large show ground and exhibition complex just outside the city, hall 3 being architecturally a rather nice old building, reminiscent of those at Harrogate. We had a small stand, but as can be seen from the photos, it looked rather attractive.

I checked in to the hotel and, in the true spirit of the audio industry, made for the bar, only to find several stalwarts of our industry already well established there. It was a most convivial evening!



From left; David Mongey, Terry Baldwin and Andy Tinsey

The exhibition is similar to PLASA but on a smaller scale. Most of the exhibitors were entertainment/conference related. Commercial sound companies were mostly to be found on the Sound Productions stand. The number of attendees was not great, but those we did speak to were very interested in the ISCE and what we had to offer. A recurring theme was our involvement in training and the feasibility of running courses in Ireland, something the Council might like to consider, as backing would certainly be available from the distributors on both sides of the border.

On the second day, David Mongey, of Mongey Communications (supporting members from Co Kildare), presented the ISCE seminar entitled *Belt, Braces and Bailing Twine* where he shared his experiences in planning for field events in Ireland. It was a very interesting and well attended seminar. He also did an excellent job selling the ISCE!

My return trip was no less eventful with gales and high seas, the highlight being the ship lurching violently, accompanied by a huge crash of glass. According to the Holyhead local paper, the crash was £10,000 worth of booze and perfume falling off the shelves in the shop! ♦



David Mongey of Mongey Communications

Feeding the fire

David Read *MInstSCE TMIET Audeval*

As we know it's a funny old world and sometimes, the seemingly smallest issues can become hugely contentious – especially when on construction sites. Unfortunately, it's not always a laughing matter.

I have had many heated and noisy exchanges in regard to the low voltage feed to voice alarm systems. Yes, that's right – that one bit of cable from a distribution board to the local isolator of a VA has nearly got me beaten up on several occasions.

But why would that be? Well, I recently came across this comment on a forum: '...but on the current job the main contractors are telling us that the supply should never be red in case someone cuts through it thinking its a fire alarm cable at 24V not 230V'

What? Well that goes some way to explain it – apparently there are some people that consider cutting live fire alarm cables is acceptable or that cable sheath colour is a suitable substitution for a safe system of work.

The above comment was posted by an electrician. Therefore we are not educating our related trades of the specific requirements and are failing in regard to BS 5839-8: 2008 Sec 6 (exchange of information). The demarcation in regard to this issue is distorted due to the fact that the LV feed needs to comply to both BS 7671: 2008, in terms of electrical safety, and BS 5839-8: 2008 in terms of integrity and fire safety.

The standard arguments

I am going to assume that electricians know their own standards well enough and focus on some of the most commonly overlooked issues.

The first misconceptions that need to be removed are: the LV feed is not part of the VA, and, the LV feed to a VA is no different to the supply to anything else.

The first point is clarified quite simply by BS 5839-8: 2008 Sec 26.1 that states: 'The mains supply is regarded as an integral part of the voice alarm system...'. Job done! But don't abdicate responsibility just yet Mr Sparkie as BS 7671 states 'The regulations are intended to be applied to electrical installations generally but, in certain cases, they may need to be supplemented by... other British Standards' and, guess what, BS 5839 is listed in

Regulation 101 of BS 7671 and it is also cross-referenced in Regulation 560.10.

Now the above has been established let's look at why the VA LV feed is different from other circuits. Often overlooked is that BS 5839-8: Sec 26.1 requires the feed to be dedicated to the VA (although sharing it with the fire detection system is acceptable) and the circuit should be derived from a point in the electrical system close to the main incoming isolating device.

This is normally challenged by the electrical contractor on the grounds that the VA racks are generally placed in a switch/equipment room with a local distribution board therefore they can be fed from that – which is an easier pull of a smaller cable for them – and cite the classic argument, 'non-compliant due to lack of local isolation'.

The 'lack of local isolation' excuse is negated by the requirement to have a double pole isolator (not a 13A switched fused spur!) local to the VA. This allows for lock-off (under the control of the VA technician), for the purposes of commissioning and maintenance, to be achieved without any access to LV distribution switchgear.

This local distribution board could be many units downstream from the main incoming and although this would be acceptable, if all units en route were labelled accordingly, it does leave the VA more vulnerable to an uncontrolled mains power down.

