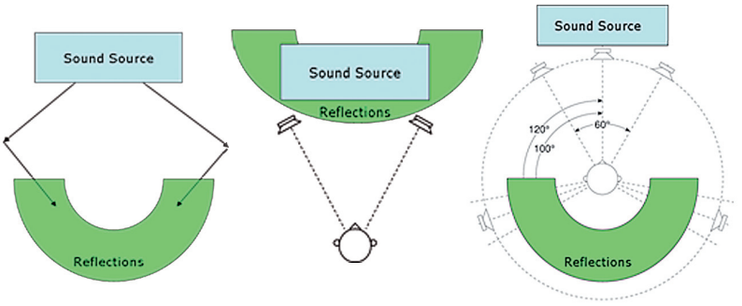
Developing the 5100 mobile surround mic

DPA describes its 5100 as a 'plug and play' solution for 5.1 capture that employs five miniature pressure transducers with interference tubes and acoustic baffles. DPA product specialist MIKKEL NYMAND explains the thinking and processes behind it.



Having used, designed and delivered quite a few different surround microphone arrays over time, DPA knows about the different needs and applications of recording acoustic surround sound. The most recent demand is the need for portability for what we could call 'instant' surround sound capture or 'surround to-go' — productions where you don't have the set-up time and space that music recording producers normally have. Broadcasting, whether it's news, documentary, entertainment, postproduction or sports, will very soon have to deliver 5.1 sound to their High Definition productions and they'll need a precise, fast working and reliable tool for this.

The demands for a mobile surround microphone are simple: portability; light-weight; robustness; ease-of-use; wind and water protection; quick set-up time without needing additional processing; and the impressive and enveloping sound quality listeners expect.

Before going much further it is appropriate to point out some general thoughts regarding surround sound production. The goal for surround productions in general is to envelop the listener and to intensify the audio experience. There must be a significant difference to stereo productions otherwise it adds no new experience for the listener.

It is also important to distinguish between produced surround and acoustic surround. Produced surround is where a sometimes high number of mono channels are surround panned in the sound field. Most modern mixers and workstations are able to deliver this functionality to create a virtual reality. Acoustic surround, on the other hand, aims to increase the feeling of presence in a specific acoustic sound environment by capturing the characteristics of the acoustics using surround microphone techniques.

The major benefit of 5.1 surround compared to stereo is that the directions where ambience is picked up from is also where it will be played back from. The figures show an original, but simplified sound stage and its playback artefact in stereo and more authentic 5.1 surround playback.

Well balanced surround will capture the entire sound field and have optimised imaging and localisation and will not only represent the direct signal in the front system and the ambience in the surrounds, but it will also have a smooth coherent sound all around the listener. Good acoustic surround requires good microphones that have a neutral character to create an authentic feeling of 'being there' and they should have wide dynamic and frequency ranges. Good acoustic surround requires identical microphones with excellent off-axis response and minimal phase deviations to be able to make a smooth blend in the surround stage between front and rear channels.

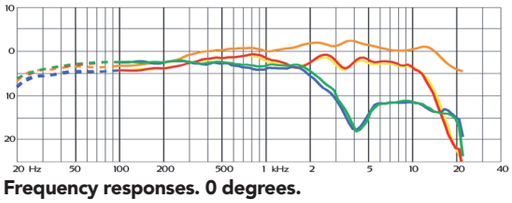
COINCIDENT ARRAYS VS SPACED ARRAYS — Coincident techniques (localisation cues based only on level differences between signals) can create proper localisation accuracy but will lack envelopment and result in a small sweet spot. The advantage of a coincident array is that it is compact and portable.

A spaced microphone surround array will create a three-dimensional enveloping sensation by providing adequate amounts of decorrelation between the signals (localisation cues are based on time-of-arrival differences). When adapting the microphone placement (distance and angle) to the sound field, spaced arrays still provide proper localisation accuracy.

