Dynamic SoundField

The technology behind the world's leading soundfield system

Overview

1. Introduction

Dynamic SoundField is Phonak's first ever soundfield system. Many customers have asked us to come up with a soundfield system in the past, but we felt we should only enter into this field if we could significantly enhance customer benefit.

With respect to soundfield technology we considered customers to be children, teachers, school directors and educational audiologists. We analyzed current soundfield systems, talked to professionals, studied room acoustics in detail, and only then did our large group of engineers and audiologists at Phonak Communications in Murten, Switzerland, develop what is today Dynamic SoundField.

Our team had ambitious targets: significantly improve speech intelligibility in classrooms over traditional soundfield systems; reduce the time and money required for installation; reduce settings complexity for teachers; eliminate the patchworking required when combining a soundfield system with personal FM systems; make a system that is comfortable to wear and use; and build a system that is ready for the future. Issues such as feedback, dead spots and lack of robustness were also addressed. Phonak developed a totally new wireless transmission technology for Dynamic SoundField. This is the key to many of the revolutionary features and solutions on-board.

In this guide we detail the advanced technology behind Dynamic SoundField and show you some of the system's latest formal "speech test in noise" results.

PHONAK life is on

2. The Dynamic Speech Extractor

One of the most significant features of Dynamic SoundField is its dynamic behavior. The purpose of a soundfield system is to increase speech intelligibility in the classroom. For optimal listening, the voice of the teacher should be clearly audible for all children in the classroom. Noise, distance and reverberation however often make understanding difficult and noise is the biggest problem of all.

The World Health Organization (WHO), the American National Standards Institute (ANSI) and the Department for Education and Skills in London (DfES) have issued norms for maximum background classroom noise levels. These norms are seldom met however, and these norms are for unoccupied school class rooms only. That means that any additional noise created by the children themselves in the classroom, is beyond the scope of the norms. But this does not mean that this noise is not relevant for the learning conditions in the classroom! On the contrary, once a classroom is filled with students, the norms for unoccupied classrooms can no longer be fulfilled.

Noise levels inside classrooms can be high, and they vary from school to school, from one classroom to another. Most importantly, background noise levels vary considerably during a typical school day. A soundfield system should therefore deliver both good intelligibility and a comfortable sound pressure level of the amplified voice of the teacher. In quiet situations, less amplification is required. In noise, the gain should be higher. A traditional soundfield system does not automatically track ambient noise levels, which means its volume can only be correct some of the time during the day. At certain points the system's gain will be too low, resulting in insufficient speech understanding by students. Or else too high, resulting in uncomfortably loud amplified speech. This inability to dealing effectively with noise may have contributed to the recent shift in attention towards reverberation in classrooms and its effect on speech understanding.

Although reverberation itself has a negative impact on speech understanding, in a classroom environment it is the background noise level that is the dominating factor limiting intelligibility. In classrooms reverberation time constants may be around 1s. Such reverberation without background noise is not on its own a very difficult listening condition. This is not to say that reverberation does not matter, but it matters in a different way than many professionals think: the biggest effect of reverberation in a classroom is that it increases the background noise level. So good room acoustics remain important but also remain difficult and expensive to achieve. To conquer the problem of fluctuating background noise in classrooms, whether exacerbated by reverberation or not, Phonak took an intelligent approach.

Phonak's Dynamic SoundField continuously monitors the background noise level in the classroom and adapts its gain accordingly and automatically. This surrounding noise compensation is set in such a way as to produce an STI (Speech Transmission Index) of 0.6 at different noise levels, ensuring excellent intelligibility of the teacher's voice. This is, in effect, applying the very successful and proven principle of Phonak's Dynamic FM technology to soundfield.

Ambient noise levels are measured using the microphone of the **inspiro** transmitter microphone, which is Phonak's Dynamic SoundField transmitter.

In quiet conditions, below 54 dB SPL classroom noise, the gain is kept at a value of 6 dB ("gain" refers here to a standard listening situation in a standard classroom). This will result in a Signal to Noise Ratio (SNR) of at least 12 dB. At lower noise levels the SNR will be higher. For instance, at 44 dB SPL noise level the SNR will be + 20 dB. Intelligibility will be degraded significantly when the SNR drops below +10 dB. Between 54 and 66 dB SPL classroom noise level the gain of Dynamic SoundField is automatically increased to maintain a SNR of +10 dB (Figures 1 and 2). This is, once again, valid for a typical classroom with a reverberation time RT60 of 0.9 s. The maximum gain the system delivers is 20 dB.

DSF automatic gain adjustment

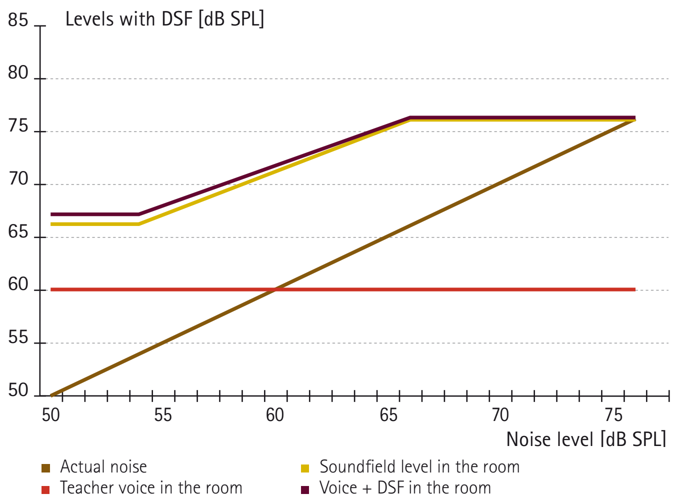


Figure 1.
Dynamic behavior of Dynamic SoundField. For classroom noise levels above 54 dB SPL the gain is automatically increased (light blue line).