There is naturally a containment route between the areas as they both have a need for fire detection so the only additional containment is at the end break-out points. Like all parts of the electrical installation, this containment should comply in regard to loading, support spacing and conduit bends and where cable tray or basket is used then the LV feed should be secured with metal cable ties at appropriate places to ensure the circuits integrity in the case of fire.

Similarly, if direct clipping is used anywhere in the run then suitable P clips and fixing methods, rather than plastic hammer clips, should be used. Plastic containment should not be used.

Being that the LV feed is part of the VA it should not be contained in the same cable management system compartment as other LV circuits but in a separate,

non-combustible, compartment or system for fire detection and voice alarm. It should be a screened cable so as to maintain segregation between LV and ELV circuits (BS 5839-8: Sec 27.14). And, yes, without question it has to be a fire resisting cable (BS 5839-8: Sec 27.2), not singles or standard twin and earth.

It should be noted that, wherever the LV feed is sourced from, the VA racks should have a suitably rated connection to the switch/equipment room local earth bar.

Colourful language

The only times I have heard grown men argue about colours on site is in regard to football shirts or cables. There is an opinion within electrical circles that the LV feed to the VA should be the same colour as other LV supply cables. I have actually heard some people say it should be orange (not as mad as it first seems as I believe that this is derived from either the fact that MICC comes in orange or from BS 1710*). But it should be the same colour as the rest of the VA cabling (BS 5839-8:Sec 27.16), which will generally be red.

Final circuit

The LV feed to a VA, along with its containment, route, fire blocking, protective device (and earthing arrangements), isolating device should be designed, installed and tested by electrical engineers and electricians. They should be advised on all relevant requirements, as early as possible in contractual negotiations so they can price and quote accordingly. The relevant certificates for the circuit(s) should be passed to the organisations responsible for certifying the voice alarm system so they can be incorporated into the information packages.

So, let the sparkies know... and don't even get me started on labelling of isolators/protection devices or circuit segregation! ♦

* BS 1710: 1984 Specification for identification of pipelines and services (not BS EN 1710!).

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Running alongside the exhibition is a programme of seminars. We have four excellent speakers, covering subjects that are sure to interest you. All seminars will be commercially neutral, although demonstrations may naturally use the speakers' own products.

10.00am

The Regulatory Reform Order (Fire Safety) 2005 **Andy Scott MInstSCE, SigNET (AC) Ltd**

The Regulatory Reform Order (Fire Safety) 2005 sounds very dull but it has far-reaching effects for those involved in fire safety such as installers of voice alarm systems. Andy Scott will explain what the RRO is, how it works, what people's responsibilities are and finally, examples of successful prosecutions resulting in fines in excess of £450K and terms of imprisonment for breaches of fire safety law.

11.00am

The pitfalls of project managing, from specification to handover – relating to VA contracting **Rupert Moon MInstSCE, Consultant**

A light-hearted look at the process of project delivery and what can (and often does) go wrong along the way. Using purely hypothetical examples, this seminar is intended to provoke lively discussions, exploring potential solutions to the seemingly unavoidable issues encountered when balancing the needs of all relevant contractual parties.

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2.30pm

Switching amplifier topologies – exposing the sub classes!

Anthony Smith MAES MInstSCE, Current Thinking Ltd

Power amplifiers fall into classes based on output topology and much is known about the linear classes A through C. However, there is still much mystery about switching amplifiers, all of which fall into the ubiquitous class D.

The advent of new silicon, faster devices and DSP has led to a flurry of new terms to baffle and confuse, but are they all that complex?

Anthony will discuss the basics of class D amplifiers, from the simple to the exotic, and will provide a bottom up summary of their benefits and pitfalls.

3.50pm

Digital audio networking – which technology?

James Kennedy, Peavey Electronics Ltd

With the arrival of many new digital audio networking technologies within the Industry in recent times, we now, as the consumer, supplier and installer, have so many viable options available to us for transporting digital audio over standard IEEE802.3 ethernet networks.

We take a look and compare the three leading technologies in the field to ascertain their make-up and place in the market. Will one of these emerge as an unofficial standard? What does the future hold?

Exhibitors so far

Ampetronic Ltd

Ateis UK Ltd

Baldwin Boxall

BC Technology Ltd

Cloud Electronics Ltd

Communication Technology

Current Thinking Ltd

DNH World-wide

Duran Audio

Fuzion plc

Ikon AVS Ltd

Institute of Acoustics

Rackz

RCF

RK Sound Engineering

RW Salt Communications

Sennheiser UK Ltd

Signet (AC) Ltd

Shuttlesound

TOA Corporation UK Ltd

Voice Perfect Ltd



Congratulations to Bill on his 90th Birthday

Bill Preedy, a long-serving ISCE member, was joined by family and friends at the RAF Club in Piccadilly, London, last November to celebrate his 90th birthday.

