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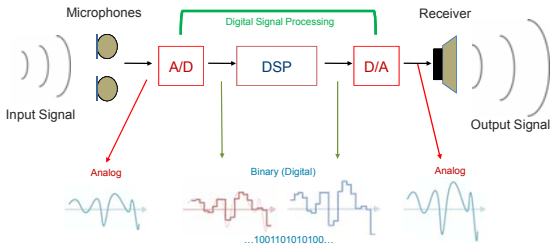
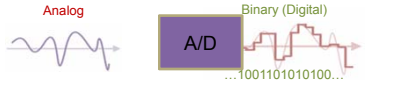
ANALOG TO DIGITAL CONVERTER



TODAY'S AGENDA

- **After this course learners will be able to explain the process of the A/D conversion of the audio signal.**
- **After this course learners will be able to describe the different wireless technology used in hearing aids to share data.**
- **After this course learners will be able to explain the benefits of WidexLink.**

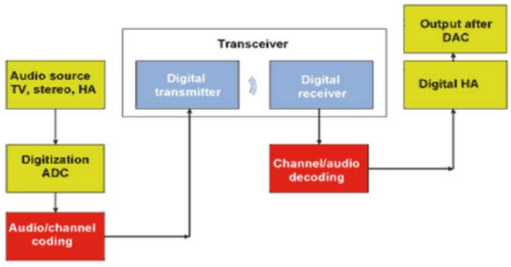
ANALOG TO DIGITAL CONVERTER



- Accuracy of the A/D conversion will impact the following:

UNDERSTANDING WIRELESS TECHNOLOGY?

ANALOG TO DIGITAL CONVERTER



WHAT IS WIRELESS TECHNOLOGY?

WIDEXLINK™

900 MHZ

NFMI

WHAT IS WIRELESS TECHNOLOGY?

Electromagnetic energy involves 2 things with hearing aids:

1. Signal (acoustic) or information
2. Means to carry the "information" form one place to another

WHAT DOES IT MEAN???

WHAT IS WIRELESS TECHNOLOGY?

Electromagnetic information can be carried via analog or digital technology

1. Analog
   a) Telecoils
   b) FM Systems
2. Digital

WHAT IS WIRELESS TECHNOLOGY?

"Electronic products and systems that interact by using electromagnetic energy to carry information between these products, enabling communication."

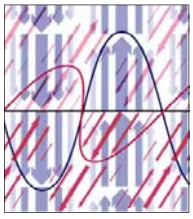
WIRELESS TECHNOLOGY TODAY

EM = Electromagnetic Waves

Not audible unless they are converted to a sound wave.

Easily modified = EM waves excellent carriers of data.

EM waves cover a wide range of frequencies - *carrier frequency*



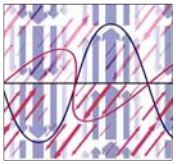
WIRELESS TECHNOLOGY TODAY

Carrier Frequency depends

- how much information
- how much power is available
- transmission distance
- how many other devices are using that frequency
- local laws and regulations

Higher carrier frequencies = more information

Lower carrier frequencies = less power for transmission



ADVANTAGES OF NFMI

- Fast connection
  - No delay
- Low battery drain – uses very little power
  - Low current drain on Hearing Aids
- Can transmit through almost anything

WIRELESS TECHNOLOGY TODAY

RF = Radio Frequency

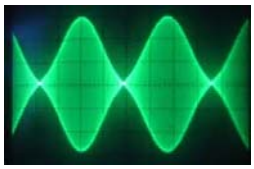
Electromagnetic wave frequencies = 3 kHz to 300 GHz

- ***Carrier Frequencies***

Use an antenna to generate and transmit

Designed to radiate into free space = Far-Field

- Radar / TV Broadcasting / Satellite / Cell-Phone
- Microwave
- Infra-Red
- WidexLink™
- Bluetooth



DRAWBACKS OF NFMI

- Short transmission distance
  - 1 meter
- Need a “Gateway device” around the neck when connecting to anything further than 1 meter
- Size
- Sound quality can be affected by the orientation of the gateway device and hearing aid receiver coil
- Magnetic sources may also cause interference
  - Old computer monitors
  - Fluorescent lights