SNC & SNR

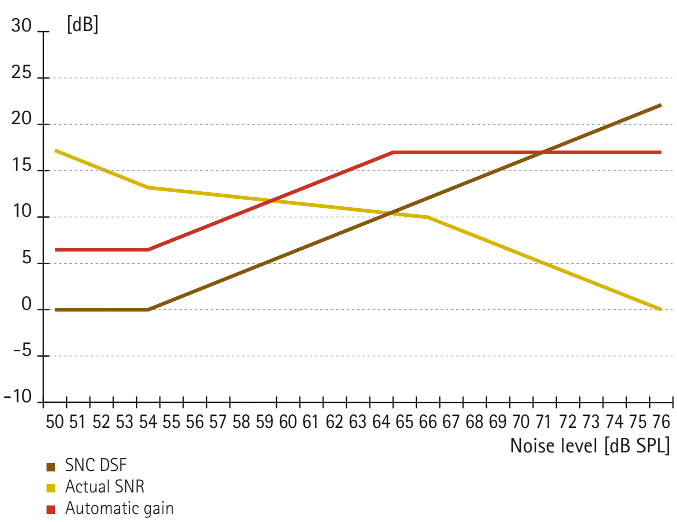


Figure 2.
The automatic Surrounding Noise Compensation (SNC) (blue line) increases the gain with increasing noise level (yellow line), resulting in a Signal to Noise Ratio (SNR) well above 10 dB up to 66 dB SPL ambient noise level.

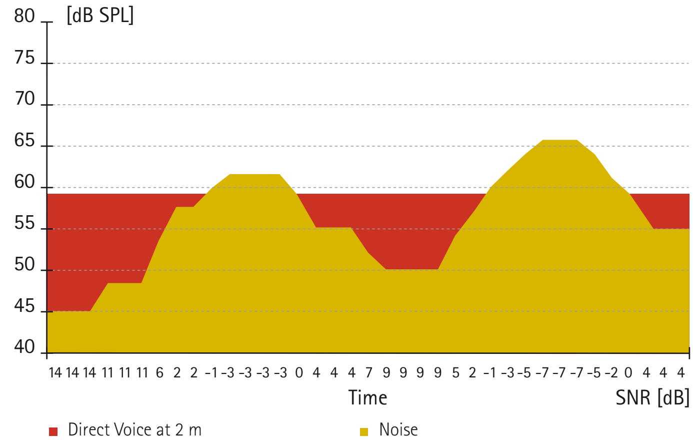


Figure 3.
Noise levels in classrooms vary considerably during the day and at many occasions SNR's may be well below +10 dB or even negative.

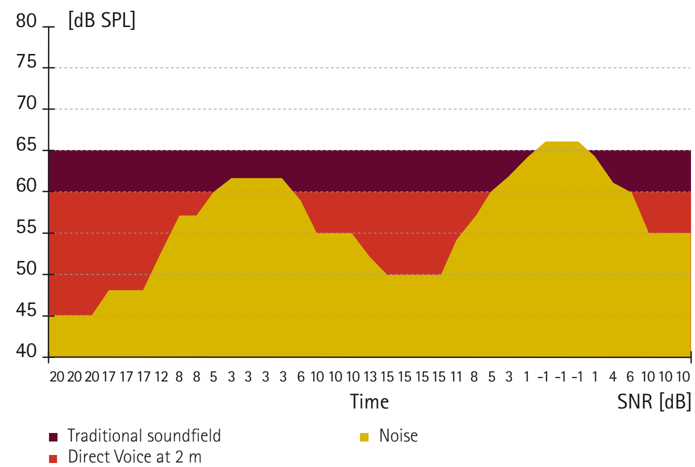


Figure 4.
With a traditional soundfield system a fixed gain is applied, which does not follow the ambient noise level, resulting in poor SNR's in noisy situations.

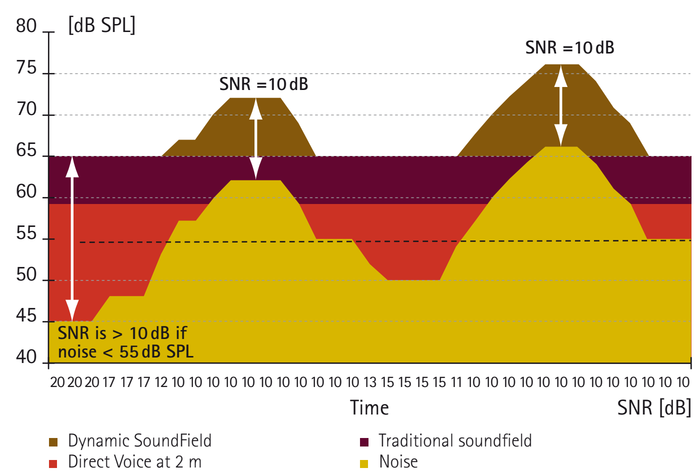


Figure 5.
Dynamic SoundField tracks the ambient noise level, giving optimal SNR's during the whole school day.

