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.
UNDERSTANDING WIRELESS TECHNOLOGY?

Analog...1001101010100...

Binary (Digital)...1001101010100...

Analog to Digital Converter

Microphones
Input Signal

Digital Signal Processing

AVD → DSP → D/A

Analogue → Binary (Digital) → Analogue

Receiver
Output Signal
Accuracy of the A/D conversion will impact the following:

- Input Range
- Sampling Frequency
- Bit Depth & Dynamic Range
- Internal Noise
- Battery Consumption

**ANALOG TO DIGITAL CONVERTER**

Audio source
TV, stereo, HA

Digitization
ADC

Audio/channel coding

Transceiver

Digital transmitter

Digital receiver

Channel/audio decoding

Output after DAC

Digital HA
WHAT IS WIRELESS TECHNOLOGY?

WIDEXLINK™

Radio Waves

2.4 GHz

900 MHz

WHAT DOES IT MEAN???

Wireless devices, streaming rich content, like video and audio.

Devices that connect with both. The center of your wireless world.

Sensor devices, sending small bits of data, using very little energy.

Whoa.
WHAT IS WIRELESS TECHNOLOGY?

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

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 IS WIRELESS TECHNOLOGY?

Electromagnetic information can be carried via analog or digital technology

1. Analog
   a) Telecoils
   b) FM Systems

2. Digital

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*
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

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
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

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
**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**

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

DRAWBACKS OF 2.4 GHZ

- High battery consumption
- Can't send information through the skull, need to find a way around it
WIRELESS TECHNOLOGY TODAY

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

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 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

2.4 GHZ VS. 900 MHZ
WIRELESS TECHNOLOGY TODAY

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

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
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

WIRELESS TECHNOLOGY TODAY

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
  - Fitbit-like devices
  - Public transportation apps
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 BLE

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

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 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**

- 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
**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

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
<th>Note:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling frequency</td>
<td>25 kHz</td>
<td></td>
</tr>
<tr>
<td>Processing frequency</td>
<td>2.12 MHz</td>
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<tr>
<td>Memory</td>
<td>512 kbit</td>
<td></td>
</tr>
<tr>
<td>Bitrate</td>
<td>212 kbit/s</td>
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</tr>
<tr>
<td>Processing delay in HA</td>
<td>2-5 ms</td>
<td>Shortest in the industry.</td>
</tr>
</tbody>
</table>

WIDEXLINK™ CONNECTIVITY

InterEar Connectivity
DEX Compatibility

- FM-DEX
- TV-DEX
- Call-DEX
- RC-DEX
- Com-DEX
WIDEX CONNECTIVITY

WidexLink™
- RF Signal
- "Audio Coding method which is custom designed for use in a hearing aid platform"
- Developed a new (patented) 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

FOR MORE INFORMATION ON WIDEXLINK

Authors: Kuk, F., Crose, B., Korhonen, P., Kyhn, T., Makebjerg, M., Rank, M.L., Kidmose, P., Jensen, M.H., Larsen, S.M.; Ungstrup, M.

Authors: Kuk, F., Korhonen, P., Crose B., Kyhn, T., Markebjerg, M., Rank, M.L., Kidmose, P., Jensen, M.H., Larsen, S.M., Ungstrup, M.

Cognitive Ergonomics: Making it Simple.
Authors: Andersen, H., Holm, H., Rose, S.
FOR MORE INFORMATION ON WIDEXLINK

Authors: Kuk, F., Crose B., Kyhn, T., Mørkebjerg, M., Rank, M.L., Nørgaard, M., Pontoppidan, F.

Authors: Crose B., Kuk, F., Bindeballe, H.
TRI-LINK™ TECHNOLOGY

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
TRI-LINK™ TECHNOLOGY

WIDEXLINK™

- Widex proprietary wireless codec
- Extremely 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

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
WHAT IS WIRELESS TECHNOLOGY?

WIDEXLINK™

Radio Waves

2.4 GHz

NFMI

Wireless devices, streaming rich content, like video and audio. Devices that connect with both. The center of your wireless world. Sensor devices, sending small bits of data, using very little energy.

900 MHz
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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