WIRELESS TECHNOLOGY TODAY

NFMI = Near-Field Magnetic Induction

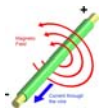
Near-Field = Short Range Wireless

Low Energy Magnetic Field = Low Power

Fast connection = Instantaneous

Less Interference; Nulls

Combined with Bluetooth using an intermediary device



WIRELESS TECHNOLOGY TODAY

2.4 GHz

RF Carrier Frequency

- (79 channels)
- Bluetooth
- Cordless Landline Phones
- Car Alarms
- Microwaves
- Video / Security Systems
- Wireless Data Networks
- Remote Control Cars / Droids

ADVANTAGES OF 2.4 GHZ

- Long distance signal transmission
- Does not require “Gateway Device”
- Robust reliable connections
- High transmitted data capacity, bandwidth, stereo, and low distortion
- Low delay from source to listener
- No echo problems and no lip synchronization

ADVANTAGES OF 900 MHZ

- Does not require a “Gateway Device”
- Long distance signal transmission
- Relatively low power consumption
- Low delay from source to listener
- No echo problem and no lip synchronization when watching TV

DRAWBACKS OF 2.4 GHZ

- High battery consumption
- Can’t send information through the skull, need to find a way around it

DRAWBACKS OF 900 MHZ

- Only 4 channels available for use
  - Not used or available all over the world
- Lower frequency so sharing less information than a 2.4 GHz signal
- Low Fidelity/sound quality

WIRELESS TECHNOLOGY TODAY

900 MHz

900 MHZ

RF Carrier Frequency
- (4 Channels in US)
  - Not Applicable Worldwide
- More Distance
- Lower Power – Energy
- Low Fidelity / Quality
- Video Transmission
- Closed-Circuit TV

2.4 GHZ VS. 900 MHZ

WIRELESS TECHNOLOGY TODAY

Bluetooth

BLUETOOTH (Traditional)

- RF signal - 100 meters
- Carrier Frequency = 2.4 GHz
- File transfers between devices
- Continuous Streaming
  - Lots of data at close range
- Garage-door
- Baby monitors
- Wireless headsets
- Wireless keyboards, speakers, printers

WIRELESS TECHNOLOGY TODAY

Bluetooth 4.0

BLUETOOTH LOW ENERGY

- RF signal - 100 meters
- Carrier Frequency = 2.4 GHz
- Introduced in 2011 as Bluetooth 4.0.
- Low power consumption.
  - Exchange small amounts of data periodically.
  - Sleep mode except when connected
- Connection times a few mS vs. Bluetooth ~100mS.
- Data rates are so high at 1 Mb/s.
  - Blood pressure monitors
  - Fibit-like devices
  - Public transportation apps

ADVANTAGES OF BLUETOOTH

- Able to transmit over a longer distance than NFMI
  - 100 meters
- Open system
- Channel hops to minimize interference
- Compatibility – Bluetooth is by far the best known personal area networking technology in the world, and is backed by all the main manufacturers of consumer devices

ADVANTAGES OF BLE

- Better battery consumption than traditional Bluetooth
- Simplicity – the radio is based on the familiar Classic Bluetooth radio, and its simple mode of operation can be managed by a small protocol stack
- Robust radio – designers can target a line-of-sight range of as much as 100m. A frequency-hopping scheme makes a Bluetooth LE radio highly resistant to interference
- Real-time operation – a connection between devices can be made, data transferred and the connection shut down, in just 3ms
- Compatibility – Bluetooth is by far the best known personal area networking technology in the world, and is backed by all the main manufacturers of consumer devices.

DRAWBACKS OF BLUETOOTH

- Delay in sound can cause a mismatch between audio and visual signals
- Uses a lot of power consumption
- Continuous drain/continuous streaming
- Expensive to use in devices

DRAWBACKS OF BLE

- Streaming BLE connections use less of the actual original signal due to the connection.
- Not backwards compatible with traditional Bluetooth devices

WIRELESS TECHNOLOGY TODAY

Bluetooth vs. Bluetooth Low Energy – There is a Difference

In summary:

1. Bluetooth & Bluetooth Low Energy are used for very different purposes
2. **Bluetooth** can handle a lot of data, but consumes battery life quickly and costs a lot more.
3. **BLE** is used for applications that do not need to exchange large amounts of data, and can therefore run on battery power for years at a cheaper cost.
4. It all depends on what you're trying to accomplish.

