DIGITAL MICROPHONES – AES42 AND ALL THAT

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AES42 Digital Microphones have been around for 10 years now and still many people seem to be in the dark about them and the advantages that are to be had. In these ten years the number of microphones has risen to over 40 from three major manufacturers (four if you include the measurement microphone from Gefell) and an increasing number of interfaces and recorders is becoming available. In this paper I will look at what AES42 is all about, I will discuss the advantages of digital microphones and look at the latest additions in AES42-2010 published in March this year.

INTRODUCTION

AES42 started in 2001 with the publication of the first version of the specification – AES42-2001. This was updated in 2006 with the publication of AES42-2006 and again early this year with the publication of AES42-2010.

At the end of the last century a few companies had started to produce digital microphones, but there was no standard and every one was different. At the AES European Convection in 1997 the various companies were urged to work together and the international standard, AES42, was the result.

WHY DIGITAL MICROPHONES?

The Analogue Chain

Let's start by looking at the traditional analogue chain and the bottlenecks involved.

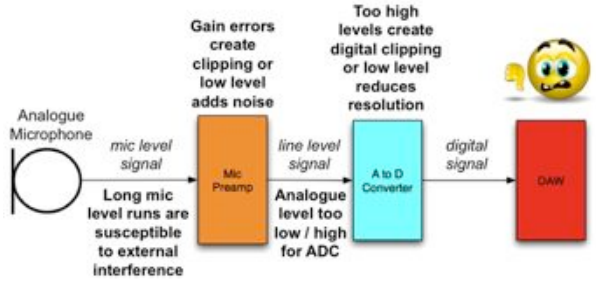

Figure 1: Analogue Bottlenecks

The analogue microphone is connected by cable to the pre-amplifier. This cable can be very long and can pick up noise and interference.

The pre-amplifier (mixer input) raises the level, adding a little noise in the analogue circuit and gain errors can create clipping or add extra noise if set too low. This is also another place where RF interference can enter the chain. The signal exits at line level on another cable that can also pick up RF interference. On to the ADC with the risk of clipping if the level is too high. You have to back-off to allow headroom, but too much and you reduce resolution.

The result – reduced dynamic range at best and distorted and clipped audio with external interference at worst.

By having the ADC inside the microphone all this is removed. Instantly making the signal immune from external RF interference along the chain, as the signal is in digits from the start.

Let's look at this in another way:-

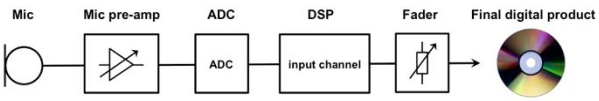

Figure 2: The Analogue Chain

We have, for example, an analogue microphone with a 130dB dynamic range.

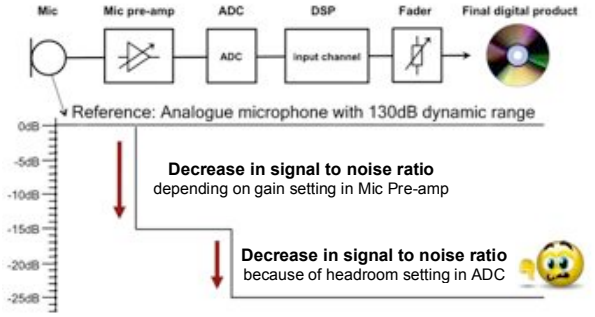

Figure 3: Decrease in s/n ratio

Firstly, you can never have a perfect signal chain as analogue circuits add noise – OK, it's small, but each extra stage adds its bit. Also, you have to raise the signal level of the microphone without raising it so much that the signal distorts, so you have to back-off a bit.

The same with the ADC, you must keep the signal under 0dBFS or the signal will clip – so you set the level to allow sufficient headroom for peaks to prevent this happening – the EBU norm is to use -18dBFS as the 0VU point.

As you can see from figure 3 above, these can result in a decrease in signal-to-noise of about 25dB.

Making it Better

So – how does an AES42 microphone improve this?

