Feedback Management in Hearing Aid Technology

Education & Training

@StarkeyHearing

CAN YOU HEAR ME?

If you have any technical problems, please stay logged on and call Audiology Online at 1-800-753-2160

This session is available for 1/.1 CEU

Must stay logged on for the full session

Must successfully complete a short quiz

Helpful Tools

- Check the File Share pod for helpful downloads
- Chat Box may be used for questions
- Use the  icon to enlarge your viewing area

Course Objectives

- Attendees will know what acoustic feedback is and why it occurs
- Attendees will be able to discuss the consequences of acoustic feedback on a listener
- Attendees will understand the approaches to feedback management available in hearing aid technology today

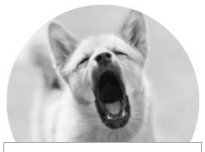
Defining Feedback

Feedback

Squealing

Whistle

Ringing



Howling

Screeching

Humming

Screaming

Buzzing

Feedback

ACOUSTIC	Occurs when the output of the receiver leaks out of the ear canal, enters the microphone and is reamplified
MECHANICAL	Occurs when physical vibrations of the receiver diaphragm are transmitted back to the microphone diaphragm through contact with the hearing aid casing
ELECTRONIC	Occurs when there is a malfunction in the device's circuitry

Mechanical Feedback

Customs

- More susceptible
- Receiver and microphone are in the same housing
- Vibrational energy can lead to feedback

BTEs and RICs

- Less susceptible
- Greater physical separation between components
- RIC receiver is moved out of the instrument case

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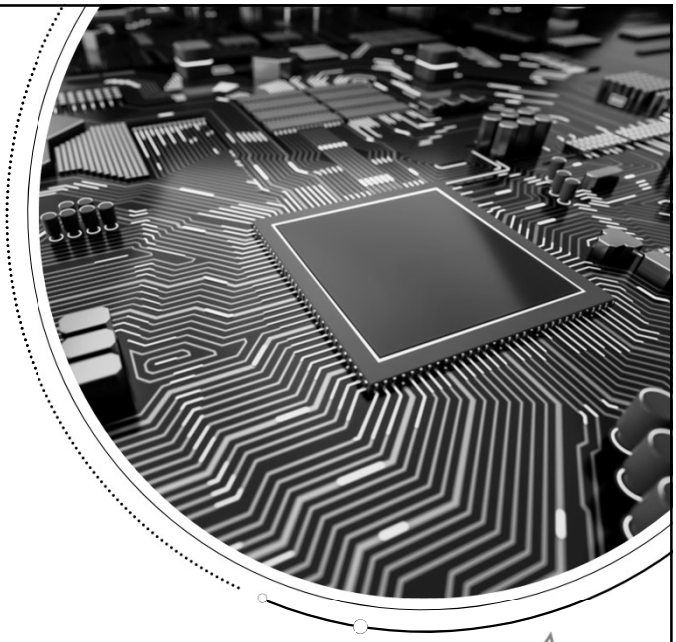
Electronic Feedback

Malfunction in the components of the device

Solution involves opening the case and determining the source of the problem and possible replacement of the electronics of the device

Requires attention from the manufacturer



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Testing for Internal Feedback

Seal the receiver off at the canal tip and hold the device up to the ear to listen - any whistling will verify and confirm internal feedback.

- Fingertip
- Putty
- Listening stethoscope

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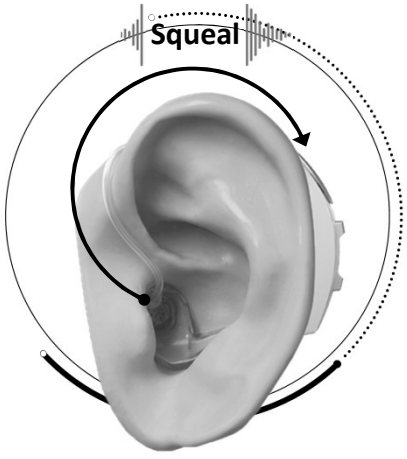
Acoustic Feedback

- Sound wave from the receiver leaks back to the microphone
- Amplified signal –> reamplified
- Undesired oscillations in the hearing aid create instability
- Instability can lead to an audible sound that is usually unpleasant



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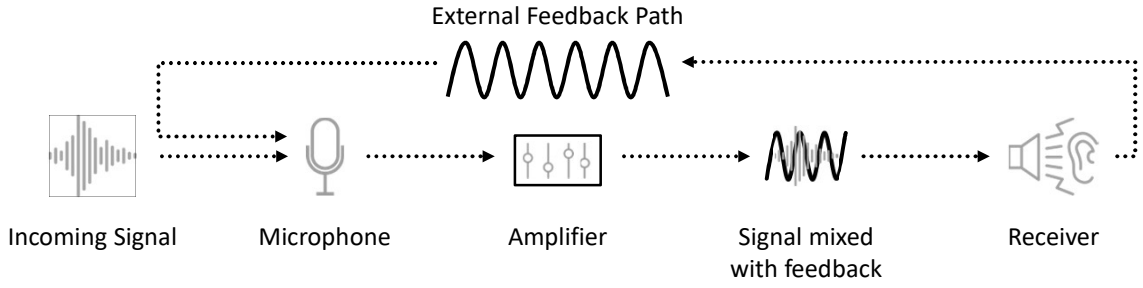
Acoustic Feedback