WIDEXLINK™ WIRELESS TRANSMISSION

- Efficiency – lower current usage
  - Reduced transmission size
- Flexibility – various functions and applications
- Robustness – security, minimize drop outs and artifacts
  - Minimize interference
  - Accurate identification
- Quality – superior sound
  - Stereo
  - Echo-Free
  - Greatest accuracy
  - MP3 sound quality

WIRELESS TECHNOLOGY TODAY

ANDROID & BLE:

- This allows Android apps to communicate with BLE devices that have low power requirements: proximity sensors, heart rate monitors, fitness devices.

WIDEXLINK™ WIRELESS TRANSMISSION

Short-range antenna

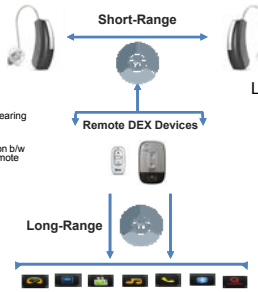
Long-range antenna

WIDEXLINK™ WIRELESS CONNECTIVITY

Proprietary wireless communication designed specifically for hearing loss and hearing aids

- **Patented** - created and owned by WiDEX
- Communicates **21 times per second** between hearing aids
- Providing high quality stereo sound, echo-free wireless communication to external audio devices
  - Cell phone, TV, Stereo, iPAD, Landline Phone
- **DEX** assistive listening devices from WiDEX.

WIDEXLINK™ WIRELESS TRANSMISSION



Short-range:

- Instant, ongoing synchronization and **coordination** b/w hearing aids
- 21 times a second
- Binaural transmission b/w hearing aids and remote devices

Long-range:

- Transmission b/w remote devices and external audio
- TV
- Cell phone
- MP3
- Other audio devices

WIDEXLINK™ SPECIFICATIONS

Sampling frequency	25 kHz
Processing frequency	2.12 MHz
Memory	512 kbit
Bitrate	212 kbit/s
Processing delay in HA	2-5 ms ⟵ Shortest in the industry.

FOR MORE INFORMATION ON WIDEXLINK

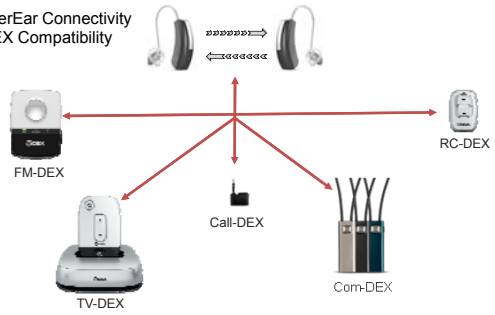
Digital Wireless Hearing Aids, Part 1: A Primer.
Authors: Kuk, F., Crose, B., Korhonen, P., Kyhn, T., Møkebjerg, M., Rank, M.L., Kidmose, P., Jensen, M.H., Larsen, S.M., Ungstrup, M.
Source: Hearing Review, 17(3): 54-67, 2010

Digital Wireless Hearing Aids, Part 2: Considerations in Developing a New Wireless Platform.
Authors: Kuk, F., Korhonen, P., Crose B., Kyhn, T., Mørkebjerg, M., Rank, ML., Kidmose, P., Jensen, MH., Larsen, SM., Ungstrup, M.
Source: Hearing Review, 18(6): 46-53, 2011

Cognitive Ergonomics: Making it Simple.
Authors: Andersen, H., Holm, H., Rose, S.
Source: Hearing Review, 19(2): 40-47, 2012

WIDEXLINK™ CONNECTIVITY

InterEar Connectivity
DEX Compatibility



FOR MORE INFORMATION ON WIDEXLINK

Digital Wireless Hearing Aids, Part 3: Audiological Benefits.
Authors: Kuk, F., Crose B., Kyhn, T., Mørkebjerg, M., Rank, ML., Nørgaard, M., Pontoppidan, F.
Source: Hearing Review, 18(8): 48-56, 2011

