



# All About FM

A guide on the benefits of using FM systems with hearing aids

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# Introduction

Understanding speech in noisy environments can be difficult for any child, but for a child with hearing loss it is even more challenging. Children need access to speech to develop their hearing, language, and learning skills. Background noise, distance from the person speaking, and reverberation (echo) are common obstacles that significantly reduce the child's access to crucial speech information. Although today's advanced hearing aids can improve the quality, audibility, and clarity of the speech signal, they cannot remove all obstacles to speech understanding.

FM technology is the most effective way to improve speech understanding in difficult listening situations. FM systems work in tandem with the child's hearing aids by adding a special, remote microphone that can be placed much closer to the speaker. This transmits the speech signal directly to the ear, thereby limiting the influence from noise, distance, or reverberation.

There is a major difference between hearing speech (audibility) and actually understanding it (intelligibility). Children need to be able to understand sounds. They also need to be able to differentiate between sounds and words. And FM systems can definitely help. The purpose of this booklet is to provide parents, teachers, and caregivers with comprehensive information about the invaluable benefits of these systems, both at home, at school, and at play.



## The Need for FM



Children with hearing loss, however mild, rarely talk about their inability to understand family members or the teacher. If they are young and still learning language, they are unable to tell when speech is unclear or buried in background noise. In many cases they may not even be aware that they missed a question or misunderstood directions. It is well documented that children with hearing impairment, as well as those with normal hearing, demonstrate difficulty in understanding speech when there is background noise, distance between

the speaker and the child, and reverberation (echoes).

### **When noise muffles speech**

Background noise is present in most listening environments including classrooms, kitchens, and sporting events. Hearing aids cannot selectively amplify only the speaker's voice; they also pick up background sounds. In many difficult and noisy situations hearing aids alone cannot make the speaker's voice clearer or even louder. Sometimes the level of the speech signal might actually be lower than the level of the background noise.

The comparison of speech and noise levels is referred to as signal-to-noise ratio (SNR), and it represents the difference in loudness between the primary signal (i.e., teacher or family member) and the background noise. The greater the distance between speaker and listener, the less intense the sound becomes, making it more difficult for the listener to hear properly since background noise often remain the same. In other words, the lower the SNR, the more difficult it is for the listener to understand. A child with hearing loss needs the speech signal to be substantially louder than the noise - even higher than the level required by his or her normal-hearing peer in the same situation.

### **How FM redresses the balance**

FM technology improves SNR considerably. It picks up the speaker's voice virtually centimetres from the mouth and instantly delivers it to the ear for amplification. The distance the sound must travel from the speaker to the hearing aid is no longer an issue, as the FM microphone reduces that distance to mere centimetres.

The effect is as if the person speaking, (originally at a distance from the child and surrounded by noise), is now talking at a comfortable level directly into the child's hearing aid. The result is a clear, consistent supply of information, which maximizes speech understanding at all times.

Research demonstrates\* that when children use an FM system for a period of time, their rate of language development - especially grammatical complexity - actually matches that of their classmates. FM systems also help to reduce the delay in language so often related to hearing impairment. Another benefit is that they make children feel more secure; even when their caregivers move out of sight, they remain within hearing range.

In short, FM technology is a highly effective tool that helps children with a hearing loss overcome the three major obstacles to speech understanding: noise, distance and reverberation.