Factors Influencing the Feedback Path

- Venting
- Loose fit / Poor coupling
- Cracked or damaged earmold or shell
- Improper alignment of the receiver
- Hearing aid gain

Factors Influencing the Feedback Path

- Cerumen
- Hats, Scarves and other Head Coverings
- Jaw and head movements
- Hugs
- Coughing, chewing, sneezing, yawning, talking
- Positioning an object near the ear
- Hand – inserting/removing the hearing aids

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Effects of Feedback

- Loudness Discomfort
- Sound Annoyance
- Distortion / Reduced Sound Quality
- Reduced Speech Understanding
- Reduced Perceived Benefit of Amplification
- Hearing aids don’t work well - Stigma
- Embarrassing
- Hearing aid rejection

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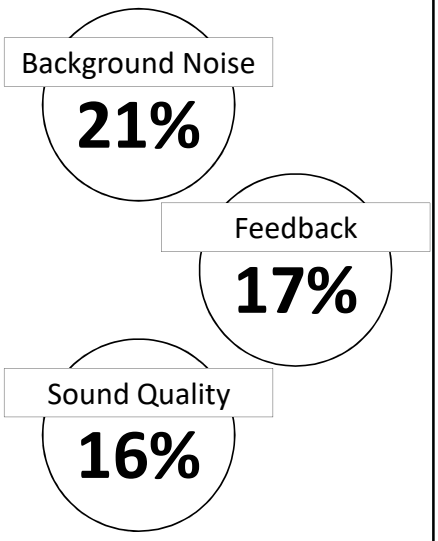
"The most common reasons people stop wearing or return their hearing aids are because the device is physically uncomfortable or does not perform as well as expected…

Performance falls short of expectations when there is too much background noise, too much feedback and/or poor sound quality."

MarkeTrak 9



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"Top Reasons No Longer Have Hearing Aid"

MarkeTrak 10

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Feedback Management

Goals of Feedback Management

- Better physical fit and comfort
- Make soft sounds more audible
- Increase speech understanding
- Improve sound quality
- Better performance in all environments

Managing Feedback

Acoustic Adjustments

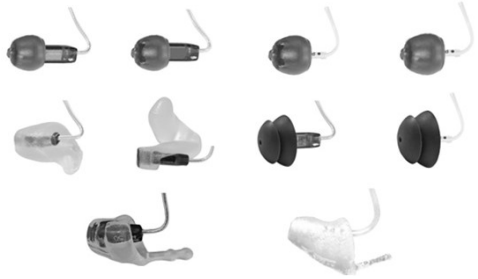
Gain Reduction

Feedback Cancellation

Acoustic Adjustments

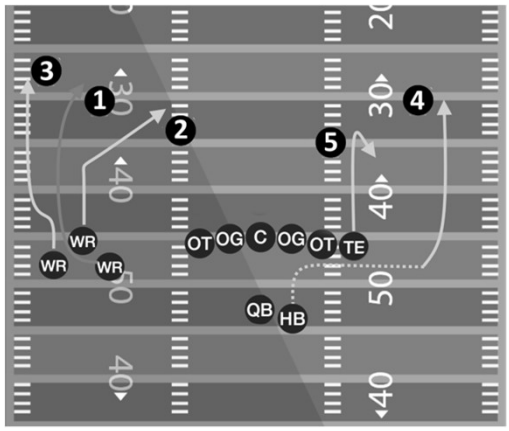
Reduce the leakage of sound

- Vent Diameter
- Diameter of 1st Bend
- Tubing Size
- Dome Size
- Custom Earmolds
- Stock Earmolds