Both ambient noise and speech levels are measured by **inspiro** with time constants of 5 s. An ill-placed microphone, detected by means of an abnormally soft voice input at the microphone, will be compensated for by an extra additional gain in the Dynamic Loudspeaker.

In parallel to Dynamic Speech Extractor, another algorithm is also applied: the Dynamic Equalizer. This algorithm shapes the frequency response depending on the classroom noise level. In quiet, the total signal from the loudspeaker unit, plus the direct voice of the teacher,

Cut-off frequency Dynamic Equalizer

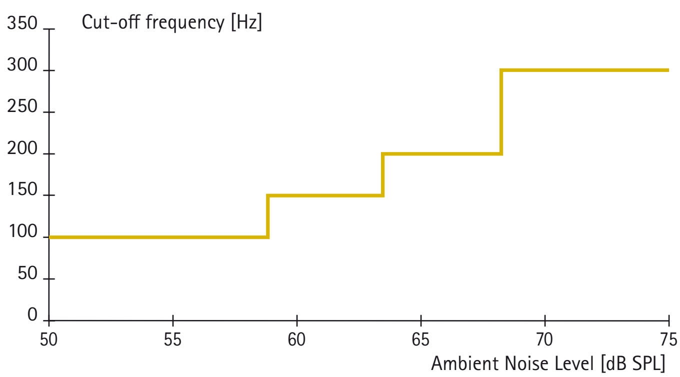


Figure 6.
The cut-off frequency of the Dynamic Equalizer increases with increasing ambient noise level.

will sound completely natural, with an overall combined frequency response that is flat. To minimize late reverberations from the amplified signal, a high pass filter is applied at higher gain levels. Higher gain levels are applied in noisy conditions, and reverberation increases noise levels in classrooms, so the limitation of late reverberations by acoustic filtering at higher gain levels makes sense.

The exact cut-off frequency of the high pass filter is dependent on the ambient noise level. For higher noise levels, the cut-off frequency is increased from 100 Hz to 300 Hz with two intermediate steps. This not only limits late reverberations, but also puts an emphasis on higher frequencies for better speech understanding, due to the increased audibility of mid- and high-frequency consonants and limiting upward spread of masking by low frequency sounds. The limitation of late reverberations which, psycho-acoustically speaking function like noise, improves speech understanding. The intelligent design of the loudspeaker unit (see paragraph 5) also limits late reverberation and is complementary to this filtering effect.

3. Digital Wireless Transmission Technology

Traditional soundfield systems use different transmission technologies to transmit the voice of the teacher to the loudspeaker. There are wired and wireless technologies available. Wired solutions limit the teacher's mobility in class tremendously and in modern day educational settings this is no longer considered a viable option. Wireless technologies are based on either infrared transmission or FM technology. Both of these wireless technologies can transmit sound either in an analogue way or digitally. The choice of transmission technology in the development of a new soundfield system has a tremendous impact on several very important features of the final product:

- What is the operating range of a transmitter?
- Is a free line of sight required between transmitter and receiver?
- How much power does a transmitter consume and as a consequence what is the autonomy of a fully charged transmitter battery?
- What is the audio bandwidth?
- What is the noise floor and what is the system's dynamic range in the audio domain?
- Are any dead spots in a classroom likely to occur where the transmitter does not reach the receiver and the loudspeaker does not amplify the voice of the teacher?
- Is any interference possible from similar nearby systems or from any other appliances such as WiFi, tube lighting, Bluetooth devices, or from sunlight (as often is the case with infrared systems)?
- Is it possible to send and receive or only to send?
- Is it possible to send and receive something other than the audio signal, such as control data, in parallel to the audio stream?
- Is it possible to combine soundfield with a FM system?
- Does one need additional devices such as reflectors to reach all corners of a classroom?
- How many channels can be used simultaneously without interference?
- How difficult and flexible is channel planning?

After careful and extensive analysis of currently available technologies Phonak decided none of these were really doing an excellent job at fulfilling all these goals. Under ideal conditions all technologies can deliver a voice signal to a loudspeaker, but not much more was possible with these systems. In challenging situations interferences or dead spots occur frequently. Advanced and more intelligent features to improve system performance did not appear to be possible with today's transmission options. For Dynamic SoundField, Phonak therefore developed a totally new digital wireless transmission technology: DM.

DM stands for Digital Modulation. It is a newly designed highly intelligent digital transmission technology in the 2.4 GHz band. Audio signals are digitized and packaged in very short (160 µs) digital bursts of codes and broadcast several times each at different channels between 2.4000 and 2.4835 GHz. Frequency hopping between channels avoids any interference issues and repetition of the broadcast ensures correct reception. If the system detects that a given channel is occupied, for instance by a WLAN network or Bluetooth, it will notice this and automatically hop around these occupied channels. And if, despite all efforts, an audio package is not received correctly, intelligent packet loss concealment algorithms on the receiver side (in the loudspeaker unit) "fill in the blanks" to ensure superb sound quality and listening comfort.
DM also enables impressive sound quality thanks to an audio frequency bandwidth, from 200 to 7500 Hz, and a signal to noise ratio of >55 dB. With DM no frequency planning or allocation of frequencies to specific classrooms is required, unlike with systems that use FM as their chosen transmission technology.