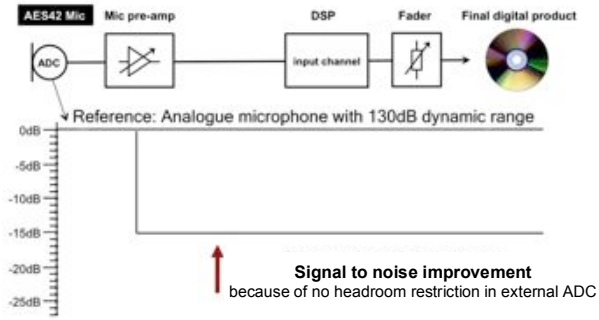

Figure 4: ADC in the Microphone

By having an ADC in the microphone itself, specifically designed for the capsule, we remove the need to "back-off" and so get an ideal translation from analogue to digital.

So we get back the first section of the reduced headroom.

Next we remove the external microphone pre-amplifier from the chain – in fact we can also remove the line driver amplifier from the microphone as well; leaving the absolute minimum of analogue components in the microphone itself – basically the capsule, the FET and not much more.

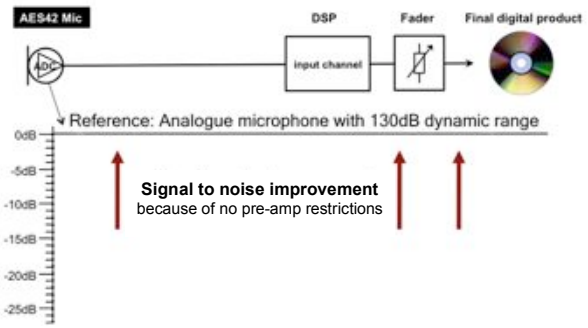

Figure 5: No External Microphone Pre-amplifier

So now we have available the full dynamic range of the microphone and the sound of the capsule, not coloured by analogue circuitry.

This is not saying that analogue microphones themselves are bad as, in theory, the figures of analogue and AES42 digital microphones are about the same.

However, the audio signal leaves the AES42 microphone as digits; while the audio signal from the analogue microphone has to travel along cables that are prone to RF interference, circuitry that adds noise, and the need to back-off from the optimum to allow for headroom and signal peaks.

THE AES42 SIGNAL

The AES42 signal carries data in both directions.

At the heart is the 24-bit AES3 audio stream. Piggy-backed on top of this is microphone data like: make, model number and serial number.

Going the other way is 10V phantom power with a maximum current draw of 250mA – pulses can peak 2V above this for control signals. Also going this way is remote-control data for adjustments in the microphone, for switching the red and blue lights and for adjusting the polar-pattern of switchable-pattern microphones.

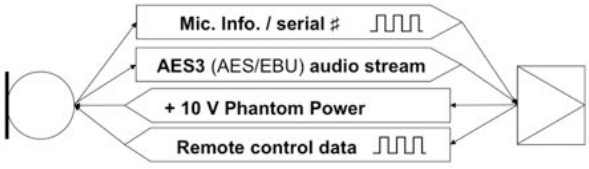

Figure 6: The AES42 Signal

It is also possible to update the firmware in the microphones via the controller attached to a computer.

The AES42 digital microphone removes the analogue noise, RF interference and the deterioration of the

audio signal as it travels along the analogue audio chain and replaces it with clean audio, immune from external interference, digitised as close to the microphone capsule as possible.

THE AES42 MICROPHONE

Mode-1 / Mode-2

AES42 allows for two different modes of operation:

Mode-1 is AES42 in its basic form. Each microphone is free-running from its own internal clock – so, if you want to use several AES42 microphones together, they will have to go through a sample-rate converter to clock them.

Mode-2 allows the microphones to be clocked from the receiving equipment – the clock signal is sent to the microphones as part of the data stream. Advantages include: no SRC and a constant phase relationship (close to 0°) between different mics, independent of cable length or other influences. Mode-2 devices can also be run as Mode-1 when being used in a system that also contains microphones that work Mode-1 only.

What Else does AES42 Offer?

It's easiest to see this visually – this is a channel strip from the Neumann RCS software, but the data is inherent in the AES42 specs. for all microphones:

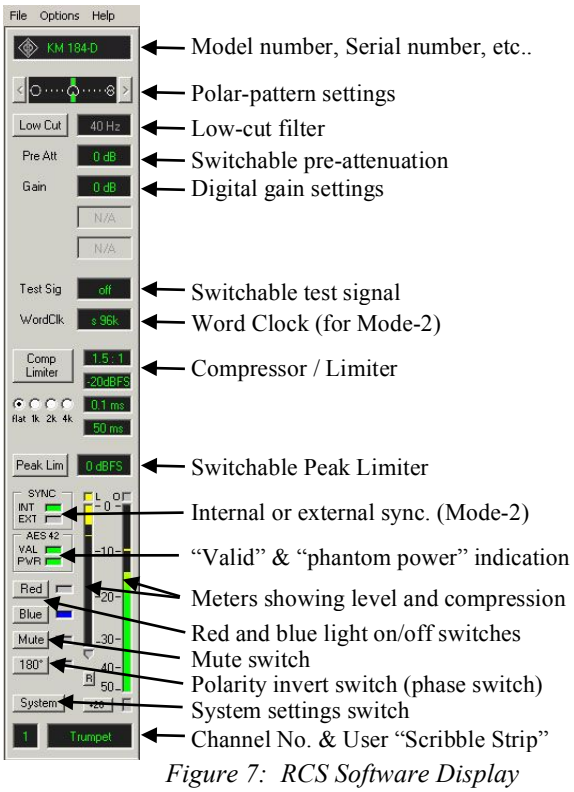

Figure 7: RCS Software Display

You can see from figure 7 that there is a lot in there.

The basic AES42 settings are:

- Polar-pattern (15 steps – omni to fig-8)
- Low-cut filter (none, 40Hz, 80Hz, 120Hz)
- Pre-attenuation (none, 6dB, 12dB, 18dB)
- Gain (unity to +63dB in 1dB steps)
- Peak limiter (on/off)
- Mute
- Mode-2 synchronisation

The polar-pattern settings obviously only apply to a dual-diaphragm switchable-pattern microphone. At the moment the original Neumann "Solution-D" D-01 is the only microphone to use this feature. No doubt more will follow. This section is "greyed-out" if the connected microphone is not a switchable-pattern one.

The low-cut filter and pre-attenuation settings are extremely useful and can be changed without direct access to the microphone itself.

Although signal gain is not really necessary, as it does not improve the signal quality – it is useful to have as it enables easier monitoring while recording.

The peak limiter is great for preventing momentary overloads and clipping. In my experience it works well and silently and means that you get good takes that would otherwise be lost due to overloads – for example: in a piano recording where the pianist hits the keys harder in performance than he did at the rehearsal. (This is one of the things that got me hooked on to digital microphones and one of the reasons I bought my first pair of digital microphones in 2006).

Mute is obvious and enables the easy muting of unused microphones.

Mode-2 synchronisation enables the microphones to be clocked by the system instead of requiring a sample-rate converter (as I mentioned earlier). I like this method, especially, because of the constant 0° phase relationship between the different microphones.

In all modes the basic audio signal still complies with the AES3 (AES/EBU) standard.

Complying with the AES3 standard has the added advantage that it can be very simple to power the microphone. Both Neumann and Schoeps produce simple connection kits. These, basically, send 10V

Phantom Power to the microphone and let the AES3 signal straight through. You don't need any special interfaces and can connect a single AES42 microphone (mono or stereo) directly to an AES3 (or S-PDIF if you have that version of the connection kit) input of a recorder or mixer. If you want to use more than one microphone you will need a sample-rate converter, as the connection kit is a simple mode-1 device. But this is perfect for a single microphone, or for the Schoeps SuperCMIT (which puts out two signals). It's also ideal for a simple stereo pair of Sennheiser MKH 8000 series heads with a single MZD 8000 AES42 module.

Figure 8: My Sennheiser MZD 8000 set-up with custom Y-cable and MKH 8020 stereoset

AES42 also allows extra settings, some of which are:

- Sample frequencies (8 possible: 44.1, 48, 88.2, 96, 176.4, 192, 352.8 or 384kHz)
- Stereo / mono selection
- MS / XY selection (stereo mode)
- Control of two lights
- Brightness setting for the lights (16 steps)
- Test signals
- Compressor / limiter with selectable ratio, attack and release
- Microphone identification and status flags
- Equaliser (255 manufacturer-specific settings or "no equaliser")
- Polarity switch (phase reverse) 180°
- Etc.

AES42 supports all standard sample rates from the CD-standard 44.1 all the way up to 384kHz; so it's well future-proofed.

AES42 microphones can also be 2-channel (stereo) and the specification allows normal 2-channel (XY – though, obviously, this also means ORTF and any other stereo arrangement that is normal left/right stereo) and MS (mid/side). At the moment I know of two microphones that take advantage of this: the Sennheiser MZD 8000 where you can connect two microphone heads via a custom Y-cable (see figure 8 on the left) and the Schoeps SuperCMIT which is not stereo, but puts out different information on two channels.

