

Compatibility and FM Technology
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Transmission of speech via an FM signal is an established and proven method for improving speech understanding by individuals with hearing loss. FM technology is typically used in conjunction with amplification to increase intelligibility in difficult listening environments such as listening in noise, listening at a distance, and listening in reverberant environments.

Early generation FM systems consisted of a transmitter unit that broadcast a basic narrow-band FM signal to a body-worn receiver. Compatibility issues were primarily related to the options for integrating the user's hearing aids to the FM receiver. There were typically a few potentiometers on the transmitter and/or receiver that allowed the fitter to change settings such as FM gain and MPO that needed to vary according to the hearing aid used. With the digitization of FM equipment and the use of more sophisticated signal processing schemes, the fitting of an FM system has become more complex, more so when equipment from several manufacturers is used together.

Manufacturers now incorporate advanced signal processing akin to that seen in hearing aid technology in order to provide a "cleaner" signal to the end user. Convenience options such as LED indicators are available to increase certainty for teachers and end users that transmission is occurring as expected. Receiver options have evolved with manufacturers offering an array of integrated and universal receivers that may or may not have an effect on the operation of the hearing aid itself.

As with amplification, this increasing sophistication of FM technology has associated benefits. End users and professionals involved in the fitting of FM systems benefit from clearer FM transmission and convenience options designed to improve ease of use. But this increasing sophistication also comes with some drawbacks. For example, one issue that has become more complex over the past few years relates to the mixing of equipment (hearing aid, transmitter, and/or receiver) from different manufacturers.

Consider the "FM compatibility pyramid" provided in Figure 1. The base of the pyramid represents basic issues related to FM and hearing aid compatibility that must be in place in order for FM transmission to occur. When using FM technology in conjunction with amplification, there must be some means for connecting the hearing aid to the FM receiver. Connection options can include an ear-level receiver (integrated or universal), neckloop, or Direct Audio Input (DAI). As long as there is some method for getting the FM signal into the hearing aid, compatibility exists at this level.

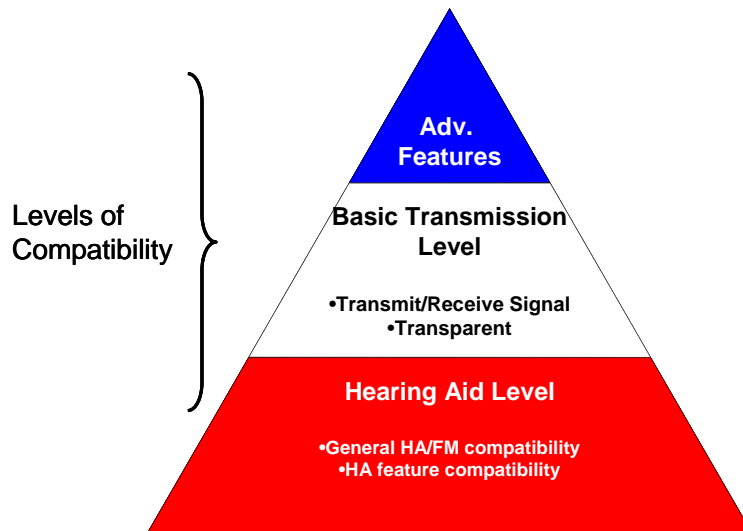


Figure 1. Pyramid representing levels of FM compatibility. Compatibility at lower levels is needed in order for compatibility at higher levels to be possible.

Compatibility at the hearing aid level is presented at the base of the pyramid as this is necessary in order for compatibility at higher levels to exist. If the hearing aid can interface with an FM receiver then reception of the FM signal, irrespective of the transmitter used, is typically ensured. However, this does not guarantee that the response will be transparent. A transparent signal is obtained when the response produced by the hearing aid alone is similar to the response obtained when an identical signal is presented through the FM system and hearing aid combined.

Figure 2 provides an example of a transparent FM fitting. The green curve is the output measured from the hearing aid when a 65 dB SPL speech stimulus is presented to the hearing aid microphone. The blue curve is the output measured from the same hearing aid when the same speech stimulus is presented via the FM transmitter. Note the overlap of the responses at all frequencies.