## Obstacle I: Noise

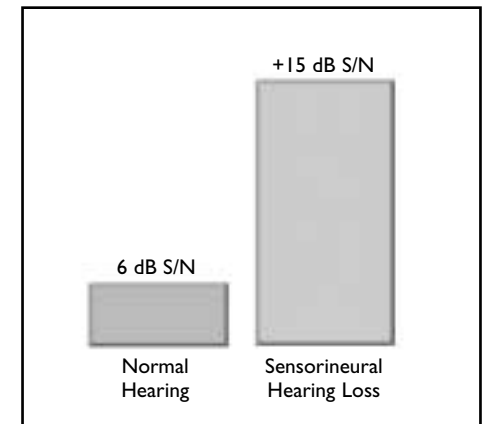
Background noise exists in most listening environments; it can emanate from both inside and outside the home or classroom. We all know how difficult it can be to follow a conversation while the television is on or the radio is playing. For children with hearing impairment, noise is more than just an annoyance. The sound of a radio or television, people talking, street traffic, playground noise, feet shuffling, papers rustling, desks and chairs moving, fans or heaters all place great demands on the child's ability to hear and understand speech.

Noise causes a general breakdown of communication and speech to such a degree that it can affect the child's performance at school. Background noise can interfere with the speech signal and either muddle it up or make it completely inaudible. And the child might miss vital directions and information given by the teacher or family member.

A number of studies\* have measured the intensity of background noise in classrooms. For a student with a hearing loss to receive the teacher's voice, the speech signal



should be 15 to 20 dB louder than the background noise. In many classroom settings, the teacher's voice is at a level of approximately 65 dB, and the background noise is approximately 60 dB (equivalent to the level of noisy typewriters in an office). This leaves a signal-to-noise ratio (SNR) of only 5 dB (65 dB - 60 dB = 5 dB). Since an SNR of 15 to 20 dB is desirable, the average classroom with a 5 dB SNR is clearly inadequate for the student with a hearing loss. Children with normal hearing also suffer when there is a poor SNR.



Required SNR, signal-to-noise ratio for speech understanding

6 \* Bess, F.H., Sinclair, J. S., & Riggs, D. (1984). Group amplification in schools for the hearing-impaired. *Ear and Hearing*, 5, 138-144. Crandall, C., & Smaldino, J. (1994). An update of classroom acoustics for children with hearing impairment. *The Volta Review*, 96, 291-306.

## Obstacle II: Distance

Hearing is a sense that entails not only the loudness and intensity of sounds, but also distance or range. A child with a hearing loss has a reduced hearing range or a smaller listening bubble than a child with normal hearing. When listening to someone talking from another room, you are using your hearing range or have a listening bubble that includes sounds of that loudness, intensity and distance. For the hearing-impaired child this range is much reduced, they have smaller listening bubbles, and the distance suddenly becomes an obstacle to understanding speech.

Research has shown that a child should be within 1-2 meters of the speaker for maximum speech understanding. This is not always possible to achieve either in the classroom or at home. Also, as the distance between the listener and the speaker increases, so does noise and reverberation.