Two signal lights are also in the specifications. The "blue" light is the normal power light of the microphone and the "red" light is an option. The second light would, most likely, be used as a "mic. live" or "on air" signal. Only the Neumann D-01 makes use of both these lights at the moment. Both lights can be varied in intensity (or even switched off), so you don't have lots of bright lights all over an orchestra in a dark orchestra pit in a theatre, for example. These are also useful for quickly identifying a microphone as you can switch the lights on and off in turn as you do a mic. check.

Test signals are self-explanatory and are very useful for system testing.

Having the compressor/limiter in the microphone is extremely useful and allows for very flexible working.

A built-in equaliser that can be manufacture tailored to the microphone is an extremely useful accessory, rather than having to use generic ones.

Polarity reverse (phase switch) is self-explanatory, of course.

AES42-2010

The new AES42-2010 standard, published in March 2011, adds the AES42 system-command set to enable storage and recall of user settings in the microphone itself (so you can set your company name, etc. inside the microphone).

It also adds a new feature: Since the original upload times were not really acceptable for a firmware update using the AES42 interface, the bit rate can now be changed. This optional higher bit rate, called Fast-DPP mode, can be used to transmit DPP commands or firmware update data. In earlier versions, a firmware update could take the best part of an hour to do; with Fast-DPP it can now be done in about a couple of minutes.

In addition, an optional periodic transmission control feature is introduced to allow manufacturer-specific command sets for remote control of microphone features. So manufacturers now have a lot more flexibility with introducing special functions to their microphones.

The AES42 specification allows for a lot of flexibility – so although the cost of an AES42 microphone may look expensive initially, there are a lot of extras inherent in the specifications that would cost a lot more if they were purchased separately for an analogue microphone.

MY OWN EXPERIENCE

When I first heard about digital microphones I was not initially that impressed – OK, a good idea, but not that special. But when I really started to look into AES42 in detail, the advantages became very clear. The two main things that got me were the increase in dynamic range I mentioned earlier and the built-in limiter to silently prevent clipping.

I was hooked, I purchased my first set of AES42 microphones at the end of 2006 – Neumann KM-D in my case – and used them on piano recital sessions in The Menuhin Hall, starting in December '06.

The first "problem" I had was that I was recording the piano from a distance of about two metres. The KM 183-D microphones I had were diffuse-field omnis (the KK 131 nearfield omni was not available then) and the sound was obviously too bright due to the diffuse field frequency response curve. Looking at the published curve and polar-pattern I could see that the microphone had a flat response at about 90° so, after experimenting with various angles, I positioned the microphones vertically, which gave the best sound that the client was happy with.

Figure 9: Richard Meyrick, Blüthner Piano and KM 183-D microphones

Figure 10: Set-up in the Green Room of The Menuhin Hall

In use the digital microphones were just as easy to use as analogue microphones – though they did keep giving me "heart failure". Every time we went to play back a take to check it, it initially sounded like nothing was recorded. There was none of that very low-level background noise you get with an analogue signal chain. You don't really notice this low level noise in practice, but your brain must hear it, because when it was not there I kept feeling the recording had failed – until I heard the take numbers being called out and the music starting. So, yes, the better dynamic range really is noticeable.

Since this first session, which ended up as four CDs with a 3,000 run of each, I have added to my kit. I now have two choices of omni heads (diffuse field and nearfield) for my Neumann KM-Ds and I also have two stereo options (cardioid and omni) based around the Sennheiser MZD 8000 module (see figure 8).

Figure 11: My Nagra VI with a pair of Neumann DMI-2Portable for four AES42 microphones powered and clocked from the recorder

I have upgraded my recording system over the last few years and my main recorder is now the Nagra VI (above). Unfortunately, unlike the AETA 4MinX and Sound Devices 788T, it cannot take in AES42 microphones directly; so I have purchased two of the

new Neumann DMI-2Portable interfaces to enable four channels of AES42 recording through the two AES3 inputs of the Nagra VI. The recorder happily supplies the DC voltage and current to power the two units and they are both clocked to the very accurate word clock of the Nagra VI.

Because the Nagra does not have sample-rate converters, I have designed the system around Mode-2 microphones; it does mean, unfortunately, that I cannot use Mode-1 microphones in the system without purchasing a sample-rate converter.

WHAT'S AVAILABLE?