Remarkably, Bill, who was awarded the Lifetime Achievement Award by the ISCE for his contribution to the sound industry, only retired 11 years ago when he had just turned 79. He had worked for Tannoy until he was 60.

Happily, Bill said he has been enjoying his golden years.

Volunteers needed

If you live in the Aylesbury area and are looking for something rewarding and worthwhile to do in your spare time, the Calibre Audio Library, are looking for volunteers.

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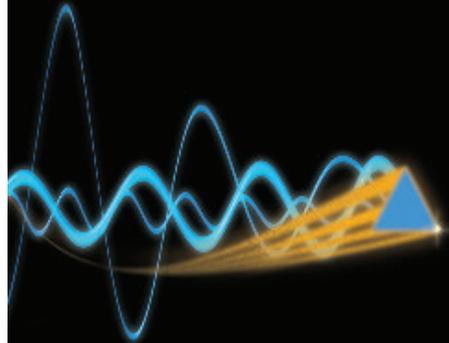
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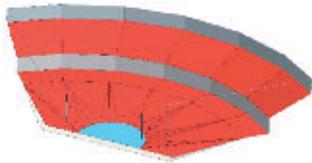
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LEADING THE WAY TO SAFETY

Duran Audio launch DDA Version 3

Duran Audio BV launched the latest version of their digital directivity analysis (DDA) software at ISE in Amsterdam.

Over the years, DDA has continued to develop and now offers a comprehensive range of features. Obviously, providing system designers with the ability to 'steer' or 'shape' the beam from their array is still at the heart of DDA but the software now offers the ability to model: direct sound, total SPL, direct to reverberant ratio, speech transmission index (STI), delay spread and receiver responses. All of which are calculated using a statistical



method. In addition, DDA also includes some unique functions, such as the delay optimiser, which calculates the optimum delay for each source (loudspeaker position) in order to align your system for the best possible intelligibility and/or clarity.

Version 3 sees many significant leaps forward. Probably the most significant new addition to the software is the introduction of 'materials'. Rather than users having to enter the reverberation time for their room manually in octave bands the RT can now be calculated from the defined materials within the model.

Users can choose to define which material is associated to each of the planes within the model. These materials can either be created by the user and stored in their DDA material library or the user could choose to use one of the existing defaults within DDA.

When importing models from CATT Acoustic (using the .CAD format) the absorption co-efficient for the materials are automatically imported into the DDA geometry, therefore saving valuable time.

DDA V3 also supports the more conventional AXYS ScopeG2 and SourceG2 product and the visual output of DDA has been greatly enhanced.

Once system designers are satisfied with their design and the investigation that they have carried out within the DDA environment, they can then choose to export their loudspeaker directivity data to CATT Acoustic, Odeon or EASE for further investigation.

DDA V3 shall be available to new and existing users from 1 February 2010 via download from the Duran Audio website www.duran-audio.com. ♦

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Challenging the architect

Peter Mapp *FInstSCE*

When I was recently asked the question “do we get the acoustics we deserve, rather than the acoustics we want by not challenging architects?”, the answer is most assuredly, yes we do. But what can be done to resolve the problem?

It is quite remarkable that no matter where I travel in the world and talk about sound system design, mention the word ‘architect’ and immediately the room is filled with groans, moans, gnashing of the teeth and rolling of the eyes. The architect, it would seem, is the natural enemy of the sound system designer and installer! But why is this the case? Surely we are all on the same side, trying to get the best sounding and looking project for the client that is achievable within the budget. In some cases this indeed is the situation, but sadly, it would seem (anecdotally at least) that such a utopian state occurs only in the minority of cases.

Interestingly, as I write this, I am returning from a design team meeting where I spent most of the day ‘sparring’ with the architect. On the other hand, I am also currently working on four other projects where I have been brought in to ‘sort out’ the acoustics and ensure that the client gets the acoustic environment he requires. In two of the cases it is a cooperative team effort, in the third, the architect patently doesn’t believe there is a problem and is of the opinion I don’t

know what I am talking about. Interestingly, I won the ‘battle’ by pointing out that, even if he didn’t believe me, the cost of providing the recommended 200 square metres of acoustic treatment paled into insignificance when compared to the liquidated damages that the client would sue for if the facility didn’t open on time – not to mention the quadruple cost and disruption that would ensue if they had to install the treatment (which they most certainly would have had to do), after handover. A no-brainer decision that everyone could see made sense.