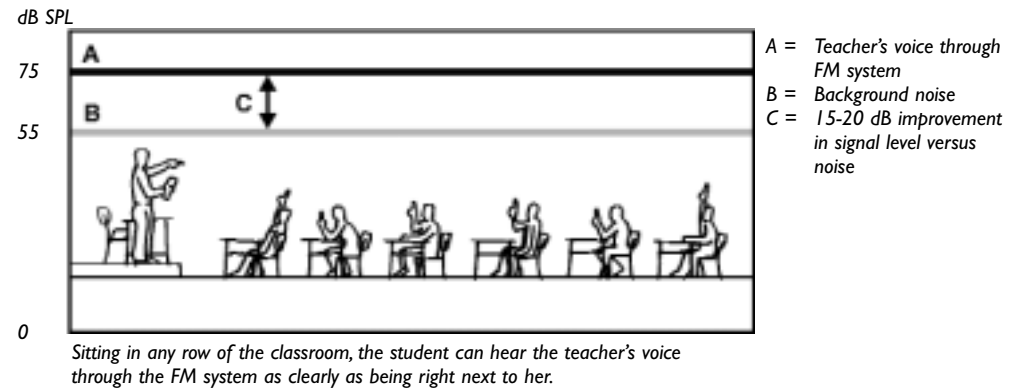
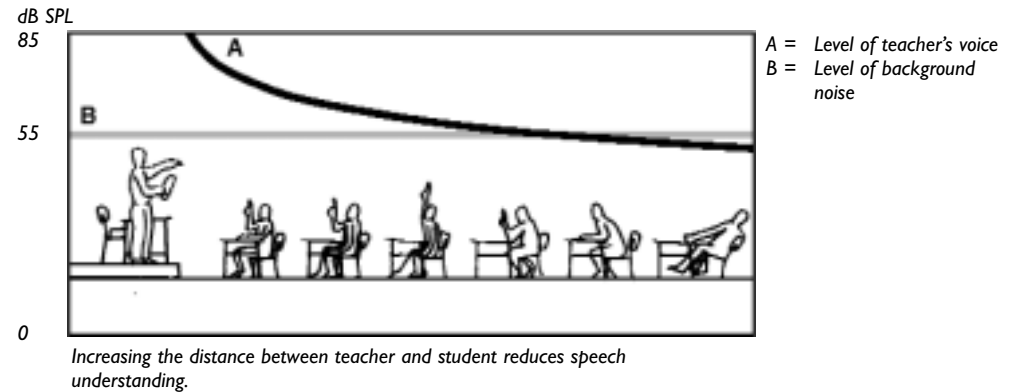
The speech signal drops 6 dB each time the distance doubles. Children in school usually sit at least one meter from the teacher. If the teacher's voice starts at 85 dB it drops to 65 dB just one meter away. This is the average level of sound



for conversational speech, and it illustrates why children with hearing impairment require a higher signal level.

Distance can also be a challenge at home. There are many situations in which children are far away from

the speaker. When playing outside or while eating dinner, factors such as distance, reverberation and noise have a detrimental affect on the speech signal. When children are out of sight, both they and their families feel more secure knowing that they can still hear each other.



## Obstacle III: Reverberation

Another obstacle to speech understanding is reverberation - more popularly known as echo. The reflection that sound makes when it 'bounces' off a surface can actually mask, or muffle the main signal. It can reduce the clarity of speech, decrease the signal-to-noise ratio (SNR) and make speech understanding more difficult.

Sounds reverberate in all rooms; some more than others, depending on the construction and furnishings. Hard walls, high ceilings, glass

windows, and uncarpeted floors common to many classrooms and kitchens reflect sounds much more than carpeted floors and acoustically treated walls and ceilings. Basically, the sound bounces off the hard surfaces (e.g., glass and tile) instead of being absorbed as by soft furnishings such as carpets and pillows.

Reverberation is the time it takes for a sound to lose its intensity by 60 dB (e.g. from 60 to 0 dB). This should be no higher than 0.3 to 0.4



seconds for people with hearing loss. Many studies have demonstrated that the higher the reverberation time (greater than 0.6), the more difficult it becomes to understand speech. Measurements taken in normal classrooms log an average reverberation time of 0.8 seconds, which is twice the recommended level. This makes understanding the teacher even harder. Reverberation can also be high at home in places like the kitchen, bathroom, and laundry room.

Improving the listening conditions can help your child's speech perception. Both at home and in the classroom you can decrease the reverberation time and improve the acoustics by using soft, absorbent materials such as carpeting, pillows, and curtains.

## Solution

Let us look more closely at how FM systems help to overcome barriers such as noise, increased distance, and reverberation.

### Less noise

FM systems reduce noise even more effectively than the special, directional microphones in today's hearing aids. They also create a higher signal-to-noise ratio (SNR). By providing more information, FM systems improve speech understanding and enable children to develop their language skills.



### Less distance

Where distance is concerned, FM systems can bring the sound closer to the listener without losing its energy and thus improve speech understanding. Since the speaker's mouth is approximately fifteen centimetres away from the microphone, physical distance is no longer an issue.

