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Microphone technology today and tomorrow – Part 1

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For decades, classical music has been recorded using specially designed high-quality studio microphones, whose sound quality set them aside from conventional microphones. As advances were made in audio technology these microphones were constantly improved and adjusted to meet the demands of the market. They have now reached a level of perfection that will be hard to beat. Can we still expect to see far-reaching innovations in the world of analogue microphone technology? Sennheiser has recently launched several new models – the MKH 8000 series and the MKH 800 TWIN – which, according to the manufacturer, have a greatly increased sound quality, offer new ways of working and give new application possibilities for stereo and surround sound productions. Elke Wisse spoke to the developers of the Sennheiser MKH series, Manfred Hibbing and Raimund Staat, and to Tonmeister and Sennheiser Recording Application Manager, Gregor Zielinsky.

Manfred Hibbing

Raimund Staat

Gregor Zielinsky

MKH 800 TWIN

The Sennheiser MKH 800 – a studio condenser microphone with switchable pick-up patterns – has been on the market since the year 2000. The MKH 800 TWIN was recently launched at the European AES Exhibition. What is the basic idea behind this microphone?

Manfred Hibbing (MH): In technological terms the MKH 800 TWIN is based on the MKH 800 but offers a technical refinement that gives the sound engineer new possibilities for recording and mixing. The MKH 800 TWIN has the same double capsule as the MKH 800 with cardioid directional characteristics pointing forwards and backwards. Unlike the MKH 800, however, the two capsule signals are not combined in the microphone in order to generate different pick-up patterns but are available separately at the microphone output of the MKH 800 TWIN.

The signals go to two faders on the mixer, and the setting of these faders determines the pick-up pattern of the microphone, making it possible to adjust the pattern remotely under monitoring conditions. The sound engineer can cross-fade click-free from one pick-up pattern to another or select any intermediate stage between

RF condenser microphones

During the early days of the change-over from valve (vacuum tube) to transistor technology, in the late fifties, a fundamental problem arose with condenser microphones. It was not possible to substitute valves (tubes) directly with transistors because of the mismatch between the low input impedance of the transistor and the high impedance of the condenser capsule. This meant that the capsule impedance had to be drastically reduced. Since the capsule impedance decreases as the frequency increases it made sense to drive the capsule using a radio frequency signal.

The RF principle works as follows: the incoming sound causes the diaphragm to vibrate, changing the capacitance of the microphone capsule accordingly. The changes in capacitance modulate an RF signal created by an oscillator in the microphone. This signal is then demodulated immediately in the microphone to produce the audio signal. The low internal impedance of the demodulator is perfect for transistor amplifiers. The microphone output only delivers the AF signal, as with other microphones, while the RF signal is filtered out.

The RF principle has several advantages over the conventional AF principle. It is particularly low-noise, tolerates damp weather conditions, works down to 0 Hz and delivers a fully floating, balanced audio signal without the need for a "bolt-on" balancing circuit.

the individual patterns. He can directly assess the resulting sound and make corrections.

That is a feature that is well known from digital microphones. Is the MKH 800 TWIN an analogue microphone with digital characteristics?

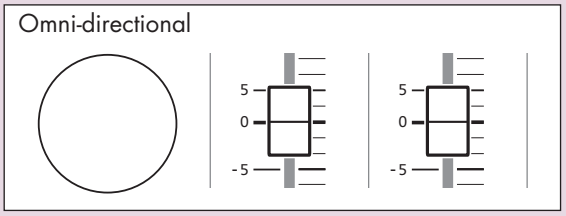
MH: It's true that you can control pick-up patterns remotely with digital microphones such as the Solution D but the MKH 800 TWIN has an additional and highly significant advantage. With a digital microphone, when you select a directional characteristic you turn two capsule signals into one signal in the microphone itself, and as a result some information is irretrievably lost.
However, we wanted to make all the information present in the microphone available. If the two capsule signals are recorded separately then the sound engineer can flexibly choose the pick-up pattern during the post-production process.

What new possibilities does this microphone offer the sound engineer in practical terms?