Microphones

The very first AES42 digital microphone was the Neumann D-01; this is an all-singing, all-dancing large diaphragm switchable-pattern microphone that incorporates almost every option that AES42 allowed.

Figure 12: Neumann D-01

Next was Schoeps. They decided to go to the other extreme and to produce a simple Mode-1 module (CMD 2) for their Collette series. This was a canny way to go, as a single module with interchangeable heads means that this single unit makes quite a lot of microphones; there is even a boundary microphone option.

Figure 13: Schoeps BLM 3 boundary capsule

There are currently 21 capsules and over 100 accessories in the series.

Figure 14: Schoeps CMD 2 with a selection of capsules

Then Neumann released the KM-D series. Similar to Schoeps in concept, this module was launched with a new range of capsules – there are now 8 capsules in the series (and a KM-A analogue module as well).

Figure 15: Neumann KM-D

Neumann have since also added various dedicated microphones, both large and small diaphragm, to their AES42 range.

Sennheiser were latecomers to AES42. They, again, went down the modular route and produced the MZD 8000 to accompany their MKH 8000 series. Sennheiser had to take a slightly different route as MKH microphones use the RF condenser principle and the heads are actually complete microphones with a normal microphone output level. Again a Mode-2 device, the MZD 8000 is unique at the moment in that it is a mono/stereo module. You can screw an MKH 8000 series head directly onto the MZD to make a single AES42 microphone, or, via a Y-cable you can connect two heads as a stereo pair (see Figure 8).

Although there is a 3dB noise penalty in this stereo mode, it has the advantage of being able to be connected to an AES3 or S-PDIF digital input by using a simple connection kit (as I discussed earlier). Sennheiser have omni, cardioid, super-cardioid, short gun and long gun heads available now. Sadly, no figure-8 or sub-cardioid heads are available yet and the Y-cable I had to make myself (though all the 8000 series remote cables and extension tubes are already stereo enabled).

Figure 16: Sennheiser MZD 8000

Schoeps then set the cat among the pigeons with their SuperCMIT gun microphone. This is not just any run-of-the-mill gun microphone – Schoeps took advantage of AES42 to include digital processing inside the microphone. They incorporated an additional rear-facing cardioid transducer inside the microphone in addition to the normal gun capsule. In its simplest form the SuperCMIT is a standard AES42 short gun microphone. But switch in the processor and the rear cardioid comes into play – polarity reversed, this capsule helps to make the microphone more directional and, uniquely, reducing the rear out-of-phase lobe. A second setting has even more processing and virtually eliminates the rear lobe completely, but with some artefacts so this option has to be used carefully. The microphone actually outputs 2-channels – SuperCMIT signal in channel 1 and (direct, single-transducer) CMIT signal in channel 2, so you can make the final decision is post-production, rather than at the time of recording.

Figure 17: Schoeps SuperCMIT

The one thing that really excites me about the SuperCMIT is not just the microphone itself, which is certainly being well received, but the possibilities for the future with DSP included inside the microphone.

The one microphone not mentioned so far is the Microtech Gefell MV 230. This is actually an AES42 measurement microphone that can accept a number of Gefell's screw-on microphone heads.

Figure 18: Gefell MV 230 with MK 221 head

Interfaces and Recorders

There are AES42 interfaces from Neumann and RME. Both Neumann and Schoeps do simple connection kits, Marian and Digigram do computer cards, Lake People do an interface with both digital and analogue outputs and StageTec, DigiCo and Innovason mixers can take AES42 microphones.

The Sound Devices 788T and AETA 4MinX portable recorders can both take AES42 microphones direct in.

Figure 19: AETA 4MinX recorder

For other recorders you need an interface, like the Neumann DMI-2Portable units that I use with my Nagra VI.

THE FUTURE

In ten years the number of AES42 microphones has risen from one to over 40 and there are now growing numbers of interfaces, recorders and mixer options.

The future looks exciting. I certainly hope that other microphone manufactures will produce AES42 microphones; for instance, DPA's new modular series seems perfect for it, as one AES42 module will make a

complete range of microphones. Also the implications of DSP inside the microphone, as demonstrated by the Schoeps SuperCMIT, invites exciting prospects for the future.

CONCLUSIONS

AES42 microphones, with the digital conversion as close to the capsule as possible, give the highest possible signal quality that cannot be degraded by the interferences and losses that analogue signals are so prone to. The AES42 standard has been refined over the years to allow a lot of options and an improved and more refined system. Having used AES42 microphones myself for five years now, I am delighted that I invested, and am continuing to invest, in this technology and I am extremely happy with the results I am getting.