### Less reverberation

Where reverberation is concerned, FM systems help to overcome the detrimental effects by delivering the sound directly to the child's ear. The direct delivery prevents the echo from masking the speaker's signal and making it less intelligible. FM systems can never completely eliminate background noise or reverberation, but they can substantially reduce the effects. They also offer high-quality amplification of the teacher's or family member's voice to the child.

### Other benefits

FM systems help the child to remain attentive at school and at home. They also help to reduce fatigue. Teachers and family members can also relax their vocal effort;



being wireless, the FM system allows the speaker to move freely around the room while talking, without having to speak loudly. The child also gains a higher level of freedom and independence.

Finally, the FM system offers an opportunity to learn incidentally through experience and interaction, as opposed to having to be explicitly taught.

## At Home



Children with a hearing impairment need consistent access to the spoken language, not just in the classroom, but throughout the day. Domestic life offers countless opportunities for learning language - from sorting the laundry to making cookies. But many reverberant and noisy situations remain, in which communication can be difficult. At home around the dinner table, the noises of the dishes, cutlery and people talking all compete with each other. This puts everyone - particularly the child with a hearing

loss - at a disadvantage. In a car the engine noise coupled with the noise from the traffic can also make hearing and understanding difficult - especially if the child is seated in the back.

The whole family can benefit from using FM systems at home. During tutorial sessions an FM system improves the signal-to-noise ratio (SNR) so that background noise becomes less distracting. Listening to the TV or to a speaker (e.g., at Sunday school) also becomes easier,

since the sound is delivered directly to the child's ear.

FM systems help the child hear and understand directions and requests in places such as the grocery store, in the car, at the zoo or in the playground. They can even be helpful for leisure activities - whether it's

piano lessons, soccer practice, gymnastics or computer games. Family vacations or gatherings are also more enjoyable when the child has constant access to the speech signal.



## At School

Hearing impairment of any type and degree affects a child's ability to learn language and acquire knowledge.

The classroom can be classified as an 'auditory-verbal' environment

where children are expected to learn by listening. 70-90% of the information provided is given verbally. Visual aids are not always available and teachers often move from one child to the next, further impacting the distance between stu-

dent and teacher. Children also often work in groups, limiting the opportunity for favourable seating arrangements. Since children spend 75% of their day engaged in auditory activities they need clear and consistent access to their teachers and classmates.

Classrooms are noisy; many studies report background noise levels between 55-75 dBA, equivalent to the level of noisy typewriters in an office. The recommended maximum level is 35 dBA. FM systems are designed to increase the loudness of the teacher's voice to improve the SNR and eliminate the detrimental competition of noise. When used in a typical classroom environment, FM systems deliver auditory information to the child, easily and consistently.



## How FM Works

FM systems contain two primary elements: a microphone (sometimes called a transmitter) and a receiver. The microphone picks up the speech sounds from the speaker and sends them to the receiver via a specific FM radio frequency. The family member, friend, or teacher wears the microphone and the child

with a hearing impairment wears the receiver, connected to his or her hearing aids. Transmission occurs instantly and effortlessly, requiring no adjustments or changes in routine for either the speaker or listener.



*The handheld microphone Lexis from Oticon. It can also be worn around the neck or clipped to your shirt pocket*



*A lapel microphone clips easily on to your clothing*

### Microphones

Many different types of microphones and receivers are available. Microphones range from a lightweight, handheld device resembling a slim cell phone to a body-worn microphone (like a small personal stereo) with a cable coupled to either a small clip-on lapel microphone or a "Madonna" boom microphone. This attaches behind the ear or neck and runs along the cheek to the mouth, (see picture on page 18).



*A body-worn transmitter with a lapel microphone*

## Receivers

A variety of wireless receivers are also available, ranging from ear level to body worn. The ear level receivers are the smallest and, as the name implies, they attach to the hearing aid at ear level. An accessory adapter (also called a 'shoe') is sometimes needed to physically couple the FM receiver to the hear-



*Hearing aid with dedicated FM receiver*

ing aid. Some receivers (dedicated) are specifically made for one model of hearing aid and connect directly to it without the need for the coupling adapter. The hearing aid may also contain an internal receiver and act as a combined hearing aid/receiver.