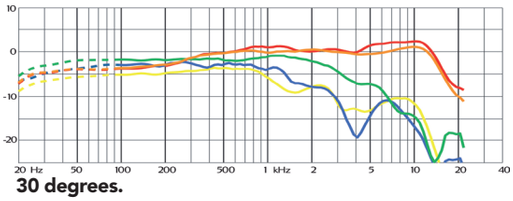
Spaced techniques generally give a nice and large sweet spot area and you sense the enlarged and enveloping sound stage in a larger listening field. The disadvantage is the size, visibility and set-up time.

There are a number of different technologies available to make a surround microphone work. Given the precise specification that it should be as compact as possible — preferably within the dimensions of this magazine — then the use of widely spaced mics with decorrelated signals is, of course, not the way to go. The directionality has to be obtained mainly by level differences and some head-related spectral cues. However, the 5100 is not a head-related phase

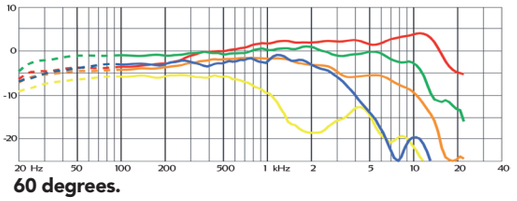
	COINCIDENT ARRAYS	SPACED ARRAYS
Envelopment	–	+
Sweet spot size	–	+
Compactness/ portability	+	–
Localisation accuracy	+	–



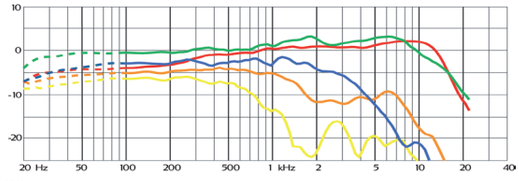
Frequency responses. 0 degrees.



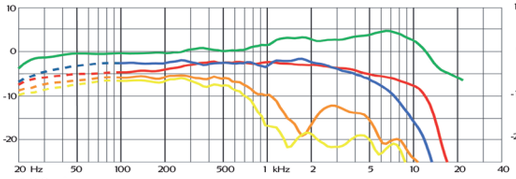
30 degrees.



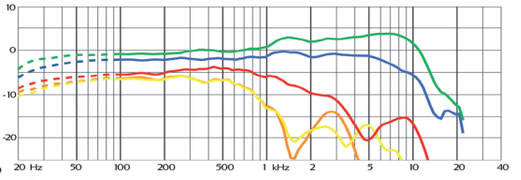
60 degrees.



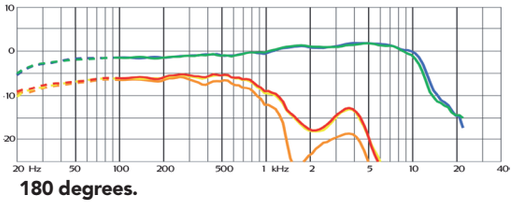
90 degrees.



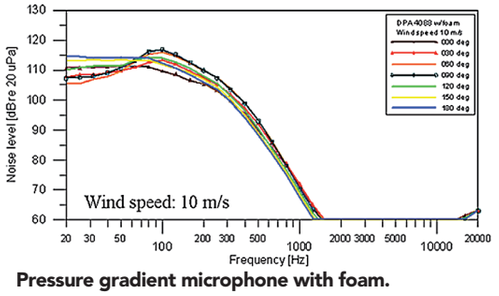
120 degrees.



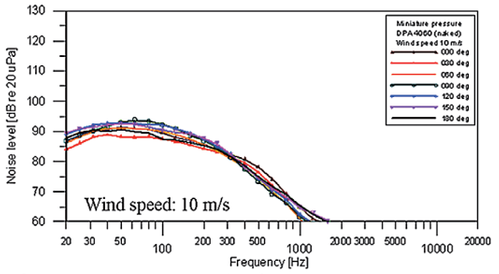
150 degrees.



180 degrees.



Pressure gradient microphone with foam.



Pressure microphone with foam.

cue solution, with microphones flush-mounted on a dummy head since that technology works best when played back on headphones (eliminating crosstalk and room tone by playing direct-to-ear).