As 2.4 GHz is a freely accessible band worldwide (a so-called ISM band: Industry, Scientific and Medical), no license is necessary. DM systems can be used without any problems in adjacent classrooms and are highly robust against interference from other Dynamic SoundField systems, Bluetooth devices, WLAN, tube lighting and so on. Dynamic SoundField uses intelligent antenna designs to ensure the best possible operating range and dead spots therefore become a thing of the past. Of course, no line of sight is required as it is with many infrared systems, and interference from sunlight or other strong light sources is also no longer an issue.

With DM technology it is not only possible to transmit an audio signal, but also to transmit and receive control data, for instance such as is required when setting up and/or maintaining a Phonak MultiTalker Network (see paragraph 7) and to continuously monitor various network components to ensure proper operation. The pairing of **inspiro** with Dynamic SoundField's DigiMaster loudspeaker unit is required, which is very easy to do, but once paired the two components stay paired, including after switch Off.

DM's power consumption is well within reasonable limits and a fully charged **inspiro** battery will last 7 to 8 hours when operating in dual Dynamic SoundField and Dynamic FM mode; easily long enough to cover a full school day.

Although not directly visible from the outside, Phonak's choice to develop a new transmission technology will no doubt prove to be crucial to the success of Dynamic SoundField. DM technology has enabled Phonak's team to devise a long list of new possible features, including the Dynamic Speech Extractor, MultiTalker Network, Monitoring, the end of frequency planning and allocation, and what's more, DM delivers the basis for supreme system performance.

4. Combining Dynamic SoundField with Dynamic FM

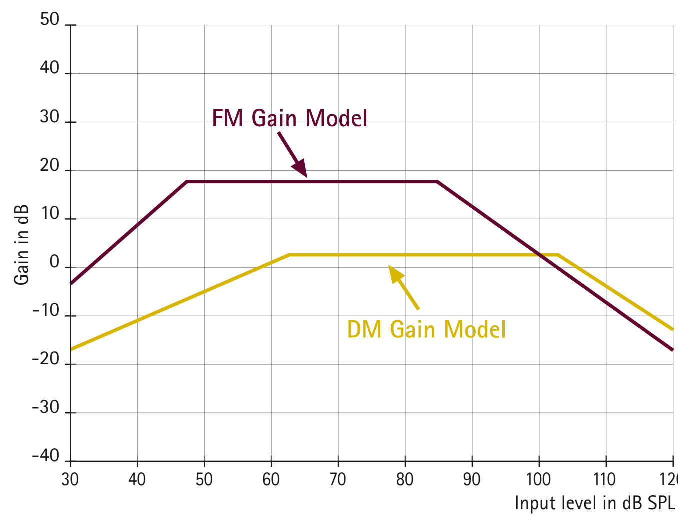
More and more students with hearing loss who wear hearing instruments or have received cochlear implants, go to regular mainstream schools. In these schools, these pupils often need a wireless FM system to hear the voice of the teacher well. In an increasing number of classrooms therefore soundfield systems are being used for children with normal hearing, while FM systems are used for one or more children with a hearing loss. This means that the teacher potentially needs to wear two wireless microphones; one for the soundfield system and one for the FM system. This is cumbersome and in truth no teacher wants to wear two microphones and two transmitter packs. Therefore in many cases, the FM transmitter is connected through an audio cable attached to its audio input to the audio output of soundfield loudspeaker unit, or one of the two systems, FM and soundfield, is simply not used.

Combining soundfield technology with personal FM systems has always proven difficult and more or less ineffective. One major drawback for instance is that by feeding a soundfield loudspeaker output through the audio input of a Dynamic FM transmitter, all the benefit of an adaptive FM Advantage is lost. Feeding the signal of a FM transmitter into a soundfield loudspeaker may prove to be ineffective as FM systems have usually a noise floor, which is perfectly okay for listeners with hearing impairment, but which is hardly acceptable for normal hearing students.

Figure 7.
The **inspiro** transmitter is capable of simultaneously transmitting an audio signal through FM radio waves towards ear level FM receivers, and DM radio waves towards the DigiMaster 5000 Dynamic SoundField loudspeaker.

Verification of the combination of a FM system and a soundfield system has continually posed real challenges to educational audiologists. It is often impossible to reach the target output for both systems with traditional technologies.

Gain – Input level



Statik transfer function

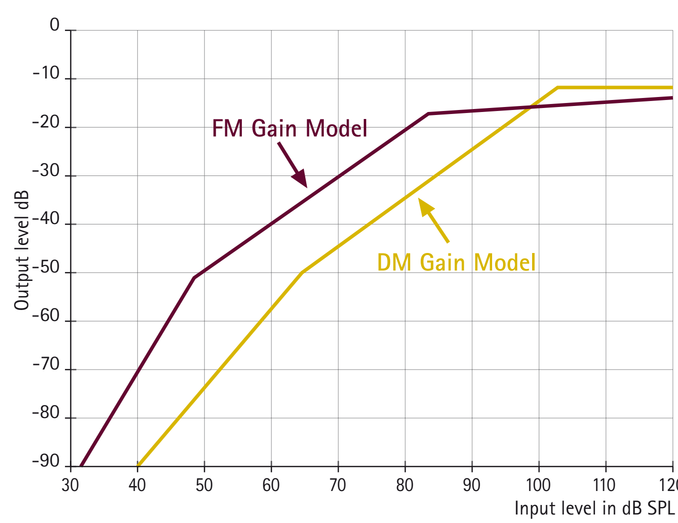


Figure 8.
Gain models for a FM system (black line) and for a soundfield system (yellow line). In the upper diagram gain as a function of input level is depicted, in the lower diagram an input-output diagram is shown.
It is clear that overall gain levels and kneepoints are markedly different for FM and for soundfield.