*Hearings aid with adapter (shoe) and universal FM receiver*



Body-worn receivers transfer sound in different ways. Some use a cord that runs from the receiver and plugs into the coupling adapter, which is attached to the hearing aid. Others use a cord that is worn around the neck. This is called a neck loop, and instead of plugging directly into the hearing aid's cou-

*Body-worn receiver and neck loop*

pling adapter, it transfers the sound via magnetic induction to the telecoil (T-coil) of the hearing aid.



*A body-worn receiver with a cord to coupling adapter and hearing aid*

### Other features

Regardless of the style of FM transmitter or receiver, the function and benefits are similar. FM systems can be used with any degree of hearing loss. Some microphones may have special features to further suppress

background noise or to process the speech sounds before the signal is delivered to the hearing aids. Some FM systems might have features that are better for younger or older children. Your hearing care professional can discuss the advantages and limitations of the various types of FM microphones and receiver systems.



# LEXIS



Lexis is a highly versatile FM system designed by Oticon. It consists of a digital directional handheld microphone combined with a wireless ear level receiver, which is lightweight and attaches easily to a child's hearing aid. The exceptional directionality of the Lexis microphone provides a high signal-to-noise ratio (SNR) that gives greater access to speech in situations where noise, distance, and reverberation are present. You can take Lexis virtually anywhere - it offers benefits in the widest possible range of listening environments.

### 3 ways to hear better

The Lexis microphone can operate in three different modes: Omni, Focus and Super Focus. Each mode offers varying degrees of directionality. In the Omni (omni-directional) mode, a single microphone is used to detect sound coming from all directions. The Focus and Super Focus modes utilize four directional microphones combined with advanced digital sound processing to separate the desired signal (i.e. teacher's or family member's voice) from the noise. The digital sound processing selectively amplifies the speech sounds in the low, mid, and high frequencies to maximize understanding.

### Great flexibility

Children encounter many different environments during the day so their FM system must be practical and adaptable. Lexis offers immense flexibility. Your child can hold it, put it around your neck, or place it on a table in the upright position. Alternatively, you can connect the system directly to a CD player, TV or computer.

Lexis also offers a choice of receivers - universal or dedicated. The universal receiver can be connected to all Behind-the-Ear (BTE) hearing aids from Oticon or other major manufacturers, while the dedicated receiver is only for certain Oticon BTE hearing aid models. With the dedicated

receiver, the coupling audio adapter (shoe) and Lexis receiver are combined in one unit, rather than two separate pieces, for a discreet, more elegant appearance.



## Benefits for Children of All Ages

Experience shows that children of all ages with varying degrees of hearing loss can benefit from FM systems. They help to improve language development and academic performance and they also help to reduce fatigue.

This table shows exactly in which situations and for which activities FM systems can be of assistance. Please note that this is only a small list of activities - there are many more!