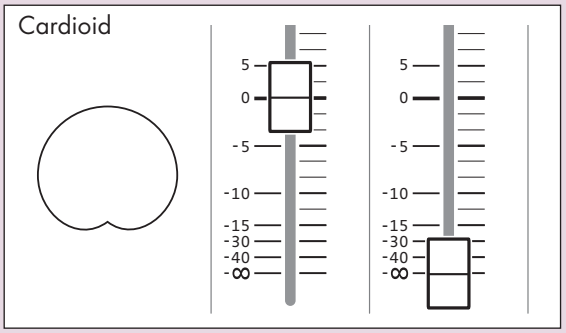
Gregor Zielinsky (GZ): This microphone is widely used for classical music, where recordings are often not made in a studio but elsewhere, using a temporary control room. These improvised control rooms do not always have ideal acoustics; the room may be too small or too noisy etc. This can lead to compromises in the mixing.
With this new microphone the sound engineer can work in a more relaxed way because he knows he can make any necessary changes to the directional characteristic of the microphone when doing the subsequent mixing in a studio under optimal conditions and will therefore be able to optimise the sound at that point. He can also adjust the pick-up pattern as part of the mixing process and even during a piece of music.

Remote control of the pick-up pattern with the MKH 800 TWIN

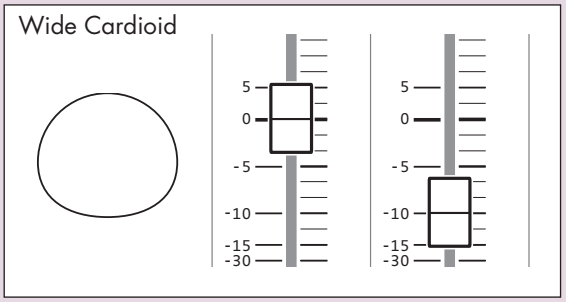
The output of the MKH 800 TWIN has a 5-pin XLR plug which is adapted using a Y cable to two 3-pin XLR plugs. The signals of the front and rear microphone capsules go to two separate tracks on a multi-track recorder and then to two separate mixer inputs. The pan controls of both channels must be set to the same corresponding positions. The volume level is set as usual with the signal of the front microphone capsule. The fader remains on this set level while the second fader – the signal of the rear microphone capsule – is moved to achieve the desired directional characteristic.



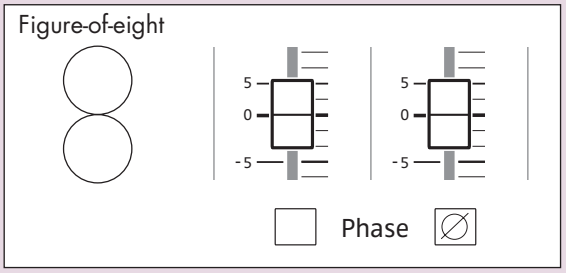
If both faders are set to the same level you get an omni-directional pick-up pattern.



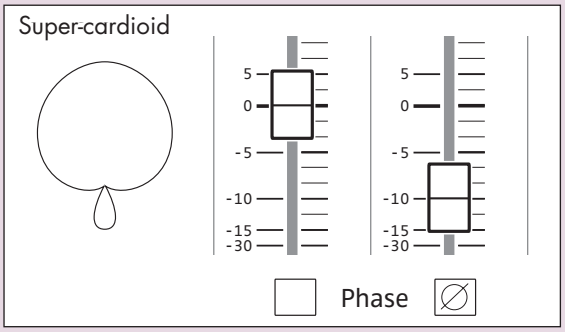
The cardioid pattern is created from the front channel only – i.e. the front microphone capsule – with the second channel muted.



If the level of the rear channel is increased, the cardioid pattern slowly becomes a wide cardioid (hypo-cardioid). The full wide cardioid pattern is achieved when the level of the rear channel is set about 10 dB lower than that of the front channel. It is then possible to go seamlessly from the wide cardioid to the omni-directional characteristic.



To achieve a figure-of-eight pattern, the phase needs to be reversed in the channel for the rear capsule and both faders must be set to the same level.



The super-cardioid pick-up pattern is achieved when the phase of the rear channel is inverted and this has about 10 dB less amplification than the front channel. As the level is increased the directional characteristic tends to go hyper-cardioid; as it is decreased it goes cardioid.

Another great advantage becomes obvious when both a stereo mix and a surround mix are produced in parallel, each of which requires different mixing with different pick-up patterns. Normally the sound engineer has to decide whether to aim for an optimal stereo or an optimal surround sound recording. Now it is possible to achieve both.

We used MKH 800 TWINs for a surround production in the auditorium of the Hanover Music Academy. A surround microphone mount was fitted with four TWINs at its bars and a regular cardioid at the centre.

Surround sound recordings often have the problem that the audio signal "disintegrates", leaving the impression of a separate front and rear signal. With the TWIN we can now cross-fade continuously from the cardioid to the omnidirectional pattern. This is an important improvement because now you can integrate the sides harmoniously and get the perfect, coherent surround sound for each room.