With Dynamic SoundField Phonak has solved this dilemma once and for all, by combining both Dynamic FM and Dynamic SoundField transmission technologies inside one transmitter while offering two optimized digital audio signal processing schemes for both applications. The gain model for FM is markedly different from the gain model for a soundfield system, however this is dealt with automatically.
Once the voice of the teacher is picked up by the EasyBoom microphone and converted to a digital signal by an AD converter, the signal paths for Dynamic FM and Dynamic SoundField are separated.

The gain models for soundfield and for FM are different for various reasons: firstly of all the definition of gain is already different for both systems. Secondly, the output of a FM system is fed into a hearing instrument, which means a certain range of optimal output level of the FM receiver has to be observed. The output of a soundfield system is the amplified sound coming out of the loudspeaker. Here the optimal listening conditions by students with normal hearing need to be observed, and feedback as a consequence of a gain which is set too high limits the maximum gain.

inspiro can operate as a Dynamic FM transmitter, a Dynamic SoundField transmitter, or can transmit both at the same time. Of course the operating mode of **inspiro** can be changed between these three modes at any time and at no cost, with the help of Phonak's FM SuccessWare. In order to ensure Dynamic SoundField's peak functionality, the new EasyBoom microphone must be used, as the FM gain model used was calculated taking the sensitivity of this microphone into account.

With this exclusive and highly effective approach, all the hassles, challenges and doubts involved with combining a FM system with existing types of soundfield system are a thing of the past. By employing separate dynamic gain models for both FM and soundfield, and by employing different transmission technologies for both applications, no compromises need to be made on either side.

5. Loudspeaker Design

The design of the loudspeaker has a big impact on the distribution of sound throughout a room. Indeed it is not for no reason that attempts have taken place to rename soundfield products 'audio distribution systems'. To help evenly distribute amplified sound throughout a classroom some manufacturers have even gone as far as to offer four loudspeakers, which need to be mounted at different locations in the classroom. This approach, which results in cumbersome systems, is usually the result of lackluster loudspeaker design and no or insufficiently working feedback cancellation algorithms. On top of that, an evenly distributed sound is not the same as a good signal-to-noise ratio when it comes to understanding speech.

Dynamic SoundField's DigiMaster 5000 loudspeaker unit features a line array of 12 miniature high quality loudspeakers. The maximum average output level is 89 dB SPL at 1 m distance (with the volume control turned up by +8 dB, an ambient noise level of >60 dB SPL and a speech level of 75 dB SPL at 1 m distance) and the maximum peak level at 1 m is 96 dB SPL. The height of the array is 650 mm and the distance between the centres of two adjacent loudspeakers is 54 mm.

This design has the effect that the array emits sound predominantly in the horizontal plane, with a good horizontal spread, but with a low vertical spread. The vertical aperture of the main sound lobe at 500 Hz is +/–25° and at 2000 Hz no more than just +/–7°.
The result is that sound is amplified and spread throughout the room differently from a single loudspeaker unit (also called a "monopole"

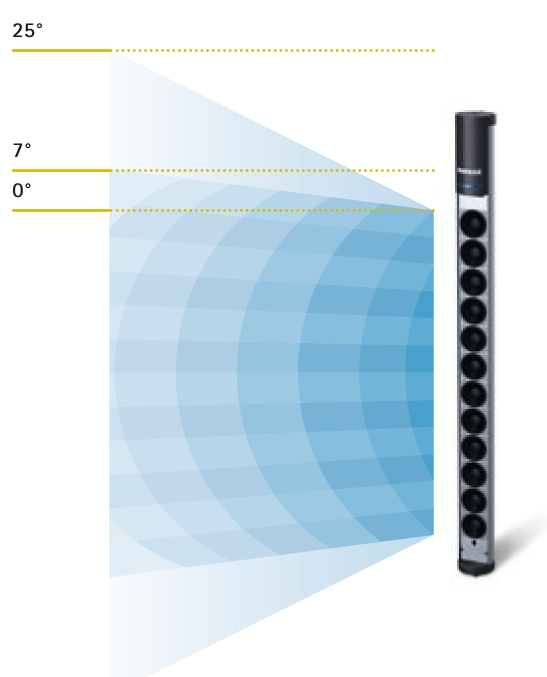
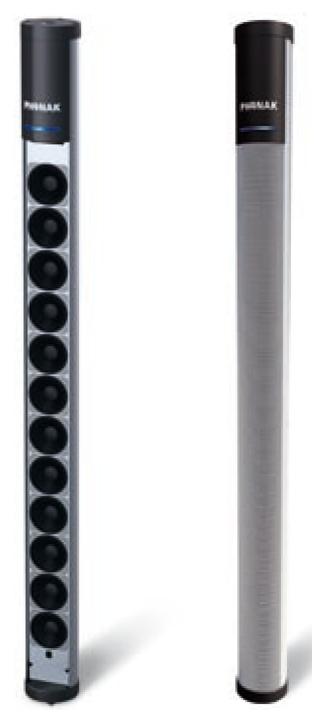


Figure 9.
Main acoustical lobes at 500 Hz and 2000 Hz with an aperture of +/–25° and +/–7° respectively.

