How to Use micon Frequency Compression

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Abstract:

micon Frequency Compression is a new feature available in Connexx 7 designed to help restore audibility of high frequency speech cues lost. This paper explains what Frequency Compression is, when to use Frequency Compression (including some applicable use cases), and how to activate it within Connexx 7.
I. What is Frequency Compression?

Frequency compression is a recent solution which has been shown to deliver benefit to patients with severe to profound high frequency hearing losses and/or patients with suspected cochlear dead regions.

Despite technological advancements in amplification, severe to profound high frequency hearing loss configurations pose challenges for the Hearing Care Professional (HCP) as well as the hearing impaired. The goal is to provide enough gain for high frequency sounds to achieve audibility. Unfortunately, these gain requirements are often beyond the capabilities of even the most advanced, powerful technology.

Similar challenges arise in individuals with cochlear dead regions. A dead region is an area in the cochlea where the inner hair cells and/or the auditory neurons are functioning very poorly, if at all (Moore, et al., 2010). Unfortunately, providing amplification to these dead regions generates little or no benefit, and in some cases may actually deteriorate speech intelligibility.

Frequency Compression (FCo) provides a solution to these issues. FCo is a non-linear function whereby higher frequencies are compressed and moved into pre-determined lower frequency regions where better residual hearing is present. Figure 1 shows an example of frequency compression. As a result of compression, the patient will be able to detect sounds which were formerly “lost” in the dead regions of the cochlea. The compressed frequency cues are moved to a new frequency destination ultimately providing a different tonality than produced in the natural environment.

![Figure 1: Principle of frequency compression. a) Original Spectrum. b) Compressed spectrum. Spectrum below f_min remains unmodified while spectrum between f_min and f_end is compressed into the band from f_min to f_max.](image)

The micon frequency/compression ratios are prescribed individually based on scientifically proven data. This researched approach yields improved audibility of high frequency sounds, as well as improved speech understanding in noise for some individuals.

Stimulation to the areas on the basilar membrane that are not affected by the dead region aids in the prevention of further sensory deprivation and the prevention of the off-frequency listening that takes place if dead regions are stimulated. Leaving the lower part of the signal uncompressed allows for keep-
ing the incoming signal as intact and uncompressed as possible. This conservative but effective strategy also preserves the sound quality of the output signal to be as natural as possible.

II. When should I use micon Frequency Compression?

The Siemens approach to applying Frequency Compression (FCo) during First Fit is unique because the candidacy selection is based on a clinically proven procedure. There are two use cases where FCo is recommended:

1) Individuals who may have cochlear dead regions
2) Individuals with hearing loss that inhibits the interpretation of high frequency information even with amplification

Traditionally, frequency lowering algorithms have been used as an amplification option for ski-slope or severe to profound hearing losses. The key to success with FCo is to use it for those individuals for which it is recommended. In fact, there are disadvantages to its application for individuals with mild to moderate hearing losses, e.g. the degradation of speech intelligibility in noise (Glista, et. al., 2009).

The candidacy for FCo is determined based on the audiogram. Siemens follows research-based recommendations for calculating dead regions (Moore, 2010). Criteria for candidacy selection include a large drop in hearing thresholds between octaves and the hearing thresholds being greater or equal than 80dB HL. In totally open fittings, FCo is deactivated per default as the sound quality can be reduced due to the original spectrum superposed with the frequency compressed spectrum.

Figure 2: Example audiograms, for which frequency compression is activated after first fit.
2a: sloping hearing loss
2b: severe loss
IV. How to Use FCo in Connexx 7

Figure 3 presents an overview of the frequency compression functionality in Connexx 7. A screen shot of the frequency compression menu is provided in Figure 3. Focus attention points A,B,C,D are explained in the following. Figure 4 shows a closer view of the compression parameters and Figure 5 shows a close-up of the simulated gain response box with detailed labeling of the shaded areas.

**Figure 3**: Frequency compression in Connexx 7 using micon fit (experienced setting, double dome) for audiogram of Figure 2a. Note: if the entered audiogram suggests that FCo should be activated, it will default “on” for both sides (left and right). The settings will be based on the threshold for the better ear to maintain a consistent sound.

- **A** Frequency Compression can be located within the Fine Tuning task card
- **B** Frequency Compression (FCo) will default “on” should the audiometric data entered meet criteria mentioned above. This will be indicated by a check mark placed in the box within Frequency Compression located in the Fine tuning task card.
- **C** Frequency compression settings can be modified via 2 slider controls: f_min (the cut off frequency) & f_max (maximal audible frequency after FCo).
  The best applicable settings for f_min and f_max are calculated by Connexx also if the criteria for candidacy based on the audiogram are not met. In case the HCP wants to try out the benefit of using FCo for a particular patient nevertheless, he will only need to activate the frequency compression via B.
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The gradually shaded area (between \( f_{\min} \) and \( f_{\max} \)) represents the frequency band into which the original band from \( f_{\min} \) to \( f_{\end} \) is compressed. The white area is the region which remains unaffected by frequency compression.

Figure 4: Detailed view of Frequency Compression configuration. Frequency compression can be applied manually by placing a check mark in the box next to Frequency Compression.

Figure 5: Explanation of the curve display when using Frequency Compression.

Fitting Advice for FCo:

Siemens has provided proprietary fitting strategies to allow for the highest spontaneous acceptance and audibility level for patients. The implementation of micon fit also follows this principle. The FCo settings applied during First Fit will be an ideal starting point to achieve this goal. It is recommended to remain with the settings after first fit and have the patient acclimatize to the frequency compressed sound for at least two weeks. Reading out loud exercises within this acclimatization period can be beneficial to increase the audibility benefit, especially the discrimination of “s”, “sh”, “f” etc. It is vital, however, to maintain the flexibility that Connexx has always promoted. Therefore deviation from these settings is available if needed in a follow-up fitting.
To improve Sound Quality:

In cases where the FCo settings results in a small residual unmodified band (i.e. f_min set lower than 2.5kHz, this is typically the case for very severe losses like shown in Figure 2b) and an improved sound quality is needed, the prescribed FCo setting may be too strong compression. To decrease the compression, raise the f_max slider. The result will be less frequency movement to the compressed destination area. Figure 6 shows the display difference before and after adjustment of f_max.

Figure 6: Improving the sound quality for patients with severe hearing loss.
6a: Example first fit setting
6b: Setting after raising f_max

In cases where FCo results in a larger unmodified band (this is the case e.g. for the sloping hearing loss, Figure 2a), raise the f_min slider to increase the uncompressed band and more of the original input will remain unmodified.

Figure 7a: Example first fit setting
Figure 7b: Setting after raising f_min
To improve audibility / discrimination:

In cases where even more frequency compression is needed to improve audibility for patients with severe hearing losses, where Connexx has prescribed frequency compression already below 2.5khz, decrease f_max to move more information in the patients’ audible range.

In cases where the patient’s residual hearing extends further out in the high frequency range, audibility may be improved by decreasing f_min even further than suggested by Connexx.
Figure 9: Improving the audibility/discrimination for patients with sloping hearing losses.
9a: Example first fit setting
9b: Setting after decreasing $f_{\text{min}}$