So how should we deal with architects and try and ensure that we do get appropriate acoustic conditions?

Firstly, you need to be confident. Now that doesn’t mean arrogant or overbearing. But you need to have done your homework and know the likely scale of the problem and associated implications eg the VA system will not meet the BS intelligibility requirements if a suitable acoustic environment is not provided.

Secondly, don’t use jargon and technical terms unless absolutely necessary and don’t hide behind them and try and bamboozle the architect. Just explain in a straightforward manner the problem and the implications and don’t ask for an OTT solution. Carpeting the ceiling, no matter how acoustically desirable, is just not going to happen!



Thirdly, use our industry standards to your advantage. If it is a life safety system there are several standards that will need to be conformed to. Politely suggest that, if the architect cannot provide you with a suitable acoustic environment, he should take responsibility for the outcome. Liquidated damages or the failure to obtain an operating license can act as remarkably effective architectural laxatives.

Remember that architects are visual animals, so provide them with visual representations of the problem. For example, use coloured computer simulation plots and graphics. To vaguely say "it won't work" simply isn't good enough. You are dealing with a professional and you must be equally professional. You have to show them that there is some solid scientific or engineering foundation to your concerns. If you are not acoustically adept – then hire a consultant or persuade the client to hire one to provide an independent assessment.

I deal with architects almost every working day. Some are definitely 'on-side' and want to do the best they can – it has often never struck them that what they are doing may be having a huge adverse acoustic impact and when handled in the right way, they will try and agree a reasonable solution.

On the other hand there are those that care not a jot about acoustics or sound quality or those that understand the need for and demand high sound quality – but won't let it affect the visual appearance of their project. An example of that member of the species was my sparring partner today. How am I going to win my argument and achieve good intelligibility and sound quality?

Well in this case, I can see the point of what will be some simply stunning architecture and finishes and therefore, I am not going to pursue using acoustic treatment, unless I can think of an approach or product that is in keeping with the architecture. Instead my solution will be an electro-acoustic one. However, until I do the sums, I do not know if I can actually make it work. I suspect I can – I just need to negotiate the space for some fairly large loudspeakers. But now it becomes the architect's choice... I just need to gently steer him in the right direction – as one professional to another. ♦

EVC40

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- Protected Against Open and Short Circuit Conditions
- System Control for up to 160 Outstations
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The system is capable of driving up to 40 outstations per panel, and 4 panels can be networked together to give a total of 160 outstations.



Fire
Emergency
Telephone
Outstation



Emergency
Refuge
Outstation



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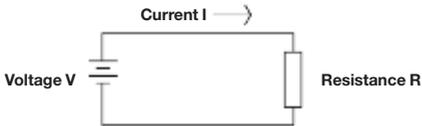
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Calculations part 2

John Woodgate *FirstSCE*

Down to the electronics!

With that background we can begin to tackle Ohm's Law. In words, the voltage V in a simple circuit is equal to the current I multiplied by the resistance R . (Ohm didn't write it like that, but then that was long ago.)



There are no actual numbers mentioned, so we can use the letters to write the equation that the words mean:

$$V = IR$$

V , I and R are called the 'terms' in the equation. Well, that's jolly good if we know the current and the resistance but we usually know the voltage, and probably the resistance rather than the current – we have to know two things to calculate the third. So, if we know V and R , how can we find I ?

Well, we could get rid of the R on the right side by dividing by it, and to keep the equation balanced we have to divide the left side by R as well:

$$\begin{aligned} V/R &= IR/R \\ &= I \end{aligned}$$

Bingo! We can, of course just turn the whole thing round to read $I = V/R$.

If we know the voltage and current, how do we find the resistance? How do we get rid of the I from the right side of $V = IR$? Just divide both sides by it, like we did before:

$$\begin{aligned} V/I &= IR/I \\ &= R \end{aligned}$$

There are only three ways of writing Ohm's Law and we have found all of them:

$$V = IR, V/R = I \text{ and } V/I = R.$$

Power

We found the resistance R by dividing the voltage V by the current I . If we multiply them instead, we get the power P :

$$P = VI$$

Just as for the Ohm's Law equations, there are two other versions of this one, which is called Joule's Law:

$$V = P/I \text{ and } I = P/V$$

For example, a 100 W lamp on 230 V mains draws a current of $100/230 = 0.44$ A. (Since the lamp is a pure resistance, it doesn't matter that the mains is AC, but if that is still a worry, assume that the lamp is on a 230 V DC supply.)