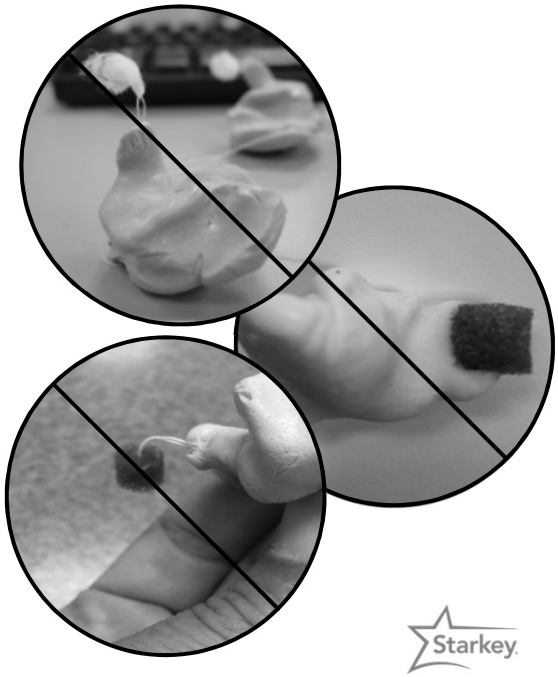
The Best Defense is a Good Offense

- Ear Impressions
- Coupling
- Alignment
- Gain Selection
- Venting

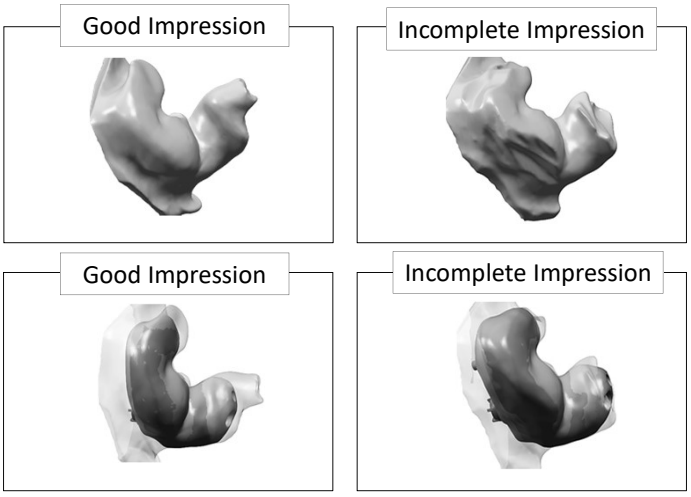


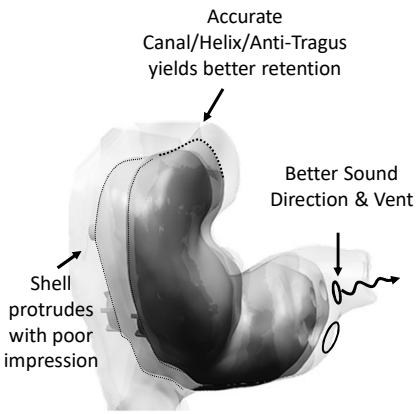
Good Ear Impressions

- Use cotton otoblocks
- Capture the full concha bowl and helix for proper alignment in the ear
- Deep impression for CIC and IIC orders
- Send new impressions with each order

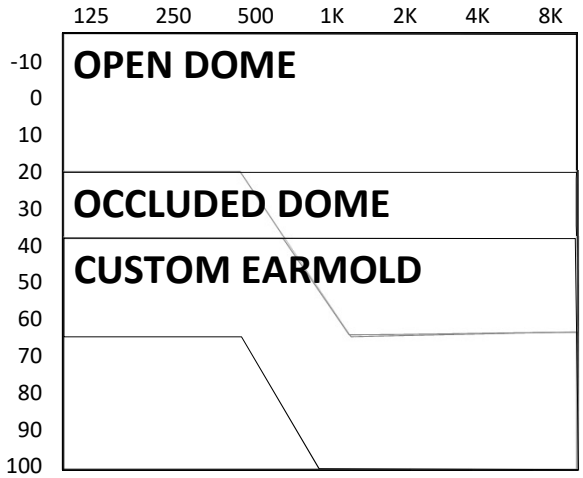


Complete vs Incomplete Impressions





Where's the Cut Off?



RIC Custom Earmolds

		Hearing Loss					
		Mild	*Mild-to-Moderate*	*Moderate*	*Moderate-to-Severe*	*Severe*	*Profound*
Custom Earmolds	RIC Canal with Maximum Vent	●	●	●			Custom Fit (Embedded) Receiver 70 gain
	RIC Canal Lock with Maximum Vent	●	●	●			
	RIC Canal with Large Vent	●	●	●			
	RIC Canal Lock Medium Vent	●	●	●	●		
	RIC Canal with Small Vent	●	●	●	●	●	
	RIC Skeleton with Small Vent	●	●	●	●	●	

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RIC Stock Earmolds

		Hearing Loss					
		Mild	*Mild-to-Moderate*	*Moderate*	*Moderate-to-Severe*	*Severe*	*Profound*
Stock Earmolds	Open Comfort Bud	●	●	●			
	Occluded Comfort Bud			●	●		
	Power Dome				●	●	
	RIC Stock Eamold	●	●	●	●	●	
	Stock Helix RIC	●	●	●			

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Earmolds/Domes

When to replace:

- Weight changes
- Size changes (children/surgery)
- Hearing threshold changes
- Ear canal tissue stretching
- Damage
- Loose Fit
- Feedback

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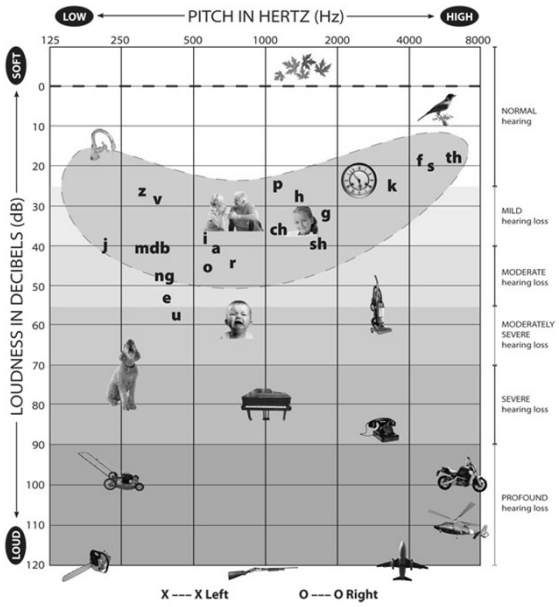
Hearing Aid Gain

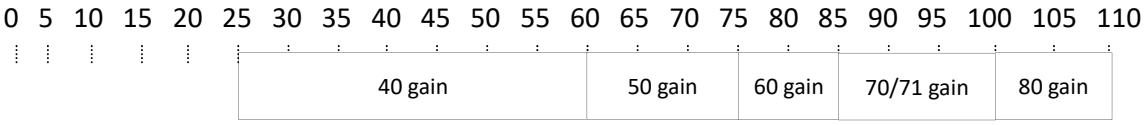
The difference between the input level and the output (in dB SPL)

"Amplification that allows a person with hearing loss to hear, communicate, and participate more fully in daily activities."