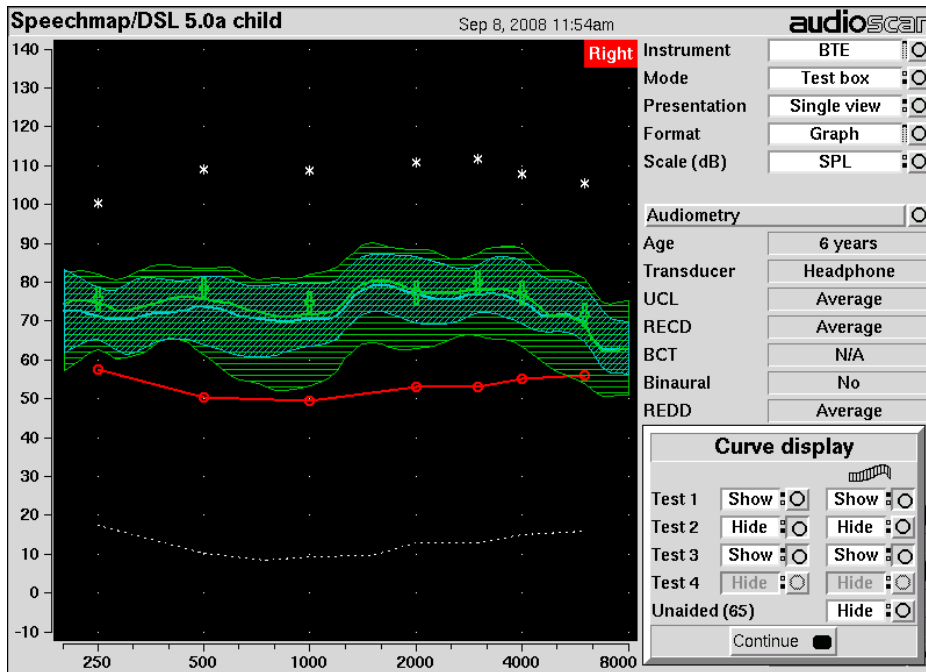


Figure 2. Example of a transparent FM fitting.

The second tier of the pyramid represents compatibility issues associated with obtaining a transparent signal when using a transmitter and receiver from different manufacturers. Factors that can impact the degree of transparency include impedance values in the hearing aid, how the manufacturer addresses high frequency noise in the FM signal, and the input/output characteristics exhibited by a specific transmitter.

When mixing equipment from different manufacturers, transparency is sometimes obtained with the equipment set “out of the box”. It is common, however, that one or two adjustments may need to take place in order to provide a transparent response. This does not mean that transmitters and receivers from different manufacturers are not compatible, rather this compatibility is typically not “plug and play” in nature.

For example, the Oticon Amigo FM system includes a pre- and de- emphasis feature to deal with high frequency noise inherent in the transmission of narrow-band FM signals. When transmitting an FM signal, it is common to provide a high frequency boost to the response from the transmitter (pre-emphasis). On the receiver side, this high frequency boost is reduced (de-emphasis) the result being an improved SNR in the high frequencies and a transparent frequency response.

Example One: Amigo Receiver with Phonak Transmitter

When using an Amigo transmitter or receiver with equipment that does not employ this approach, this feature would need to be disabled in order to obtain a more transparent response. In Figure 3, for example, a Phonak Campus transmitter is used with an Oticon Epoq and Oticon R12 receiver. Note the lower response in the high

frequencies. In this example, the Campus transmitter does not employ pre-emphasis in the high frequencies. However, the R12 receiver, at default settings, applies de-emphasis to the incoming signal. In this case, it would make sense to disable the de-emphasis feature in the receiver in order to improve transparency.