Surround microphone mount equipped with four MKH 800 TWINs and a central cardioid

Naturally, the best way to create surround sound is to use four TWINs. However, two TWINs can be used to create four surround channels by assigning the front cardioids to the surround front channel and the rear cardioids to the surround rear channel. Here, too, the directional characteristics can still be adjusted as desired for the front and rear, and the signal is fully stereo compatible with minimal effort and expense.

MH: I would describe the TWIN as a universal tool. Once people have grasped the principle they can use it to suit their own ideas and can give free rein to their creativity.

What other uses do you see for this equipment?

MH: With a single MKH 800 TWIN and an additional figure-of-eight microphone it is possible to create surround sound recordings using the double MS technique. The figure-of-eight is attached above and at right angles to the TWIN. After MS-LR matrixing with the signal of the figure-of-eight, the front and rear signals of the TWIN produce the front and rear surround channels. The centre channel, which can have any characteristic whatsoever, is created by combining the front and rear signals of the MKH 800 TWIN. For post-production purposes only the three original microphone signals need to be stored instead of all five surround signals.

The MKH 800 TWIN has just been launched, but the Sennheiser MKH 8000 series has been available for about a year and also relies on the MKH 800 technology. Mr. Staat, you are responsible for the development of the MKH 8000 series. What improvements have been made on previous models? What was the objective of the development?

Raimund Staat (RS): The aim was to miniaturise the previous MKH models while maintaining the "inner qualities" of the MKH 800. The result is a modular microphone that contains everything necessary to transmit the complete audio range. The main module has a capsule diameter of just 19 mm in a housing just 41 mm long, making it significantly smaller than its predecessors.

MKH 8050 microphone capsule with MZX 8000 XLR module

The microphone module has a low-impedance, balanced, floating and phantom powerable output, to which the relevant adapter module – including a digital module – can be screwed. To date three models are available: the omni-directional MKH 8020, the cardioid MKH 8040 and the supercardioid MKH 8050. They come with an XLR connection module which attaches directly onto the microphone module or at the far end of a so-called "remote" cable.

Accessories such as microphone stands or supports with integral cabling no longer require any active electronics to work without interference and the remote cables and extension tubes are fully low impedance and balanced throughout. We offer a wide range of accessories that enable our microphones to be used in all kinds of applications. These microphones are special because they offer an increased frequency response of 10 Hz to over 50 kHz, fast transient response, low noise and almost frequency-independent pick-up patterns.

At the heart of the new series is the new capacitive transducer, which is based on the symmetrical transducer of the MKH 800.

What has been changed compared to the MKH 800?

RS: We have used the same circuit engineering as was used in the MKH 800 and thanks to modern manufacturing

MKH 8050 microphone capsule

Comparison: MKH 20 and MKH 8020 with XLR module

methods we have been able to keep the same diaphragm diameter of the MKH 800 but still reduce the external dimensions.

GZ: The MKH 800 is the "father" of the MKH 8000, both technically and in terms of sound. The new models have been extensively tested in real recording situations as well as in the anechoic chamber to produce a sound that is both accurate and retains the soul of the music.

MH: In order to clarify the level of technology achieved it would be useful to mention a few details. In developing the first new condenser capsules we carried out a special acoustic dimensioning process to minimise microphone self-noise. The capsules are most sensitive in the frequency range in which the human ear is most sensitive to noise. They have now been tailored to human auditory physiology in that the capsule sensitivity has been adjusted to suit the hearing sensitivity curve. The frequency response of the capsules has been designed accordingly and is electrically linearised inside the microphone.

This process offers some advantages. It allows, among other things, an increased low frequency response without the need for a large capsule diameter. The capsule diameter can be kept to a minimum in order to achieve good directional characteristics at high frequencies. It is also possible to extend the frequency range at the upper end. This meant that the capsules could be developed with optimum directional characteristics as the linear frequency response curve does not need to be produced in the capsule itself.

With the introduction of the CD at the beginning of the eighties we had a sound storage medium that showed far less inherent distortion compared to vinyl records. Digital distortions behave in the opposite way to analogue distortions: the higher the signal level in a digital system, the less distortion occurs. In microphones the opposite is true, which meant that their inherent distortion could be heard. This manifested itself, among other things, in lower resolution where complex sound structures were concerned. Investigation revealed that it was the narrow air gap between the diaphragm and the back-plate of the condenser capsule that was responsible for this distortion.

Since widening the air gap would have brought only slight improvements and created other problems instead, we introduced symmetrical push-pull technology in order to achieve a fundamental improvement in capsule linearity. The diaphragm vibrates between two identical plates. Any non-linearities generated by each air gap are cancelled out (in the same way as +1-1=0) and the capsule operates virtually distortion-free.