loudspeaker). Whereas monopoles operate like point sources, spreading sound evenly in all directions (including unwanted directions like away from the students and towards the ceiling and the floor), the DigiMaster 5000's design drastically improves the ratio between the direct signal and the reverberant field. The direct signal is the signal that reaches the ear directly from the loudspeaker unit, following a straight line. The reverberant field reaches the ear after one or more reflections or echoes off walls, floor or ceiling. If the number of reflections remains limited, the reverberant field can be integrated in the brain together with the direct field to form a comprehensible signal. If the number of reflections is too high however, and the signal path too long, the delay of the reverberations becomes so large that the brain can no longer integrate this with the direct sound. Such so-called "late" reverberations are nothing less than noise. Poorly designed loudspeaker units create many late reverberations and in classrooms with poor acoustical properties these loudspeakers are unable to truly improve the signal-to-noise ratio at the students' ears. Since the DigiMaster 5000 is highly directive, the height of the loudspeaker is very important. The height of the loudspeaker must be optimized for the whole classroom. Therefore the middle of the array must ideally be placed at the height of the students' ears. The stand of the DigiMaster 5000 has been produced with this aim in mind, in that the centre of the array stands 1.40 m. For the wall fixation, an angle of 5° has been defined in order to optimize the sound propagation in the classroom.

The height of the array and its number of loudspeakers were deliberately chosen to optimize acoustical performance, and at the same time keep production and shipping costs within acceptable levels. More loudspeakers would have meant significantly higher costs, while the increase in acoustical benefits would become smaller and smaller with each additional loudspeaker. Fewer loudspeakers would indeed lead to a less expensive system, but its performance would no longer fulfill our stringent requirements. The DigiMaster 5000 has been designed to deliver optimal value for money.

An LED at the top of the DigiMaster unit indicates the current status of the system (working, Off etc.). An audio input socket (3.5 mm jack, >10 kΩ input impedance) meanwhile is used to hook up the DigiMaster 5000 to smartboards or any other type of audio systems.



DigiMaster 5000

6. Feedback suppression

Feedback is the phenomenon of sound, produced by a loudspeaker, feeding back into the microphone and therefore becoming amplified even more. This leads to annoyingly loud and sometimes dangerous whistling sounds, or alternatively to someone (in the case of soundfield a teacher, school audiologist or technician) setting the gain so low that potentially all benefits are lost. Setting the gain higher meanwhile will increase the minimum distance a teacher needs to keep away from the loudspeaker.

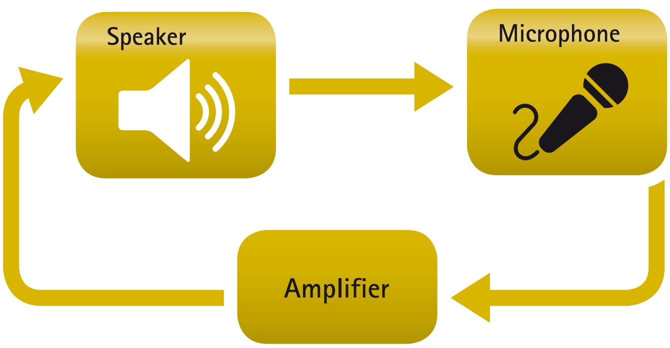
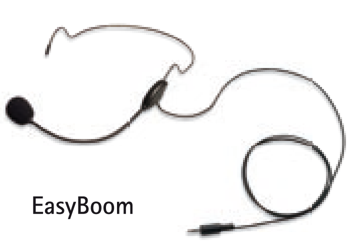


Figure 10.
The principle of audio feedback.

To minimize such feedback problems different issues must be considered:

- the design of the soundfield microphone
- the number and design of the loudspeaker unit
- the gain (volume setting) of the soundfield system
- the distance between the microphone and the loudspeaker unit
- and the possible deployment of advanced feedback suppression algorithms.

A soundfield system that creates feedback all the time is simply not usable. Feedback suppression algorithms that limit the gain to unacceptably low levels, or that create audible or even disturbing distortion of the audio signal, do not give the required benefit or listening comfort. Dynamic SoundField's hardware is designed to minimize feedback from the start through using some of the most advanced feedback suppression algorithms around today. Two main components help minimize feedback: the EasyBoom microphone and the DigiMaster 5000 loudspeaker unit (*left*).



EasyBoom

The EasyBoom microphone, with its directional sensitivity and close-to-the-mouth positioning, picks up the voice of the teacher at the perfect place and at a high sound pressure level, whereas for instance using a lapel-worn microphone immediately limits the amount of amplification available to the soundfield system, seriously compromising the benefit for the students. The DigiMaster 5000 loudspeaker unit radiates sound waves predominantly in the horizontal plane. As it is not a point source, at least not at close proximity, it is capable of delivering higher sound pressure levels than a monopole loudspeaker at the same distance, or loudspeaker arrays with just two or four loudspeakers at the same amplification (amplification here being defined as the level of the amplified speech at the teacher's microphone position). As the teacher is often in front of the class and the loudspeaker array in most instances is also at the front, less gain is required to reach the same sound pressure level at the back of the classroom. In addition to its highly optimized hardware design, Dynamic SoundField also uses an intelligent feedback suppression system. This dual suppression system employs two different algorithms; one operates in the time domain at low system gain settings (which generally equals fairly quiet conditions) and at higher gain settings a different algorithm, which operates in the frequency domain, takes over. The feedback suppression algorithm active at low gain is optimized to deliver the best possible sound quality. In quiet conditions even the slightest distortion can be heard and should be avoided. As the gain of the Dynamic SoundField system in quiet conditions is relatively low, the system can afford to deploy a fairly mild form of feedback suppression. In fact, in fairly quiet conditions the audio signal does not go through the so-called Wiener Filter for feedback suppression. As long as there is no feedback the feedback canceller does not create any artifact, distortion or reduction of gain. The pure audio signal, as picked up by the EasyBoom, is used for amplification.