AES42 EQUIPMENT

I will conclude with a list of the AES42 compatible products that I have managed to find to date. It's not a complete list as I do know of various other things that are in development, but as they have not been officially announced yet, think it prudent not to include them here.

Microphones

Neumann

D-01	Large diaphragm switchable-pattern
KM-D series	
KK 183	diffuse field omni
KK 184	cardioid
KK 185	super-cardioid
KK 131	nearfield (flat) omni
KK 133	diffuse field omni with ball
KK 143	wide cardioid (sub-cardioid)
KK 145	cardioid with bass roll-off
KK 120	figure-8
TLM 103-D	Large diaphragm cardioid
KMS 104-D	Vocal cardioid
KMS 105-D	Vocal super-cardioid
KMR 81-D	Short gun
KMR 82-D	Long gun (coming soon)

Schoeps

Collette series – CMD 2 with:

MK 2	nearfield omni (flat)
MK 2H	omni with a mild HF lift
MK 2S	omni with a slight HF lift
MK 3	diffuse field omni
MK 21	wide-cardioid
MK 21H	wide-cardioid with a mild HF lift
MK 22	open cardioid
MK 4	cardioid
MK 4V	cardioid (vertical, side fire)
MK 41	super-cardioid
MK 41V	super-cardioid (vertical, side-fire)
MK 8	figure-8
MK 5	passive switchable, omni / cardioid
BLM 3	hemispherical boundary
BLM	boundary adaptor for MK capsules

Plus various speech-optimised MK capsule versions

SuperCMIT	gun microphone with DSP

Sennheiser

MKH 8000 series – MZD 8000 with:

MKH 8020	omni
MKH 8040	cardioid
MKH 8050	super-cardioid
MKH 8060	short gun
MKH 8070	long gun (rifle)

MZD 8000 + Y-cable with:

MKH 8020 stereoset	2 x omni
MKH 8040 stereoset	2 x cardioid

MZD 8000 + XLR-5F adaptor cable with:

MKH 800 TWIN	infinitely variable pattern

Microtech Gefell

MV 230	omni-directional measurement microphone with a selection of interchangeable capsules

Interfaces

DigiCo

AES42 input card for DigiCo consoles

Digigram

VX222HR-Mic	1-mic (mono/stereo), Mode-1, SRC
VX222e-Mic	as above but PCIexpress

Innovason

Mode-2 by controlling Neumann DMI-8 via Ethernet

Lake People

DAC C462	1-mic (mono/stereo)

Marian

TRACE AES 42-4 4-mics PCI card, Modes-1 & 2

Microtech Gefell

USB interface – 1-mic (mono/stereo), Mode-1

Neumann

DMI-2	2-mics, Mode-2
DMI-2Portable	2-mics, DC powered, Mode-2
DMI-8	8-mics, Mode-2 *
AES connection kit	1-mic (mono/stereo), Mode-1
S-PDIF connection kit	1-mic (mono/stereo), Mode-1

RME

DMC 842	8-mics, Mode-1 & Mode-2 *

Schoeps

PSD 2U/Hirose	1-mic (mono/stereo), Mode-1
PSD 2U/co-axial	1-mic (mono/stereo), Mode-1

StageTec

XER-M	Mode-1 input card for NEXUS, SRC

* Connectivity:
The DMI-8 can connect via EtherSound or ADAT.
The DMC 842 can connect via MADI, EtherSound or USB

Recorders

AETA	4MinX
Sound Devices	788T

About the Author

John Willett (Circle Sound Services) is a freelance consultant, writer and classical music recordist.

He established Circle Sound Services in 1978, initially as a "spare time" business, but is now full time. He has recorded a number of CDs including one in Classic FM's "Full Works" series and is well regarded for his solo piano recordings. Microphones have always been his passion as is also his desire to "capture the performance". He has been recording digitally since 1983 and (according to "Music Week") was the first to produce an album by digitally overdubbing using a pair of PCM-F1 units. He has been using digital microphones since 2006 and is regarded as an expert on the subject. He has written for several publications including Sound On Sound and Line Up. He is the President of the International Federation of Soundhunters, Chairman of the British Sound Recording Association and is on the Executive Committee of the Institute of Broadcast Sound. He is a member of the APRS as well as the AES. In a past life he was Technical Manager at Sennheiser UK.

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