Our initial working model was cut from a cardboard box and had five omnidirectional microphones. The performance was surprisingly good. Envelopment and localisation was rich but frequency response suffered from comb-filtering. We chose the well known method of separating the omni microphones with some absorbing material and the challenge then was to find a material close enough to not let sound through and yet open enough not to reflect it. A fibre-like material was developed to act as acoustic baffles (partition walls) between the microphones, like a Jäcklin Disc does for improving localisation in AB stereo arrays.

True pressure omnidirectional microphones have some advantages over pressure gradient directional types — the distortion is typically lower resulting in a more natural sound colour, proximity effect is nonexistent resulting in a consistent low frequency response regardless of distance to sound source, and wind and handling noise is much lower, which is a major plus when it comes to the applications the 5100 is designed for. As seen on the graphs, the wind noise on a pressure microphone is typically a minimum of 20dB lower than on a pressure gradient below 200Hz (where wind noise is most prominent).

Nearly a decade of research and development at DPA Microphones in the use and design of interference tubes means we know how to design them and use them to control the behaviour of a microphone. Directionality and frequency response can be controlled and for the first time in our industry we've used interference tubes on pressure microphones — a technology normally found on pressure gradient capsules for shotgun microphones. We've introduced the DiPMic (Directional Pressure Microphone) principle on the three front microphones and this gives us the best of both worlds — the advantages already mentioned and the psychoacoustic directional cues obtained by level and spectral shifts with interference tubes and acoustic fibre baffles.

An important issue in broadcast audio is compatibility to stereo and mono. Even the most beautiful surround mix has to be able to be played back in mono without dramatically changing the sound colour. For the 5100 we chose the front array of L, C and R microphones to be time coincident to keep the possibility to sum these to stereo or mono without causing phase cancellations. Angles between the microphones and partition walls create directionality for stereo or surround.

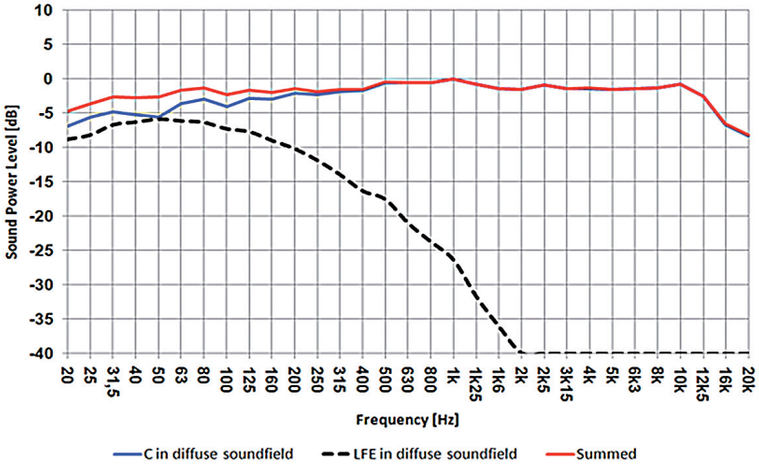
In addition to the aforementioned level and spectral differences from the DiPMic and the acoustic fibre baffles, as much time difference as possible within such a compact unit is desirable to feel the size of the surround sound component. The front array is spaced from the rear microphones and

the spacing between rear microphones is a head related distance of 185mm and contributes to the sensation being as spacious as possible. Even more spaciousness is wanted in many cases and adding delay to the rear channels is a powerful way of obtaining this.

Making the rear microphones seem as if they are 3–5m (about 10–15ms) away from the front array makes you aware of a time gap and 'improves' three-dimensionality but you have to use this technique with caution when recording percussive and dynamic content in the rears as delaying these components will create a psychoacoustic mismatch when the sources are perceived to be louder but later than the front. This is why a spaced array is always correct for any angle in terms of natural time delay between any channel.