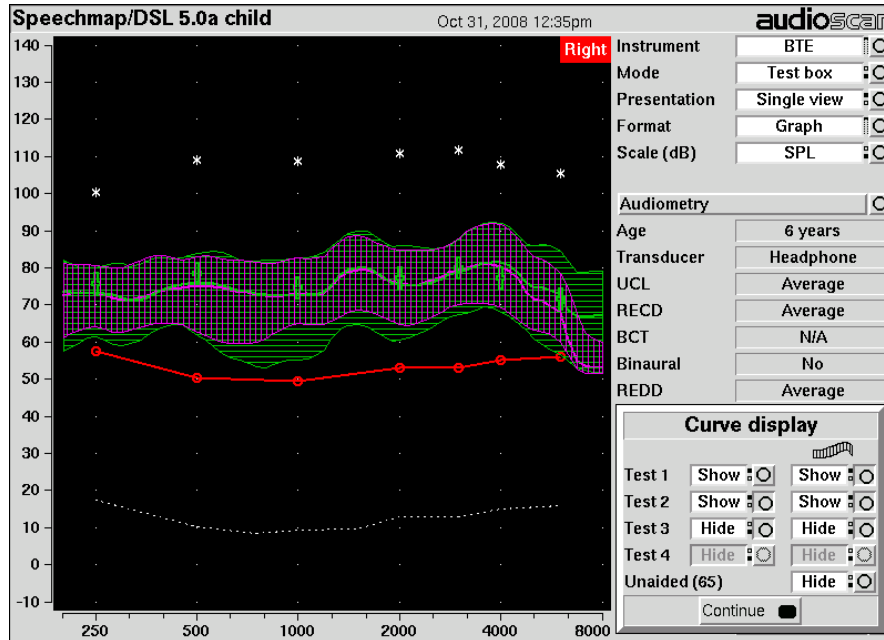


Figure 3: Results obtained with Phonak Campus transmitting to an Epoq/R12. Green curve is hearing aid alone, purple curve is hearing aid and FM system. With the de-emphasis enabled, there is a small reduction in high frequency output.

Disabling of the de-emphasis feature can be done in one of three ways:

1. Use an Amigo transmitter to disable the de-emphasis feature in the R12 receiver.
2. Use the Wireless Remote Programmer (WRP) to disable the feature in the R12 receiver.
3. When ordering the receiver, indicate that it will be used with a Phonak transmitter and it will be set accordingly before shipment

When the de-emphasis feature in the receiver is disabled, the response shown in Figure 4 is obtained. The response is transparent in the high frequencies.

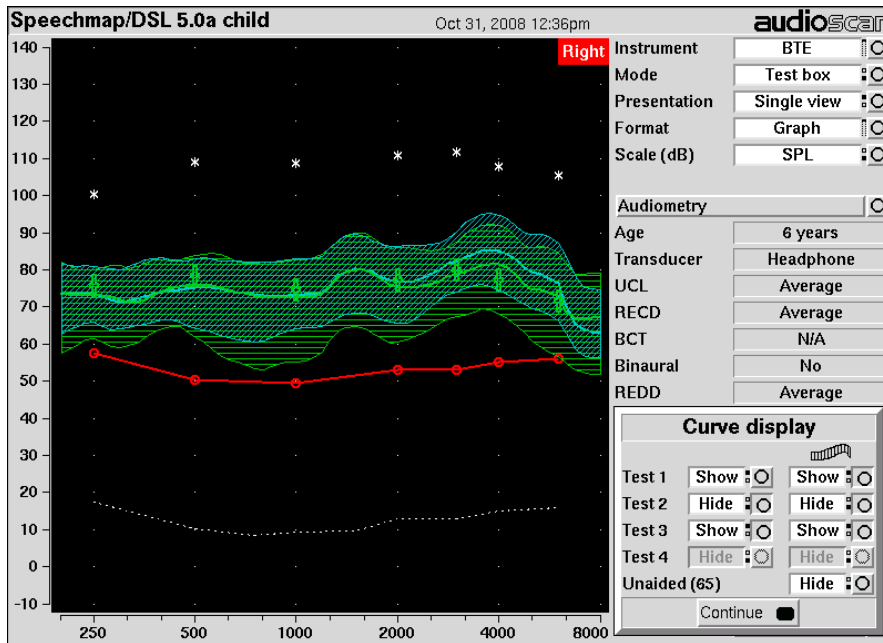


Figure 4. Results obtained with Phonak Campus transmitting to an Epoq/R12. Green curve is hearing aid alone, blue curve is hearing aid and FM system. By disabling the de-emphasis feature in the receiver, high frequency output is appropriate in the high frequencies.

Example Two: Oticon Transmitter to Phonak Receiver

The opposite approach would be taken when using an Oticon Transmitter with a receiver that does not employ a de-emphasis feature. In this case, the pre-emphasis feature in the transmitter should be turned off. If this feature is not disabled, the practitioner may notice a small high frequency boost in the high frequencies since the receiver would not reduce high frequency gain. In a worst-case scenario, forgetting to disable the pre-emphasis feature in the transmitter would result in a few extra dB of output in the high frequencies.

In general, Oticon transmitters and receivers are compatible with other manufacturers at the second level of the compatibility pyramid (see Figure 1). In order to provide a more transparent response in the high frequencies, the pre- and de-emphasis features should be disabled as needed. An adjustment of the FM gain may also be required depending on the impedance of the hearing aid employed. Any adjustment needed is typically small in nature and can be accomplished using an Amigo transmitter or WRP.

Compatibility and Advanced Features

The top level of the compatibility pyramid represents the advanced features that may be present in a FM system. Examples of Amigo advanced features include channel synchronization from either the transmitter or receiver, an LED light in the receiver, and

an auto-mute function. Digital signal processing (DSP) is used to reduce the impact of extraneous non-speech noises (e.g., ventilation fan) and to help ensure proper speaker input level. The primary issue in determining whether all or some advanced features are compatible across manufacturers relates to the location of the technology.