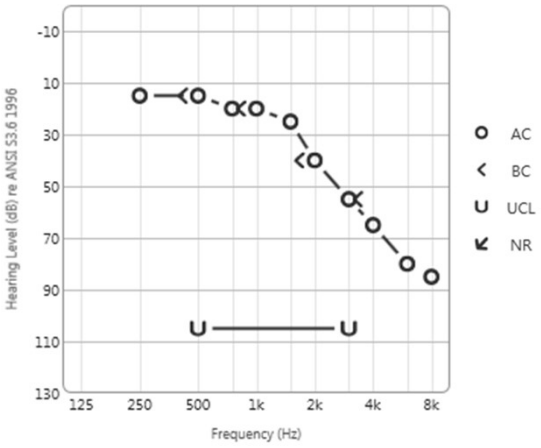


Choosing the Right Matrix

2000 Hz



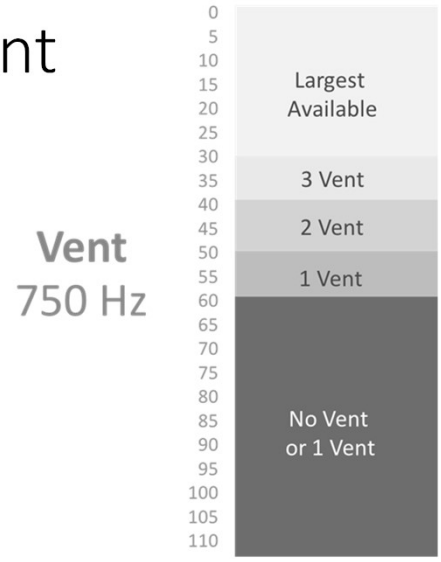
Power Requirements



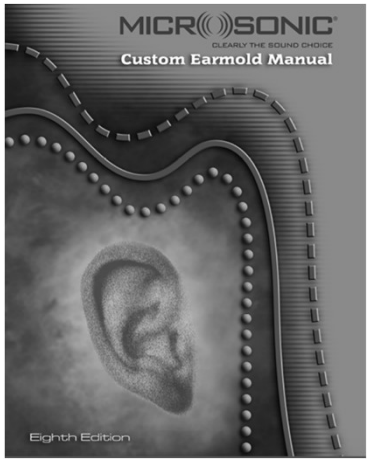
- Poor high frequency thresholds should NOT be part of the equation
- Don't want high frequency gain to overpower low frequencies
- Distortion and impact on sound quality

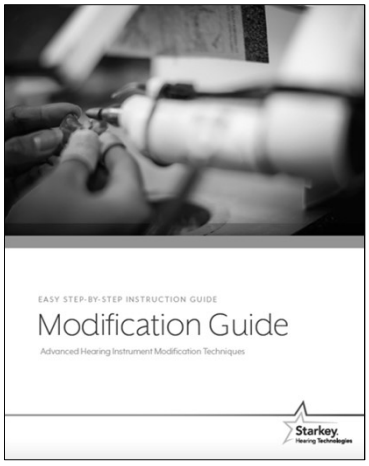
Choosing the Right Vent

- 750 Hz
- Bigger is not always better

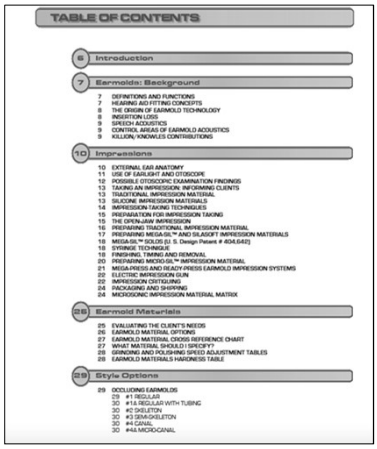


Resources





Microsonic Custom Earmold Manual



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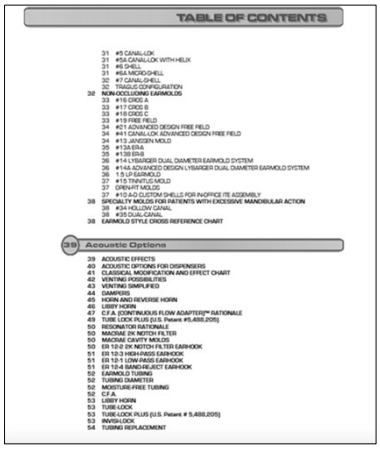

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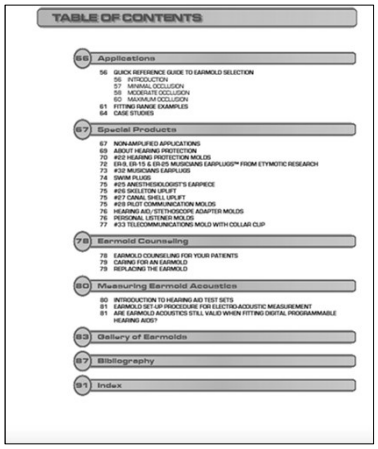