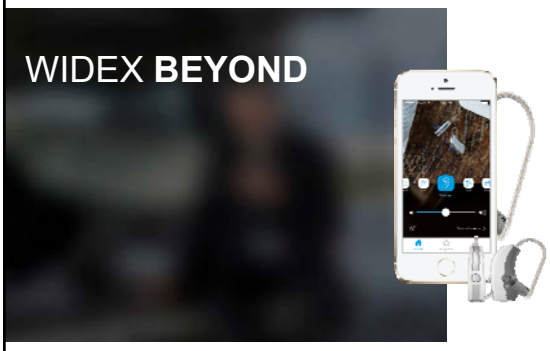
Digital Wireless Hearing Aids, Part 4: Interference.
Authors: Crose B., Kuk, F., Bindeballe, H.
Source: Hearing Review, 18(13): 30-39, 2011

WIDEX CONNECTIVITY

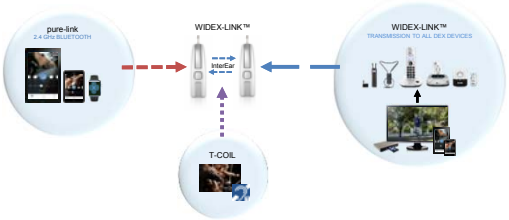
WidexLink™
- RF Signal
- ”Audio Coding method which is custom designed for use in a hearing aid platform”
- Developed a new (patiented) ***codec*** system

Codec = encoding/decoding algorithms

Bluetooth (Standard/Classic)
- Bluetooth uses 2.4 GHz carrier frequency
- Remote Mic to Com-Dex
- Bluetooth Devices to Com-Dex
- Bluetooth Devices to M-Dex



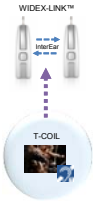
TRI-LINK™ TECHNOLOGY



TRI-LINK™ TECHNOLOGY

T-COIL

- Industry Standard – Induction
- Linear input dynamic range of 108dB SPL
- Large public buildings/venues
- MT &/or T options
- Nothing in industry that has more standardization and advantages over a large distance



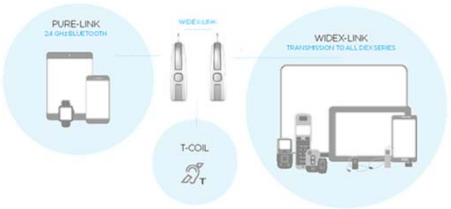
TRI-LINK™ TECHNOLOGY

PURE-LINK (2.4GHZ)

- Used for streaming audio &/or voice
- BLE = Bluetooth Low Energy
  - Different than classic Bluetooth
- Extremely low power consumption
  - compared to standard Bluetooth
- Ideal for short smooth connections
- Control connections via BEYOND APP

WIDEX BEYOND™ CONNECTIVITY

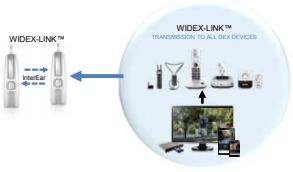
TRI-LINK™ Technology

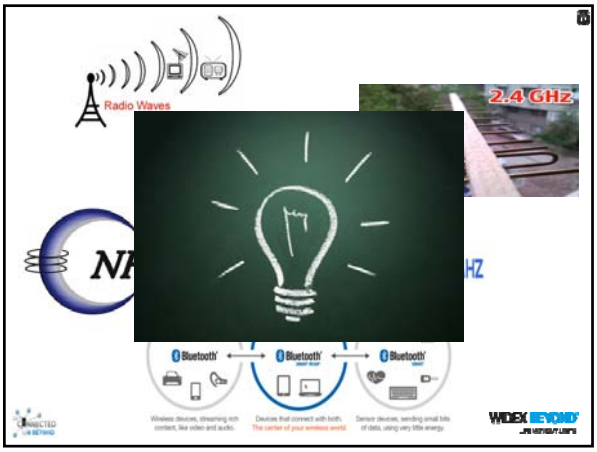


TRI-LINK™ TECHNOLOGY

WIDEXLINK™

- Widex proprietary wireless codec
- Extremly low power consumption
  - compared to BLE & Bluetooth
- Instant, ongoing communication
  - Between hearing aids
  - Direct connect to external audio sources
- Dedicated (bit-true) system
  - Multi-Phase transceiver
  - EchoFree
  - MP3 sound quality
  - 21 Hz data exchange rate





SUMMARY

- Not all wireless connections in hearing aids are the same.
- Widex provides you with a flexible and energy efficient way to transmit wirelessly with superior sound quality.
- The new Widex BEYOND hearing aid allows patients to connect wirelessly using multiple connection options.

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