Balancing FM Systems and Re-broadcasting

Colin Peake gives a comprehensive guide to setting up the optimum FM system

Rationale For Balancing
When hearing instruments are issued to a child whether they be hearing aids or cochlear implants, the audiologists will have taken great pains to ensure that the sound level and quality is optimal for the child.

The settings established will have been based on the characteristics of the hearing instrument's microphone, and the amplifiers and processors within the instrument itself, and set to match the child's hearing or sensation levels.

When some other input is applied to the hearing instrument either in place of the instrument's microphone, or as an auxiliary to it, the potential exists for upsetting the carefully arrived at settings made by the audiologist. For this reason the FM Systems which are applied to the hearing instrument, and work in conjunction with the instrument's microphone, should be carefully balanced to ensure that the sound level and quality matches that which was established by the audiologist as being appropriate for the child.

If the sound level is too low little difference will be made to the child's access to what is being said, and therefore the child's performance will similarly be unaffected. This can lead later on to the child and the professionals coming to the conclusion (justifiably under the circumstances) that a radio aid makes no difference, and the use of a valuable tool, and aid to learning, is lost; not to mention the waste of resources.

If the sound level is too high there is a serious risk of distortion, creating an altogether unpleasant sound experience for the child. Almost certainly the instrument will go into compression which will have the effect of severely limiting access to what is said in the proximity of the child: contributions from classmates, explanations from a support worker with the child, and other sounds which are part of the normal acoustic environment.

An FM System ideally should give the teacher's voice a clear advantage above the level of background noise. Of course it would be impossible to say what the background noise would be in any given classroom at any particular time – just as it is not possible to say how loud the teacher's voice would be. Therefore, two assumptions are made;

- Background noise is at 60 dB.
- The teacher's voice is 75 dB when measured approximately 15 cm (6 inches) from the mouth.

If the FM microphone is worn at the optimal position – 15 cm from the mouth, the input level would be 75 dB. When this input is transmitted to the child's FM receiver and applied to the hearing instrument it should be heard at 15 dB above the notional 60 dB level of background noise. This would give an FM advantage of 15 dB if the volume of the FM receiver is adjusted appropriately.

For cochlear implant users an FM advantage of 15 dB is deemed to be too high. 10 dB is preferred. For this reason the test box settings are 60 dB for the frequency response curve for the CI processor, and 65 dB for the FM system's microphone, the extra test box volume being allowed for by turning down the FM receiver volume. (This is also the case for many digital, non-linear hearing aids – check this with your local educational audiologist or the Ewing Foundation).

Some combinations of hearing instruments and FM Systems are straightforward and are easy to balance. Others can represent more of a challenge and may need additional equipment. Such challenges should never deter a professional from seeking to achieve the best sound quality for their pupils. This is particularly true with some cochlear implant processors.

As balancing is critical, any time that a child's hearing instrument is changed, or if there is a change in the FM equipment, the system must be balanced once again. There are many variables such as differences in the hearing instrument microphones, different settings within the hearing instrument and different settings within the FM receiver – all of which have to be taken into account.

A perfect example of the necessity for such re-balancing can be seen in children upgrading from the Cochlear Freedom to the N5 speech processor. The volume setting for an FM genie working with the Freedom processor is in the region of 5-6. With the N5 however, the volume setting is as low as 1-2, or the output setting on the genie receiver can be changed from the Hi to the Lo setting, and the volume increased to 6-7.

The notion that equipment can just be coupled together without any form of checking is completely unacceptable. Older children may indeed be able to adjust the output level on radio receivers to an appropriate setting. Younger children certainly cannot, nor would they be able to detect distortion.

Applying other inputs to the FM transmitter
Frequently, other forms of input are applied to the FM transmitter. Typically a computer output might be applied, or iPod or CD player. Again such unchecked (and uncheckable) sources should be used with great

caution, and only with children able to report accurately what they are hearing.

FM receivers are carefully balanced to give an appropriate sound level compared to the sound level of a live voice at 1 – 2 metres. Applying an uncontrolled input to a transmitter could result in there being an inadequate level for a child to access, or at worst, the sound level being too loud and distorted producing a very uncomfortable listening experience for the child.

Furthermore, it would be very difficult to apply speech discrimination testing to such situations and distorted signals would therefore be undetected.

Older children, who can judge very well for themselves whether an input is similar to, or different from, what they are used to, can of course adjust volume levels to suit their own preference; even so, distorted or missing parts of the speech signal might still go unnoticed, or if they were noticed might not be changeable using receiver settings alone.

Younger children, or children who are as yet less sophisticated listeners should not have inputs applied to FM transmitters. In the classroom situation devices that might be considered suitable for being plugged into the FM transmitter could include:

- output from the television.
- output from CD player, other audio devices
- output from the computer
- output from Soundfield device.

In the first three of the above bullet points, the ‘low-tech’ solution is acceptable, i.e. placing the transmitter near to the loudspeaker of the sound source. In this way the sound level applied to the transmitter is similar to that which is experienced by other members of the class, and can be adjusted by the class teacher for a comfortable listening experience.