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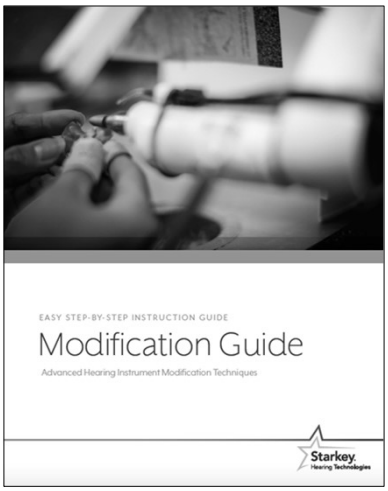
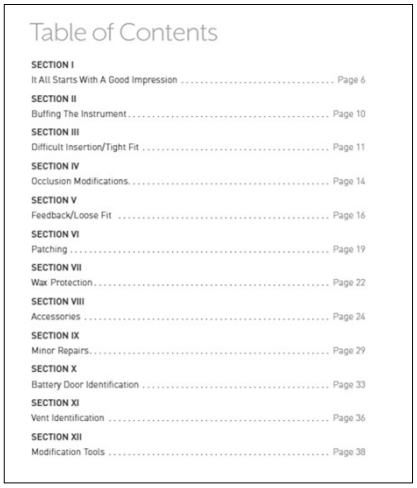
Starkey Modification Guide





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Gain Reduction

- Equally over all frequencies
- For the lowest input level (highest gain re: WDRC)
- In critical frequency regions where feedback is expected to occur
  - Notch filtering - gain is reduced in narrow frequency bands around critical frequencies

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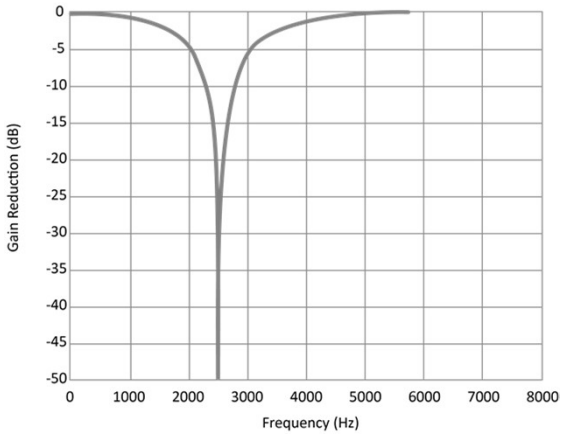
Notch Filtering

- Reduces gain in a specific frequency region
- Multiple notch filters may be used if feedback occurs at more than one frequency
- If the feedback signal changes in its frequency composition, notch filters can change



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Problems with Notch Filters

- Suppressing one frequency may create feedback at another
- Reduced audibility
- Reduced word recognition ability

Feedback Cancellation

The premise behind feedback-cancellation algorithms is similar to that of noise cancelling headphones.
It creates a copy of the feedback component and adds it out of phase to the input signal.

Hearing aid manufacturers have their own proprietary algorithms.

Goals of Feedback Cancellation

- Achieve as much gain as possible over a wide frequency range while eliminating feedback
- Preserve audibility, speech intelligibility, sound quality, and comfort
- Do not allow processing artifacts that could degrade sound quality
- Low susceptibility to tonal signals/entrainment
- Quickly adjust to feedback path changes

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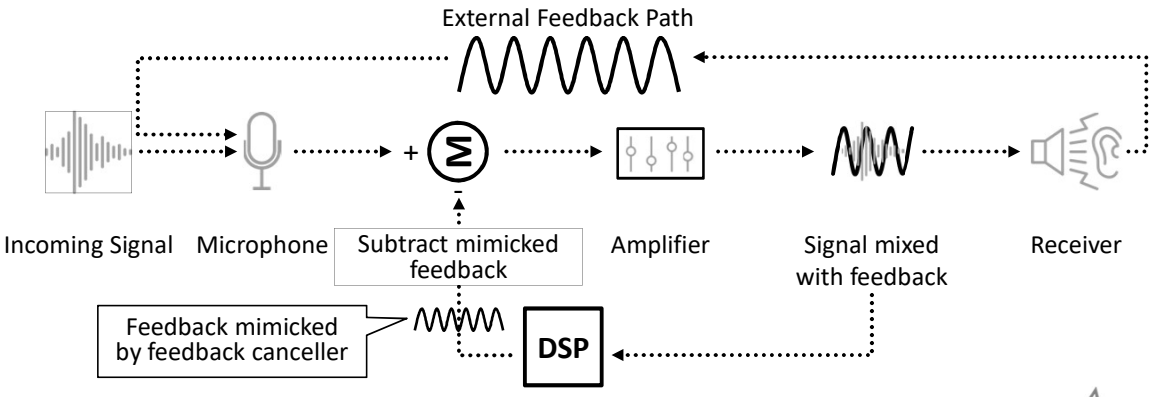
Feedback Cancellation

① Feedback path is modeled mathematically ② Subtracted from the microphone signal ③ Feedback is canceled