We can get another very useful set of equations by combining Ohm and Joule. These allow us to have power and resistance in the same equation, which saves a two-step calculation. We form these new equations by using Ohm's Law to write one of the terms in the Joule's law equation differently.

For example:

$$\begin{aligned} P &= VI \\ &= IR \times I \\ &= I^2R \end{aligned}$$

Clearly, there is a set of these:

$$P = V^2/R$$

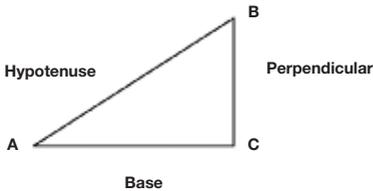
but the others need a bit more care:

$$\begin{aligned} V^2 &= PR, \text{ so } V = \sqrt{PR} \\ I^2 &= P/R, \text{ so } I = \sqrt{P/R} \end{aligned}$$

The brackets in \sqrt{PR} and $\sqrt{P/R}$ show that the square root operation applies to both P and R , not just P . (In proper mathematics books, this is shown by a line above the symbols, rather than brackets round them, but Word doesn't do that.)

Angles

Angles come into the picture when we consider AC circuits. The basis of the branch of mathematics called trigonometry is simply the angles in a right-angled triangle.



The angle at C is the right-angle (90 degrees), and we are interested in angle A. In particular, we are interested in the ratios of the lengths of the sides, because they don't change, however big or small the triangle is, provided the angles don't change.

The ratio Perpendicular/Hypotenuse (P/H) is called the **sine** of angle A, written **sinA**.

The ratio Base/ Hypotenuse(B/H) is called the **cosine** of angle A, written **cosA**.

The ratio Perpendicular/Base (P/B) is called the **tangent** of angle A, written **tanA**.

There are three more ratios, just those turned upside down, which is the same as saying '1 divided by' or 'the reciprocal'. Sine turned upside down becomes cosecant (cosec), 1 divided by a cosine is a secant (sec) and the reciprocal of tangent is cotangent (cot).

Now we saw that we could get extra useful equations by combining Joule's Law and Ohm's Law. Well, by combining the three simple 'trig' equations and adding in Pythagoras (which just says that $P^2 + B^2 = H^2$), we can get literally thousands of new equations, a fairly small number of which are actually useful!

What is the connection between the sine and the sine wave? Well, if we take the hypotenuse as a spoke in a wheel whose axle is at A, then the height of the tip of the hypotenuse above the base, which is the perpendicular P, traces out a sine wave as the wheel rotates. No surprise, because H is a fixed length, and P/H is the sine of angle A.

Logarithms and decibels

Remember $3^2 \times 3^3 = 3^5$? What that shows is that using indices we can convert multiplication, which can be difficult, into adding, which is easier. Even better, we can convert division, which is even more difficult, into subtraction. So, if we want to multiply 2 by 7, how can we do it? Well, we use to use books of 'log tables'. These gave the index of 10 that corresponded to any number we looked up (to four or seven places of decimals, usually). For example:

$$2 = 10^{0.3010} \text{ and } 7 = 10^{0.8450}$$

0.3010 is the logarithm of 2 (to base 10) and 0.8450 is the log of 7.

$$\text{So } 2 \times 7 = 10^{0.3010 + 0.8450} = 10^{1.1460}$$

and then we would look up 0.1460 in the 'antilog' section, find the value 1.399, and multiply it by 10 to take account of the leading '1' in '1.1460'. Now, of course we all have calculators. But logarithms are still in wide use, disguised as 'decibels'.

Apart from making big calculations easier (our 2×7 example is not very sensible, of course, and the method is much more useful for 2476×7794 , which would take much longer to multiply out), logarithms simplify the handling of very big and very small numbers, especially those with many digits. These days, we are becoming quite used to nanometres (10^{-9} metres) and terahertz (10^{12} Hz).