The same question comes up time and time again: is it necessary to have a microphone that has a frequency response up to 50 kHz and below 10 Hz?

MH: When you look at the third octave spectrum of a symphony orchestra you see that the world of sound does not stop at 20 kHz (see illustration 1). Nobody yet knows whether frequencies beyond 20 kHz are discernable and that is why we did not want to cut the microphone off. These high frequencies are normally filtered away by microphones. With the high-resolution digital formats available today it seems eminently sensible to use microphones with a frequency response of 50 kHz.

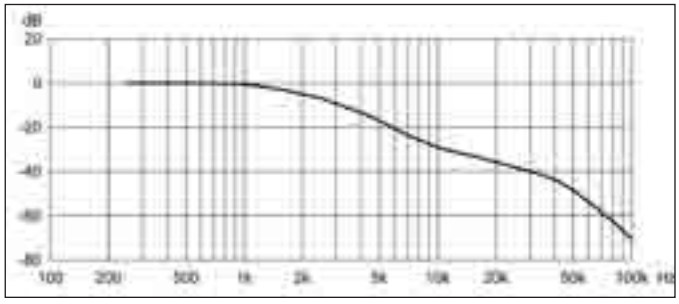


Illustration 1: Averaged third octave spectrum of a symphony orchestra. The spectrum does not end at 20 kHz but continues to show a gradual decrease as far as 50 kHz and only then drops off more steeply.

GZ: It is not just the expansion of the frequencies upwards that is important but the expansion down to the lower frequencies. Some may claim that there is no musical tone below 10 Hz but that is not true. There are some instruments that produce such frequencies, such as the gran cassa or the organ.

It is not just the frequency response that is important in a microphone but also its transient response. How does the MKH 8000 series deal with that?

MH: With on-axis sound, the transient response of the MKH 800, the MKH 800 TWIN and the MKH 8000 series can be compared to that of a 1/8" measuring microphone that transmits frequencies up to 100 kHz (see illustrations 2 and 3).

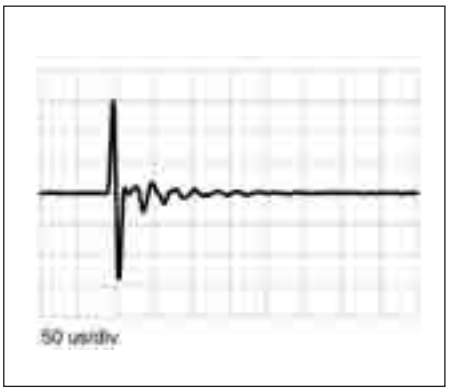


Illustration 2: Transient response of the MKH 800/MKH 800 TWIN

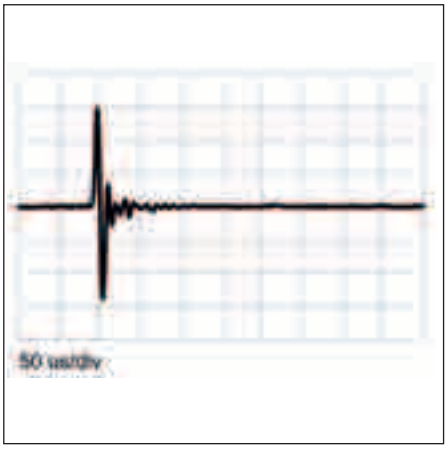
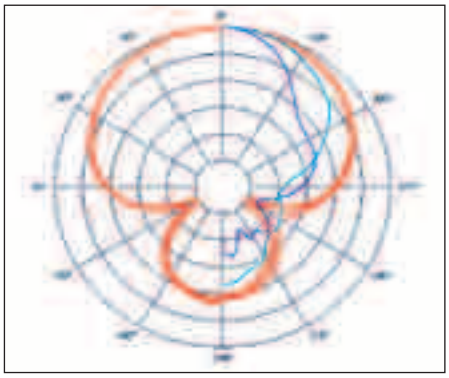
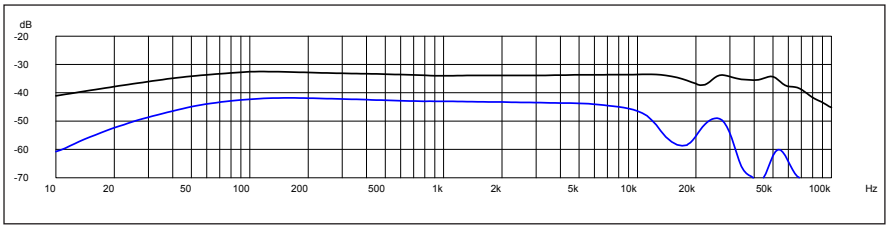


Illustration 3: Transient response of a 1/8" measuring microphone



Pick-up pattern of the MKH 8050: left 125, 250, 500, 1000 Hz; right: 2, 4, 16, 32 kHz; (up to and including 8 kHz red, 16 kHz dark blue, 32 kHz light blue)



Frequency response of the MKH 8050 at 0 degrees (black) and 90 degrees (blue)

When you look at the directional pattern it is clear that they are quite frequency-independent.