Oticon technologies that reside solely in the receiver (e.g., channel synchronization, LED to indicate appropriate functioning) are generally compatible with any FM transmitter. With the receiver-based synchronization feature, the receiver seeks the strongest FM signal in the room, regardless of what transmitter is being used. As long as the receiver is receiving an FM signal, the LED feature will function. Having receiver based technologies is important as it provides a means for setting a receiver to the appropriate channel without the need for a separate programming unit or computer.

Amigo's advanced DSP features (e.g., static noise reduction, dynamic voice optimization) are located within the transmitter. All processing is completed prior to transmission of the signal. Therefore, once the signal leaves the transmitter it is an FM signal that can be picked up and processed by any receiver. Since communication between the transmitter and receiver is not necessary, these advanced features are compatible across manufacturers.

Advanced features that require communication between the transmitter and receiver are typically not compatible across manufacturers. For example, an Oticon transmitter cannot be used for channel synchronization with a Phonak receiver (again making the case for channel synchronization as an option from the receiver side of the system). The dynamic FM gain feature in Phonak Inspiro also requires communication between the transmitter and a specific receiver. Thus this advanced feature will not work with most receivers. This does not mean Inspiro is not compatible with Oticon receivers, rather the compatibility is limited to the bottom two tiers in the pyramid.

Another aspect that needs to be considered when determining level of compatibility relates to bandwidth. It is not uncommon for today's hearing aids to provide a bandwidth that extends to 8000 Hz and beyond. Ideally this bandwidth remains available when the hearing aid is receiving a signal via FM transmission. In Figure 2, for example, a transparent signal is provided out to and including 8000 Hz. Using the same hearing aid and R12 receiver with an Inspiro FM transmitter, however, shows a lack of transparency in the very high frequencies (see Figure 5). Bandwidth compatibility should also be considered in FM fittings.

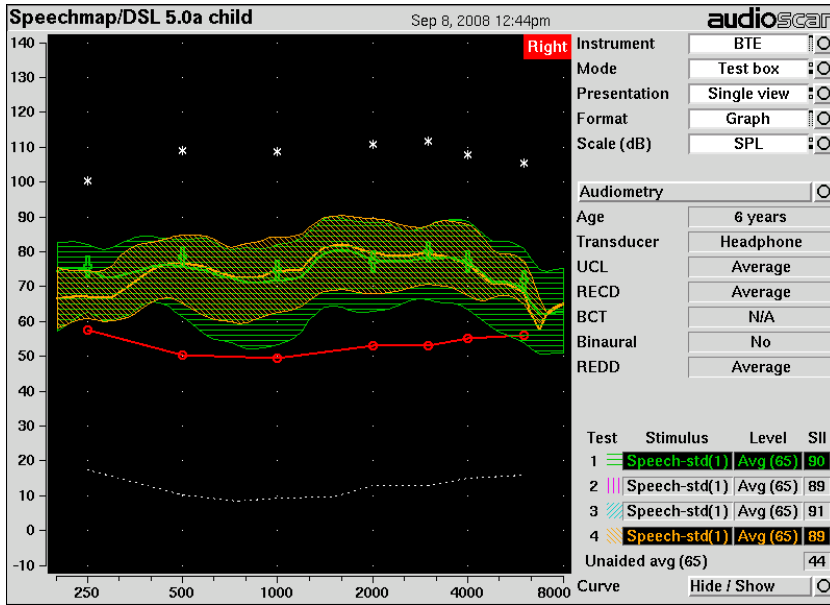


Figure 5. Green is hearing aid alone, orange is Inspiro transmitting to an Epoq/R12 combination. Note high frequency roll-off above 6000 Hz.

In summary, transmitters and receivers from different manufacturers are generally compatible at a basic level out of the box (i.e., can transmit an FM signal from point A to point B). With one or two adjustments, most combinations of transmitter, receiver, and hearing aid yield a transparent FM fitting represented by the middle tier of the compatibility pyramid.

With regard to compatibility and advanced FM features, the results are mixed. When implementation of an advanced feature does not require communication between the transmitter and receiver, then the benefit of that advanced feature can generally still be obtained when using a transmitter and receiver from different manufacturers. When communication between the transmitter and receiver is required, the advanced feature in question is generally not compatible across manufacturers.

Resources:

www.amigofm.com

www.oticonusa.com