Age groups	Benefits	Activities
Infant and toddler	<ul style="list-style-type: none"> <li>• Auditory, Speech and Language development</li> <li>• No feedback when holding or cuddling your child</li> </ul>	<ul style="list-style-type: none"> <li>• Incidental learning (your language input during routine activities; for example changing your child's diaper, changing clothes)</li> <li>• Snuggling</li> </ul>
Pre-school	<ul style="list-style-type: none"> <li>• Auditory, Speech and Language development</li> <li>• Safety and security (i.e. better access to spoken warnings)</li> <li>• Reduced fatigue</li> </ul>	<ul style="list-style-type: none"> <li>• Home activities with your language input (for example, doing dishes, washing clothes, shopping)</li> <li>• Classroom/church</li> <li>• Play time</li> <li>• Outdoor playing</li> </ul>
School	<ul style="list-style-type: none"> <li>• Academic performance</li> <li>• Attention to speaker</li> <li>• Comprehension following directions</li> <li>• Reduced fatigue</li> <li>• Safety and security (i.e. better access to spoken warnings)</li> <li>• Participation in activities</li> <li>• Cosmetics</li> </ul>	<ul style="list-style-type: none"> <li>• Classroom/church/theatre</li> <li>• Field trips</li> <li>• Parties (birthday, holidays etc.)</li> <li>• Home entertainment</li> <li>• Extra curricular activities (for example, scouting, dance class, soccer.)</li> </ul>
Adolescent	<ul style="list-style-type: none"> <li>• Independence</li> <li>• Cosmetics</li> <li>• Academic performance</li> <li>• Socialization</li> <li>• Participation in activities</li> <li>• Reduced fatigue</li> </ul>	<ul style="list-style-type: none"> <li>• Classroom/church/theatre</li> <li>• Social events (for example, sporting, restaurants, parties)</li> <li>• Home entertainment</li> </ul>
College	<ul style="list-style-type: none"> <li>• Independence</li> <li>• Cosmetics</li> <li>• Academic performance</li> <li>• Socialization</li> <li>• Reduced fatigue</li> <li>• Automobile</li> </ul>	<ul style="list-style-type: none"> <li>• Lecture hall/church/theatre</li> <li>• Social events (For example, sporting events, parties, cafeterias, meetings)</li> <li>• Home entertainment</li> </ul>

# Troubleshooting FM Systems

Consult your hearing care provider if you have questions about the functioning or performance of the FM system.

Problem	Solutions
<i>No sound at all</i>	<ul style="list-style-type: none"> <li>• Check the hearing aid in isolation to make sure it is functioning well</li> <li>• Check that the receiver mode switch is in the correct position</li> <li>• Check that the microphone mode switch is in the correct position</li> <li>• Check that the receiver and microphone channels match</li> <li>• Recharge or replace batteries</li> </ul>
<i>No FM reception</i>	<ul style="list-style-type: none"> <li>• Confirm that the coupling adapter (shoe), cord or teleloop is properly connected, undamaged, and set properly</li> <li>• Check that the mode switch is in the correct position</li> <li>• Check that the microphone is on</li> <li>• Check that the receiver and microphone channels match</li> <li>• Recharge or replace batteries</li> </ul>
<i>Weak or distorted sound</i>	<ul style="list-style-type: none"> <li>• Check for improperly fitting or clogged earmoulds, or excess ear wax</li> <li>• Recharge or replace batteries</li> </ul>
<i>Static, intermittent sound, or feedback</i>	<ul style="list-style-type: none"> <li>• Move away from sources of interference (metal structures, computers, etc.)</li> <li>• Make sure that no other microphone is broadcasting on the same channel</li> <li>• Clean and check battery contacts</li> <li>• Check for improperly fitting or clogged earmoulds, or excess ear wax</li> </ul>

## www.otikids.com

The OtiKids website is designed to provide comprehensive information for parents and teachers of children with hearing impairment. The site addresses the physical, social, and psychological aspects of hearing loss as well as the process of obtaining hearing aids. Topics include the following:

- Understanding - reviews how the ear works and the causes of hearing loss.
- Concerns - discusses how a hearing loss may affect a child socially, academically, and communicatively.
- Helping - provides an overview of the process for obtaining hearing aids.
- Networking - provides questions and answers, collection of links, recommended reading, and Oticon worldwide subsidiaries.
- Solutions - lists current Oticon products relevant to children.
- Kids Corner - designed especially for children, including explanations about hearing loss, personal stories by hearing-impaired children, and fun games.





# People first



We believe that it takes more than technology and audiology to create the best hearing instruments. That's why we put the individual needs and wishes of hearing impaired people first in our development of new hearing care solutions.