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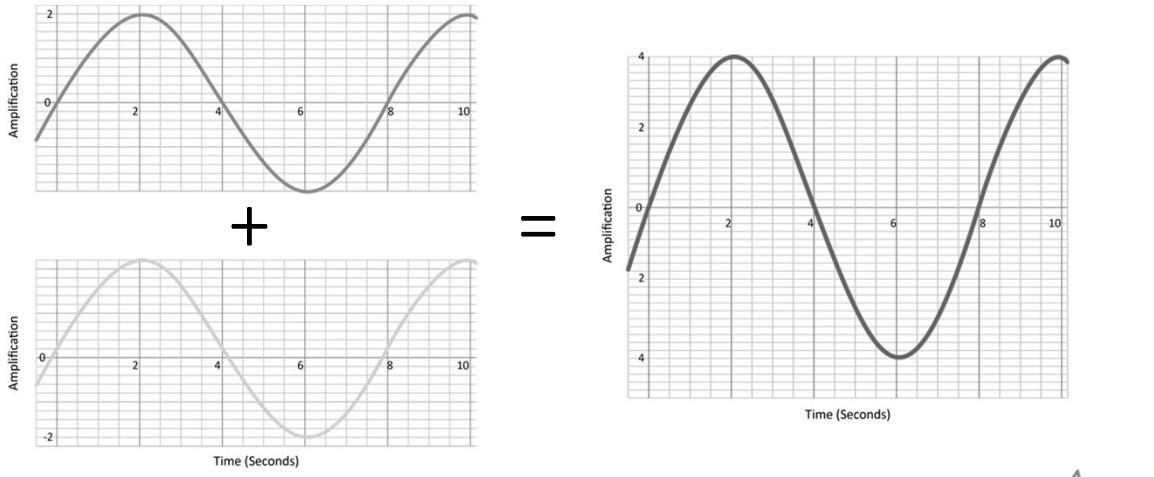
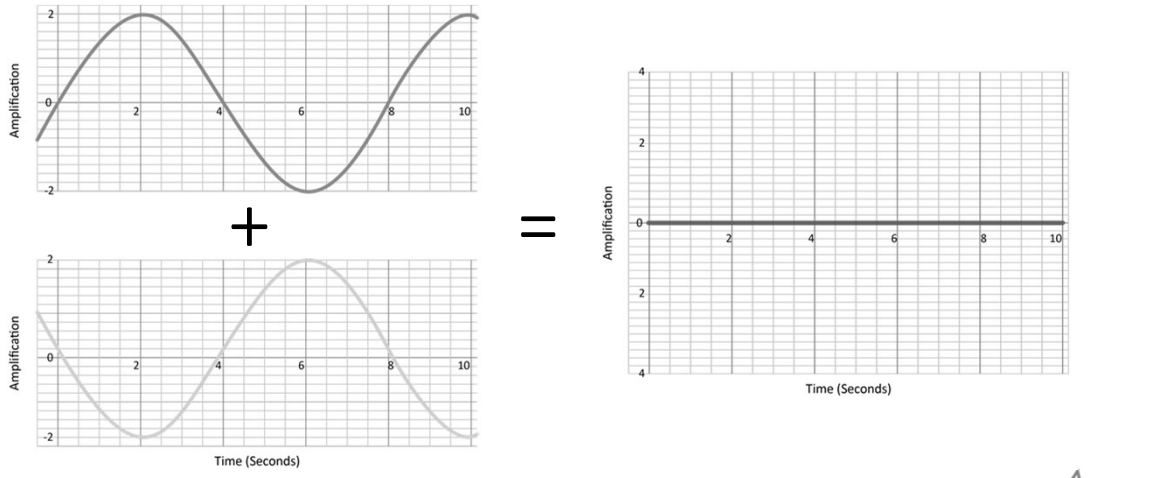
In-Phase



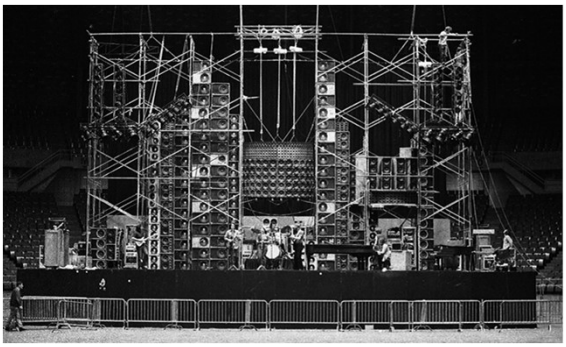
Out-of-Phase



Fun Fact

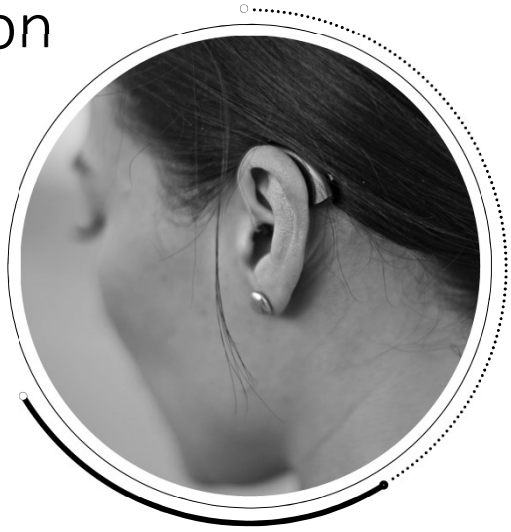
Grateful Dead's wall of sound prevented feedback by having two mics for each vocalist with one of the mics 180° out of phase of the other

- Both mics mixed on the same channel
- Everything cancelled except the voice

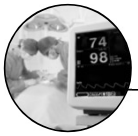


Feedback Cancellation

- No gain reduction
- Can improve the stability of the hearing aid and provide additional gain
  Compared to an instrument setting that does not use feedback cancellation
- Effective with open fits and large vents
  - Static and Adaptive Filters
  - Artifacts
  - Entrainment