However, by far the most common input applied to an FM transmitter is where this is coupled to a soundfield system using the technique known as re-broadcasting.

As this is done in the context of learning within the classroom it is important that this configuration is balanced also.

RE-BROADCASTING FM

What is rebroadcasting?

Rebroadcasting is required where two different types of sound delivery systems are in use. Typically, there may be a hearing-impaired child in a classroom using a personal FM radio system which is most likely to use narrowband FM, whilst at the same time there is a Soundfield amplification system being used utilising different technology.

It would be possible, of course, to have a class teacher wearing a transmitter to drive the Soundfield system, and a second transmitter for a hearing-impaired child’s FM receiver. Whilst such a scenario would be feasible, it is not very practical. Therefore to overcome this impracticality rebroadcasting is the best solution.

The teacher uses one microphone that broadcasts to the classroom soundfield system; this in turn is connected by a short wire to the FM transmitter, which then rebroadcasts to the child’s personal FM receiver.

However, linking the two systems together is not always straightforward, and professionals need to be alerted to some possible pitfalls.

Using both systems together has often been hailed as the “gold standard”, particularly as the NDCS Quality Standards recommends the use of personal FM systems in conjunction with Soundfield. However, QS 13 states:

> ***“Where soundfield systems are used in conjunction with personal FM systems, equipment must be selected and set up to ensure that the performance of the personal FM system is not compromised.”****…… but tests performed by the South of England Cochlear Implant Centre found that many systems significantly under-performed.

Because there are four different types of Soundfield system available, all using different types of technology,

Photograph shows the IR Swift connected to a Connevans Genie FM transmitter

Redcat with Smartlink in re-broadcast mode. Note that the input to the Smartlink is to the microphone socket.

linking the two together is not always straightforward, and there is the possibility that the system will **not** be '**set up to ensure that the performance of the personal FM system is not compromised**'. Those four types are:

- **Narrow band FM**. This is the earliest form of Soundfield system but still used in schools, and the easiest to use with personal FM. As both these systems use narrowband FM, all that is required is to ensure that both systems are switched to the same frequency. However these are increasingly being superseded by...
- **Infra red** now overtaking the use of narrowband FM in popularity – some manufacturers are now no longer producing narrowband FM Soundfield systems. Examples of infrared systems include Connevans IRSwift and IR Classmate, PC Werth's IR Front Row, and Lightspeed's Red Cat system.
- **UHF** used for large teaching areas such as school halls where a PA type of system is preferred, these systems are also preferred where playing music is a significant factor.
- **Wide band FM**, like the UHF system, is used for large spaces such as school halls where a PA type of system is preferred. This type of system can have a major impact on personal FM systems because the bandwidth can swamp up to five narrowband channels; so if there are several children using personal FM in a school, consideration has to be given to frequency allocation. Consult suppliers or manufacturers.

Balancing Sound Field Systems

Because of very large variations possible in the output of Soundfield Systems to the input of a child's personal FM transmitter, some form of balancing procedure must be undertaken. Testing done at SOECIC has revealed variations as much as 20dB too low. Rarely was the output too great.

Variations in the output of Soundfield Systems can arise from –

- variations in the volume set for the classroom
- variations in the output level setting, or
- a combination of both.

Some sound field systems have output levels to personal FM systems independent of the volume set for the classroom. Examples of these are Phonic Ear systems, and Red Cat. In these systems it is important to set the output level to the child's personal FM transmitter appropriately; once set, however, no further adjustment should be necessary.

Connevans systems such the IR Swift on the other hand not only have output level setting adjustment for auxiliary equipment, but also the volume to the FM transmitter will vary with the volume set for the classroom. This can be useful in situations where noise levels might be excessively high, or the teacher's voice may be unduly quiet and the FM user can therefore benefit from the additional SNR, but varying the volume should be a feature used with caution bearing in mind that the sound field/FM balancing will be affected.

Output adjustment for the IR Swift. Screwdriver adjustment limits disturbance

Ideally, test box balancing – the procedures for which are set out below – should be undertaken, but where this is not possible or practicable, a listening test should be done by a teacher or member of support staff. There should be no difference in volume or quality between the sound heard via the FM transmitter alone, and the sound heard via rebroadcasting FM.

Test Box Balancing

NB For infra-red devices these procedures will have to be undertaken with the test box lid open. This is perfectly acceptable and in fact is a requirement for some test box procedures, but the room should be quiet for when this is being undertaken. Also the test box would have to be levelled with the lid open. Alternatively, if a lapel microphone is available for the IR emitter the sound chamber can be closed, and more accurate curves obtained. If this procedure is undertaken, however, it is important to do a listening check in the room to ensure that the sound level and quality is not altered when a lapel microphone is employed, otherwise balance curves would be invalid.

Balancing

An output curve should be obtained for the hearing instrument in the usual way, followed by an FM curve with the receiver adjusted to match the original. The Sound Field system should then be switched on and a level set for the particular environment in which it is working in the case of the IR Swift.

The FM transmitter should be connected to the output of the Sound Field system using the appropriate cable. Note that each manufacturer uses a different connection system with their own cables, plugs etc. Most FM transmitters utilise a 2.5 mm socket into which the rebroadcast connecting lead needs to be inserted (not the 3.5 mm audio input socket in most cases) but the plugs on the connecting leads are 3.5 mm so an adapter would be required in such cases.