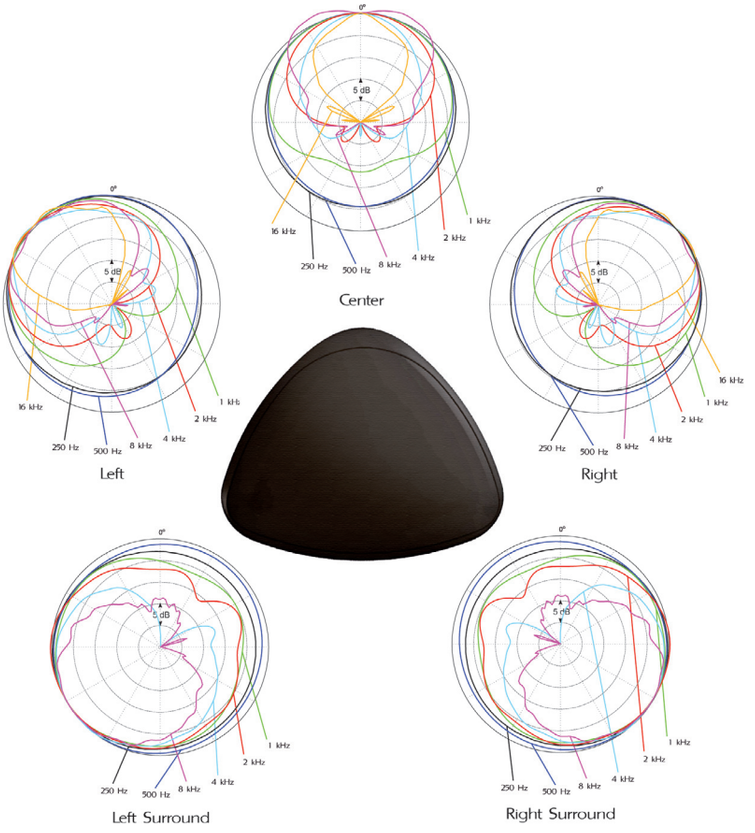
Human hearing has a high frequency roll off to sound sources coming from behind. Any component with this character will by nature be perceived as being 'ambient' or 'behind', so helping the rear channels with a 3dB shelving attenuation EQ can also be considered in some applications.

When talking about low frequency content and LFE it is important to distinguish between the LFE channel content and the use of an active subwoofer. LFE means Low Frequency Effects and derives from the film industry and is a separate channel to improve dynamics in the bass region for film mixers. It is adapted to the 5.1 ITU norm as a frequency limited channel and should be reproduced at +10dB (which means that the channel itself is at -10dB).



For the 5100 we chose to deliver a separate LFE output to be 5.1 plug and play ready. All five full bandwidth channels also contain the low frequency part down to 20Hz, the LFE output is simply the extra energy that finalises the sound colour of the unit — you're not obliged to include it but it's recommended. If downmixing, it is advisable to include the LFE channel equally to LR. The 5100 LFE output is a sum of L&R, low-pass filtered at 120Hz and attenuated 10dB. It is in-phase with the low frequency content of LR.

The 5100 LFE output can be considered to be part of the microphone's spectral



Polar patterns. Typical directional characteristics of DPA 5100 (normalised)

sound colour and as such is adjusted by ear. If you analyse the frequency response of the three front DiPMic microphones you find that they — as a result of the interference tubes — tend to have a rise in the higher frequencies. Therefore the LFE serves as a nice rich energy to the final tonal balance.

The analogue 5.1 output of the 5100 runs through a multipin Lemo connector carrying all six channels electronically balanced, while a 5m six-pair Mogami cable breaks out to six Neutrik XLR-M connectors.

We have tested the 5100 extensively on a diverse range of recording applications. We recorded moving objects like sports cars, horses, trains, planes, gun shots and even a rocket launch, captured atmospheres for football games and an auto garage but also used it for more conventional music recordings like string quartets and a church organ. We believe the end result with the 5100 is a surround atmosphere that is rich, smooth and fully enveloping, yet great in its coherence, channel separation and localisation accuracy.