Static Filter



Static Feedback Cancellation Filter

- Single filter applied
- Based on area where the highest feedback potential exists
- Useful for stable environments where the feedback path won't change
- Ideal for eliminating entrainment
- No artifact (warble) from output phase modulation

Adaptive Filter

Adaptive Feedback Cancellation Filter

- Filter is always changing to address changes to the feedback path
- Feedback canceller settings regulate the speed of adaptation to the new signal
- Balancing act re: speed of filter changes
- Faster helpful to address changing path but may yield artifacts

The Story Behind Warble and Chirp

- Adaptive Feedback Cancellation is very effective at eliminating feedback
- Phase shifts are what allow it to work so well
- When the signal with the shifted phase is combined with the original signal, Output Phase Modulation occurs
- Patient may notice a 'warbly' sound quality when larger phase shifts are applied (determined by how aggressive the algorithm is set)
- Artifact reduction refers to the management of the adaptive filter coefficients (when to engage and disengage)
- Artifact reduction can cause chirping

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Entrainment

When a feedback canceller mistakenly attempts to cancel a tonal input or the addition of a tone to the original source by the hearing aid itself.

May report hearing

- The additional tone
- Feedback after the original sound has stopped
- Modulation-type distortion of the sound
- Distortion

Entrainment artifacts

Can be eliminated by using a non-adaptive approach to feedback cancellation / static filter

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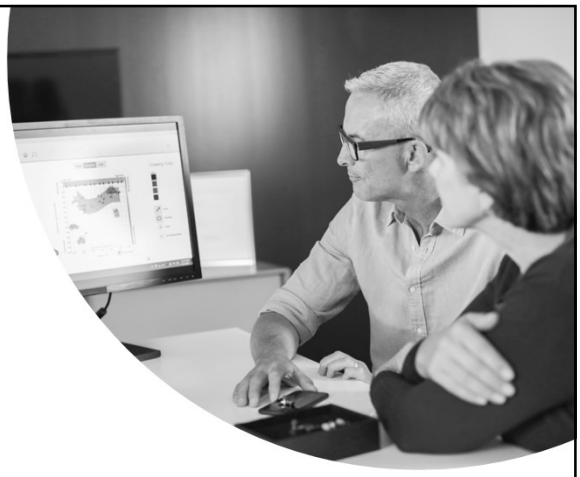
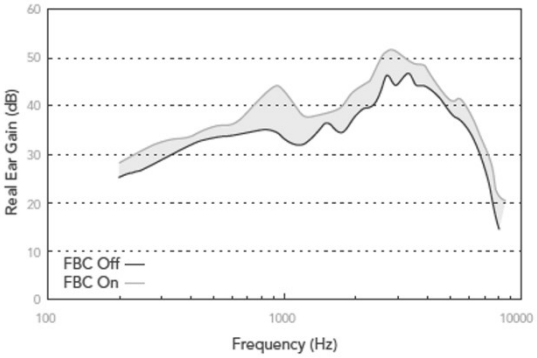
FBCX Initialization



- Broadband noise with a known spectrum (white noise) played through the hearing aid
- Creates a buzzing sound
- Frequency response of the signal at the source is compared to the response at the microphone of the hearing aid
- Measures potential feedback paths
- Frequency regions in which feedback is most likely to pose a problem are identified
- Accounts for individual anatomy and fitting
- Performed in a quiet environment

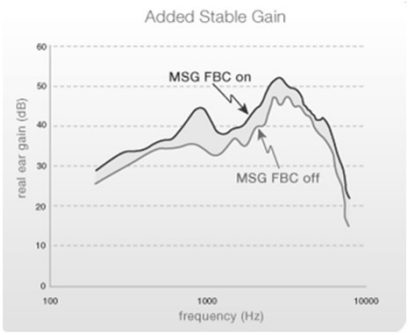
Maximum Stable Gain (MSG)

- Highest amount of gain that can be provided without risk of audible feedback or degraded sound quality due to feedback oscillation
  (Johnson et al., 2007; Ricketts et al., 2008)
- Varies as a function of frequency
- Should be greater with FBC enabled vs. disabled

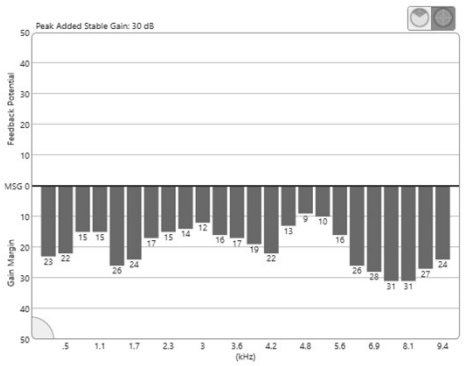


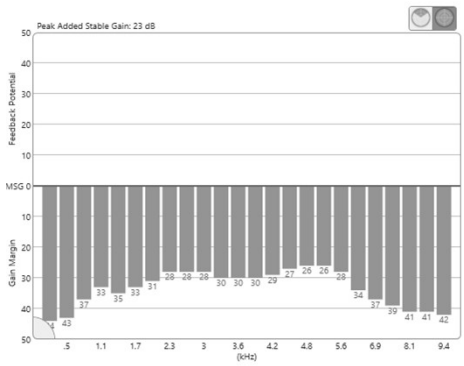
Added Stable Gain (ASG)