In noisy conditions distortion levels can be higher before they are noticed above the background noise. As it is in noise, the gain of the Dynamic SoundField is increased automatically and a more rigorous feedback suppression algorithm is required. The two feedback suppression algorithms are activated automatically depending on the actual gain of the Dynamic SoundField system, and therefore depending on the noise level in the classroom.
By taking this innovative approach Dynamic SoundField delivers optimal sound quality, avoids feedback even at high gains in noisy conditions, and does not limit the teacher's freedom of movement throughout the class.

7. MultiTalker Network

Children do not only learn from their teachers, but also from each other. The possibility to amplify not only the voice of the teacher but also the voices of other children (or a second teacher, assistant teacher or therapist) is a real asset for any soundfield system.
The same is true for FM systems. In the past a technology called "team teaching" mixed the voices of two wireless microphones into one signal for the students with hearing instruments and FM receivers. However in 2008 Phonak introduced its MultiTalker Network (MTN), with which several transmitters could transmit at the same frequency. This resulted in less noisy systems and solved many practical issues, such as eliminating the need to carefully select different FM frequencies for team teaching to avoid interference and legal issues.
In the MultiTalker Network an **inspiro** transmitter is in charge. The opportunity for other transmitter users to speak is given based on priority rules embedded in the network and the availability or lack of a speech signal at the microphone of each transmitter. Once set up, the MTN runs automatically and intuitively.
The development of Dynamic SoundField technology provided Phonak the opportunity to embed the proven concept of MultiTalker Network right from the start. The maximum number of **inspiro**/DynaMic transmitters that can be used in the MultiTalker Network is 10.

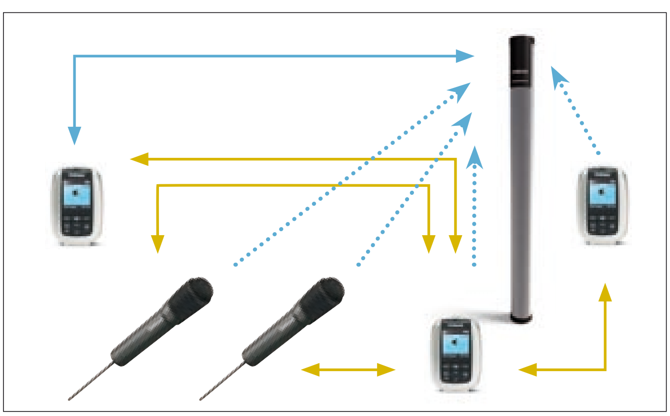


Figure 11.
In the MultiTalker Network (MTN) one **inspiro** transmitter is in charge. The opportunity for other transmitter users to speak is given based on priority rules embedded in the network and the availability or lack of a speech signal at the microphone of each transmitter. The yellow lines stand for the continuous communication between the master **inspiro** and the other transmitters in the MTN, the blue dashed lines symbolize the standby mode and the blue line the active mode of the transmitters.

8. Energy saving design

Thanks to its dedicated power supply the DigiMaster 5000 fulfills the Eco Design Standards for Europe released in January 2010. When the DigiMaster 5000 is switched Off its power consumption is less than 0.5 W. In standby mode (**inspiro** switched Off but DigiMaster 5000 still On) this is less than 1 W.
During normal operation in class, a DigiMaster 5000 typically consumes about 3 W. Compared to the energy used in lighting a classroom this is a mere fraction of the power and hence a fraction of the cost.

9. Upgrades

Schools want to benefit from developments in technology without having to continually purchase new equipment. This future-facing functionality is exactly what Phonak's Dynamic SoundField system offers. Both the **inspiro** transmitter and the DigiMaster 5000 loudspeaker array unit work like small computers on which software, called firmware, runs. This firmware determines to a large extent what functionality is possible and how the system behaves. If new or improved features become available in future, a free internet download of the latest Dynamic SoundField firmware version will make these features available in a matter of minutes, without the customer having to ship any products back to Phonak. In the past for example, **inspiro** firmware upgrades gave customers access to new and improved features including the possibility of wirelessly monitoring newly released Dynamic FM receivers, and adding new language options to the menu. The ultimate free-of-charge upgrade however is that every existing **inspiro** transmitter can now be upgraded to become a Dynamic SoundField transmitter!

Figure 12.
Both the **inspiro** transmitter and the DigiMaster 5000 loudspeaker unit feature a USB connection for firmware upgrades.

10. Latest results: formal testing of speech understanding in noise in a classroom setting

Formal tests of speech understanding in a reverberant classroom at different noise levels were held at a school in Murten, Switzerland to quantify and objectify the benefit of the Dynamic Speech Extractor used by Dynamic SoundField. 10 students were tested in free field with the German Oldenburger Satztest (sentence test). Speech was generated through a loudspeaker in a mannequin in front of the class, to simulate a teacher. The mannequin wore an **inspiro** with EasyBoom microphone as a teacher would wear it. Speech was played back in two conditions: with Dynamic SoundField switched Off and with it switched On. The DigiMaster 5000 loudspeaker unit was placed to the left of the mannequin, 1 meter from the back wall and 1.80 m away from the left-hand wall of the classroom.