RS: The capsules of the MKH 8000 have been optimised in terms of directional characteristic. It is a long-standing MKH tradition that the pick-up patterns are almost frequency-independent. If the frequency response is kept independent of the direction the sound hits the microphone then larger sound sources such as an orchestra or a grand piano keep their natural and homogeneous sound. The sound does not "disintegrate", and using additional spot microphones will not cause any problems.

GZ: The super-cardioid MKH 8050 also delivers a linear frequency response across the whole spectrum. Normally super-cardioids tend to be weaker in the bass. We used two MKH 8050s to record the organ in Chartres Cathedral. This organ in this extremely large church is fairly inaccessible because it is very high up. With a normal microphone stand it would have been impossible to reach, so we positioned the microphones on the other side of the nave, about 30 m away from the organ. The result was impressive, as normally super-cardioids cannot do this.

Sennheiser is currently using the slogan "The soul of sound". Does this imply that you are striving to focus more on the sound aesthetic of a microphone?

GZ: No electro-acoustic transducer, whether it is a microphone or a loudspeaker, is totally neutral, even when the frequency response curve is relatively flat. The Sennheiser MKH microphones MKH 20 to MKH 50 are technically excellent products but a few people have described their sound as a little "clinical". That indicates that the frequency response alone does not totally define the sound of a microphone. A microphone must have a musical sound.

What is a musical microphone?

MH: Earlier Sennheiser took the view that microphones should be as neutral as possible. All the parameters of a microphone should be the same except for the individual pick-up pattern. That was the concept behind the MKH 20 through to the MKH 50. But microphones are never totally neutral. With the MKH 800 and the MKH 800 TWIN and with all the 8000 series the individual colouration was reduced still further so that the microphones change the character of the recorded performance even less. Since this is particularly noticeable in musical recordings it is possible to talk about the microphones having a certain "musical" quality.

RS: The MKH 8000 series broke new ground. Each of the three MKH 8000 modules has its own individual character. They differ from each other in more than just the pick-up pattern. In normal miking situations, for example with the MKH 8020 as main microphone and the MKH 8040 as spot microphone, each model makes its own contribution to the sound image that the sound engineer is trying to achieve. This result can only be achieved through the physical perfection of the transducers.

GZ: When I record a violin, for example, I want to hear the fundamental tone and the wood of the violin, not the bow on the strings. On the grand piano I want to hear how the hammer hits the strings, but not the fingers hitting the keys. I want to hear the "soul" of the sound or the instrument. That doesn't mean that all sound engineers like to use an MKH 8000. The art lies in designing the sound in a way that is transparent and pleasing to the ear without manipulating it in any way. In developing the MKH 8000 one key criterion was that it should sound at least as good as the MKH 800. So these microphones were tested in real professional situations and given practical trials from a very early stage. The sound of a microphone can only be properly evaluated in a professional recording situation.

What do you see as the main areas of application for the MKH 8000 series?

GZ: The recording of classical music in a studio is just as important as recording classical live concerts, with and without cameras. The comprehensive range of accessories together with the unobtrusive Nextel finish make these microphones easy to position in live situations too. The aesthetics of the stands are well suited to a stage setting and form part of the general image of an orchestra. Due to their sound characteristics, the three available microphones can be used in all classical miking situations: the omnidirectional MKH 8020 as main microphones, the MKH 8040 and MKH 8050 as spot microphones. The super-cardioid MKH 8050 has the same frequency response as the cardioid microphone – and almost the same as the omni – so that it can be used in piano recordings, for example. Here there is always the problem that the piano microphone also picks up part of the orchestra. A super-cardioid that blends out the orchestra a little more can help to remedy this situation. For us the MKH 8000 is a universal tool that can be used in all recording situations.

Analogue microphone technology seems still to have a way to go. Even so, digital microphones continue to appear in the market, bringing with them a whole new sound aesthetic and, above all, a new operating philosophy. What can digital microphones achieve? How will they change day-to-day miking? What level of development are we at?

Read more in the next edition of VDT magazine.