- Difference in MSG with FBCX algorithm OFF vs. ON
- Additional gain available when the hearing aid's feedback cancellation algorithm is active
- Varies across manufacturers



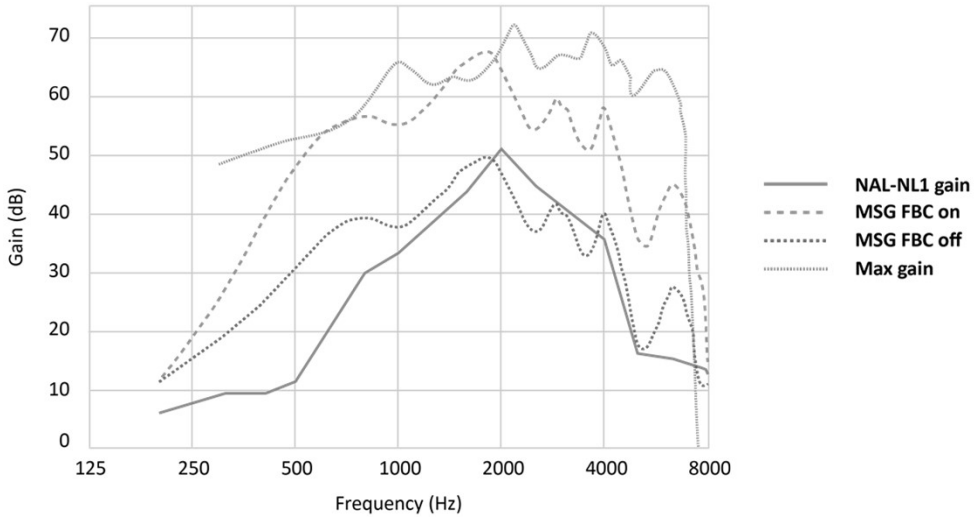
Example of FBCX Initialization





Gain Margin: Number of dB programmed gain is below maximum stable gain

Clinical Relevance of MSG and ASG



Merks, Banerjee and Trine

Additional Clinical Considerations

Added Gain Before Feedback (AGBF)

- Gain of the hearing aid programmed to a prescriptive target like NAL-NL2
- Feedback suppression OFF
- Gain is raised until feedback occurs
- Real-ear aided response (REAR) is recorded
- Feedback reduction algorithm ON and the process is repeated
- The difference between the two REARs is the AGBF

Pro

Measurement of the added gain provided by FBCX

Cons

- If HA is stable with FBCX OFF, max output may be reached with FBCX ON
- No information on Sound Quality
- Time

Maximum Real-Ear Insertion Gain (Max-REIG)

- Measure the maximum real-ear insertion gain (REIG) with feedback reduction ON
- Provides an indication of how much headroom is available for the fitting
- Compare coupling options

Gain Capping

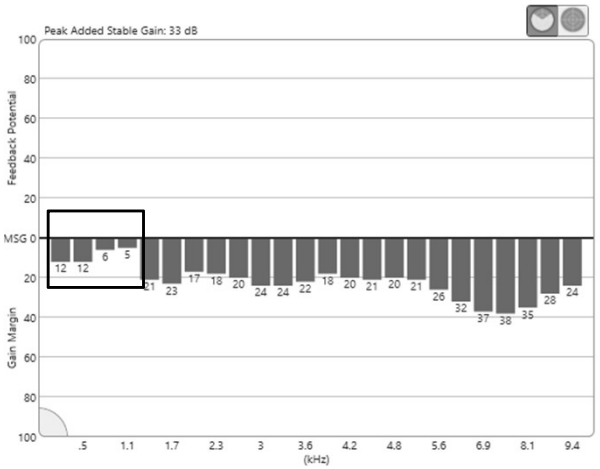
- Gain adjustments are NOT available to meet real ear targets or personal preferences
- 4 of the Big 6 companies cap gain based on the initialization process
- Real ear/speech mapping is beneficial to ensure the HA response is appropriate

FBCX Initialization

- New fittings
- Wearer reports feedback artifacts
- Changes to coupling
- Change to venting
- Re-fitting following hearing aid repair

Not Always High Frequency

- Acoustic feedback typically occurs at or near the high frequency peaks in the hearing aid frequency response - frequency with the greatest gain
- Feedback is not restricted to the HFs



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Power On Delay

Increase the power on delay give the patient time to get the hearing aids into their ears

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Custom Earmolds

Custom RIC earmolds

- Proper seal of the EAC
- Proper alignment
- Comfort

Frequency Lowering

- Feature designed to improve high frequency audibility with precipitous high frequency hearing loss
- HF bandwidth is altered
- Little-to-no high frequency gain
- Feedback less problematic

Considerations

Should only be used with the right patients

Altered sound quality

Behavioral validation required re: word recognition ability

Bone Anchored Hearing Aids (BAHA)

- Feedback source is generally broadband
- Acoustic or mechanical origin
- Leakage from the transducer back to the microphone
- Skull radiation
- Soft tissue interference

Fun Fact

"I Feel Fine" starts with a percussive feedback note

John Lennon's guitar was resting against Paul McCartney's bass amp when McCartney plucked a string

Lennon's semi-acoustic guitar picked up the amplified sound

First use of feedback on a rock record

Optimizing the Patient Journey

Feedback Management is an important tool for optimizing the patient journey with amplification

Thank You

@StarkeyHearing