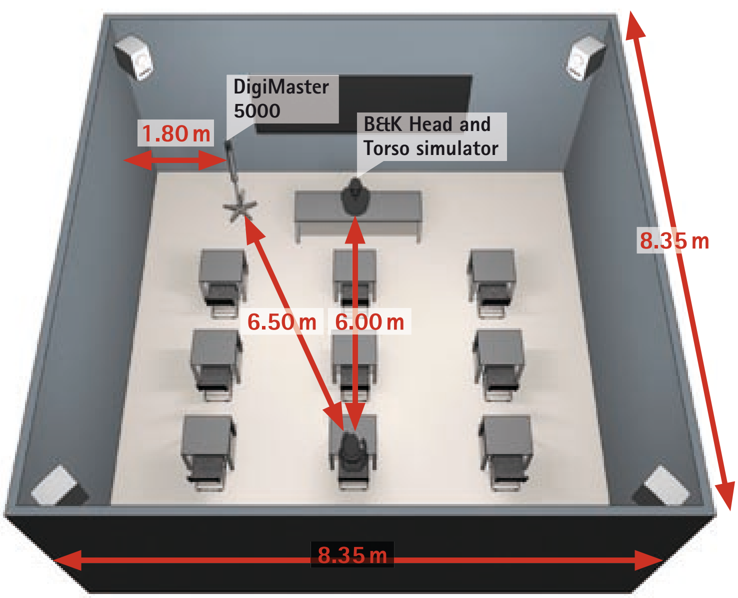


Figure 13.
Test setup for speech understanding measurements. The classroom was 8.35 by 8.35 meters.
The loudspeakers generating noise were positioned in the four corners of the classroom at 1.7 meter height.

Four loudspeakers were placed in the four corners of the class, which generated a diffuse noise field.
Students were placed either 3 meters or 6 meters from the mannequin, corresponding to a distance of 3.80 and 6.50 meters from the DigiMaster 5000 respectively.
Speech understanding tests were carried out at 50, 60 and 70 dB SPL ambient noise levels. Speech was presented at normal conversational level (65 dB SPL at 1 m at 50 and 60 dB SPL ambient noise level) and at a slightly increased level (69 dB SPL at 1 meter) for the 70 dB SPL noise condition. Without Dynamic SoundField the average speech understanding scores were 95%, 25% and 0% at 50, 60 and 70 dB SPL noise levels. With the Dynamic SoundField system switched On, average speech understanding scores were above 95% in all noise conditions, including the 70 dB SPL noise level.

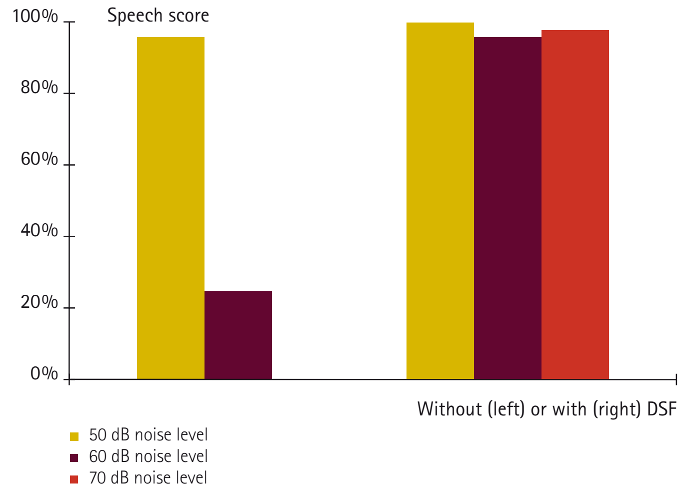


Figure 14.
With Dynamic SoundField speech understanding increases dramatically at 60 and 70 dB SPL ambient noise level, from 25% and 0% respectively to circa 95%.

It is highly unlikely that any type of acoustical treatment could even approach these results; going from no speech understanding at all to close to 100% speech understanding at 70 dB SPL ambient noise level at a distance of 6 meters away from the teacher.

11. List of abbreviations

ANSI	American National Standards Institute
B&K	Brüel and Kjær
dB	Decibel
DfES	Department for Education and Skills
DM	Digital Modulation
DSF	Dynamic SoundField
FM	Frequency Modulation
GHz	Gigahertz
Hz	Hertz
ISM Band	Industry, Medical, Science Band
LED	Light Emitting Diode
m	Meter
µs	Microsecond

MTN	MultiTalker Network
RT	Reverberation Time
s	Second
SNC	Surrounding Noise Compensation
SNR	Signal to Noise Ratio
SPL	Sound Pressure Level
STI	Speech Transmission Index
USB	Universal Serial Bus
W	Watt
WHO	World Health Organization
WLAN	Wireless Local Area Network
Wrms	Watt root mean square

12. References

1) WHO: http://whqlibdoc.who.int/hq/1999/a68672.pdf
2) ANSI S12.60-2002 American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools
3) Building Bulletin 93 (BB93), http://www.teachernet.gov.uk/management/resourcesfinanceandbuilding/schoolbuildings/environ/acoustics/
4) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:339:0045:0052:EN:PDF

EasyBoom

inspiro

DynaMic

DigiMaster 5000