For audio signals, we may have less than 1 microvolt or 100 V or more, and the range of currents can be even bigger. Sounds, too, can be very quiet or very loud, and the range of quite common sound pressures covers a ratio of 100 000 to 1. In this case, not only do logarithms help with the arithmetic, but the human ear actually responds logarithmically to sound pressure over a very wide range. To double the subjective loudness of a sound, we have to increase the sound pressure by a ratio of just over 3, not 2.

Originally, the level in decibels of a given electrical (telephone) signal was defined in terms of the log of the ratio of two powers:

$$L_{\text{signal}} \text{ (in decibels)} = 10 \lg(P_{\text{signal}}/P_{\text{reference}})$$

'lg' is the modern symbol for 'log to base 10'

The $P_{\text{reference}}$ might be 1 watt or, more likely, 1 mW.

But there must always be a reference value:

a level of, say, '14 dB' with no reference stated or established by a standard or convention, is meaningless.

Soon, the formula was modified to be expressed in terms of voltage or current. Since $P = V^2/R$, or I^2R , and the log of the square of a number is twice the log of the number, the formula becomes (for voltages):

$$L_{\text{signal}} \text{ (in decibels)} = 20 \lg(V_{\text{signal}}/V_{\text{reference}})$$

Strictly, this should apply ONLY if the R term is the same value for both voltages, but, although many efforts were made to stop decibels being used where the R values are NOT the same, they were unsuccessful. Part of the reason is that different R values rarely cause mistakes in decibel calculations. But it IS necessary to remember that a mistake MIGHT occur. For example, an amplifier that takes an input of 1 V to produce an output of 100 V has a voltage gain of 40 dB. The load resistance is 100 Ω (making it a 100 W amplifier) and the input resistance is 10 kΩ. So the input power is $1^2/10^4 \text{ W} = 10^{-4} \text{ W}$ and the output is 10^2 W , giving a ratio of 10^6 and thus a power gain of 60 dB.

Exponential or scientific notation

To avoid having to write long numbers like 6285700000000 or 0.0000000001457, we split the number into two parts, the basic numerical part and the number of zeroes. The numerical part should always be written with one digit to the left of the decimal point, such as '1.113'. But in engineering, we sometimes don't do that. The number of zeroes is expressed as a power of 10, so that three zeroes is written as '× 10³'. The number '1113' can be written '1.113 × 10³'. That's not much of an advantage for '1113', but those two biggies come out as '6.2857 × 10¹²' and '1.457 × 10⁻¹⁰'. Note that 10⁻¹⁰ means 1/10¹⁰.

Metric prefixes

To avoid similar troubles when dealing with very small or very large numbers of units, we have prefixes that indicate multiples and subdivisions. In engineering, we normally only use multiples and subdivisions in steps of 1000.

Larger than the unit		Smaller than the unit	
kilo	k × 10 ³	milli	m × 10 ⁻³
mega	M × 10 ⁶	micro	μ × 10 ⁻⁶
giga	G × 10 ⁹	nano	n × 10 ⁻⁹
tera	T × 10 ¹²	pico	p × 10 ⁻¹²
peta	P × 10 ¹⁵	femto	f × 10 ⁻¹⁵
exa	E × 10 ¹⁸	atto	a × 10 ⁻¹⁸
zetta	Z × 10 ²¹	zepto	z × 10 ⁻²¹
yotta	Y × 10 ²⁴	yocto	y × 10 ⁻²⁴

It has been seriously suggested that future prefixes should be suitable versions of groucho/a, chico/a, harpo/a and gummo/a. Zeppo has lost out.

Symbols

Symbols for voltage, current etc., and for units of measurement are part of our technical language and should be used correctly, otherwise it may come out as teknikal langwidj.

Unit	Symbol	Unit	Symbol
ampere	A	centimetre	cm
decibel	dB	degree (plane angle)	°
farad	F	gauss	Gs
gram	g	henry	H
kilohertz	kHz	kilohm	kΩ
litre	L	megahertz	MHz
metre	m	microfarad	μF
micrometre	μm	microsecond	μs
nanofarad	nF	nanosecond	ns
ohm	Ω	pascal	Pa
picofarad	pF	second (time)	s (small!)
siemens	S (Capital!)	tesla	T

Further reading

Revise GCSE: Maths Letts, ISBN 1858059321 £9.99

Revise AS & A2: Maths Letts, Available from: 04/01/2005 ISBN 1843154773 £14.99

The Art of Electronics (2nd Ed.), P. Horowitz and Hill W., Cambridge University Press, ISBN 0 521 37095 7

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