Place the sound field microphone/IR emitter in the test box in place of the FM transmitter microphone. **Note:** it needs to be in line-of-sight of the sound field equipment, and in the case of the IR Swift as far away as possible, (see below).

Turn the volume down on the main unit in the case of the Red Cat and Phonic Ear systems. This is to avoid the signal from the test box being picked up by the IR microphone and hearing instrument microphone and

Output adjustment for the Redcat. On the early version the knob could be recessed after adjustment to avoid being disturbed. This is not the case with the more recent model.

affecting the output curve. This cannot be done in the cases of the IR Swift and IR Classmate because turning the volume down will also turn the output to the FM transmitter down as well. Therefore, operate the test box as far away from the sound field system as possible.

With the test box output set to the same level as for the FM curve, start the curve running and adjust the output until the curves correspond.

Whichever microphones are under test they should be the same distance away from the signal source. Because of the slim nature of hearing instruments and lapel microphones, accurate curves can be obtained when these are placed on the target area in the FP 35. However, some IR microphone/emitter packages are wider and cause the microphone port to be a significant distance away from the sound source and this distance has to be taken into account in the interpretation of the curves produced.

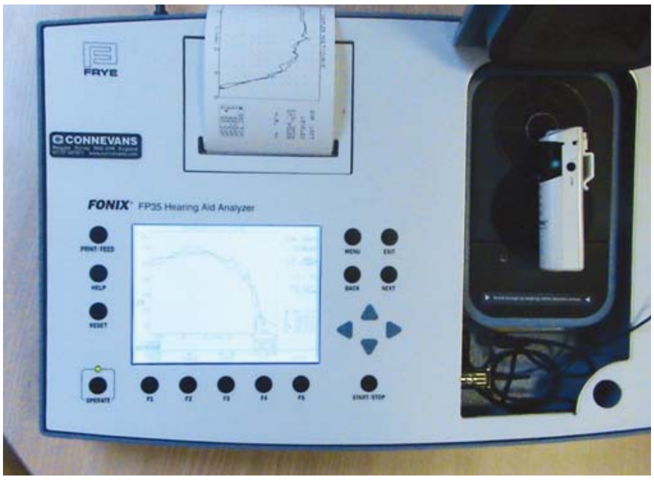
Note: the Connevans Classmate does not have an output level control and therefore cannot be adjusted as outlined above. The alternative is to have a different volume setting on the child's receiver.

In Situ Testing

As well as the electro-acoustic testing outlined above, equipment should always be checked with the user to make sure that it is right for them, and to validate the objective measures obtained.

Position the child some distance from the tester, at least three metres. This is to reduce the impact of airborne sound on the test. Using the FM System, administer a simple listening test that the child might be familiar with, for example a junior wordlist, toy test, or just simply the Ling sounds.

Set up the Soundfield System in rebroadcasting mode; turn down the sound applied to the classroom where this is allowed – again to eliminate airborne sound to the child's hearing instrument microphone – and apply the test again. There should be no difference in the results of the two tests. (If the sound level to the classroom cannot be turned down, make sure that the child is positioned as far from the Soundfield speaker as possible).



Redcat microphone in FP35 test box, and the curves produced.

Technical Note

The electro-acoustic tests outlined above assume microphones will be worn 15 cm from the mouth. Boom microphones are typically worn approximately 3 cm from the speaker's mouth and are subject to very much higher input levels, so balance curves could not be obtained by the procedures outlined. In such cases, use a lapel microphone for balancing, but check that the change of microphone does not alter the sound level or quality within the classroom.

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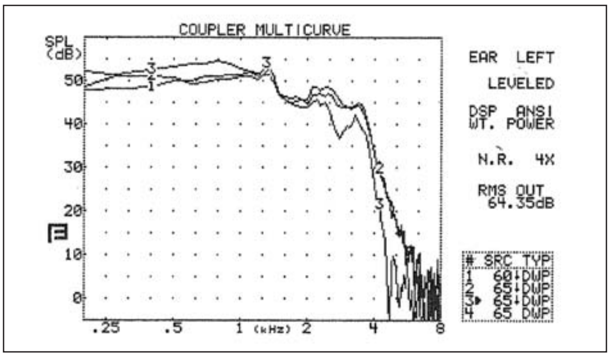
Pendant IR emitter in FP35 test box. Note the two microphone ports on the phonic ear front row pendant transmitter are some distance from the target area. This results in an exaggerated low-frequency trace on the printout, and an under stated high-frequency trace. Both these are artefacts and can be corrected by the use of a lapel microphone plugged into the IR emitter. It would not normally be necessary to go to such lengths to achieve a perfectly matched curve – live with the irregularity of the trace, it is not a reflection of the real frequency response. The same is true of other pendant emitters.



The FP35 printout for the Phonic Ear Pro-Digital transmitter (curve 3) showing typical low frequency increase and high frequency drop compared to the hearing instrument and FM curves. Curves 1 and 2 respectively.